UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Urban Freight in "Car-Free" Cities

Opportunities & Barriers in Gothenburg, Sweden

Elliot Moran
Supervisor: Michael Browne
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Graduate School, School of Business, Economics and Law, University of Gothenburg, Sweden

Abstract

Cities today suffer from congestion, poor air quality and noise pollution due to motorised vehicles in urban areas. The infrastructure related to these vehicles use a large portion of cities' already limited space, leading to the decay of public spaces. This has led city authorities to implement restrictions to vehicle movements. This thesis investigates the car-free city phenomenon, urban logistics solutions to its restrictions, and the perceived opportunities and barriers to them by municipal agencies in Gothenburg, Sweden, that would likely be responsible for its implementation. This was achieved through group interviews with said municipal agencies.

Results from the group interviews were subsequently compared to the literature. There was a considerable overlap between identified opportunities and barriers and those found in the literature. Key points identified were the opportunities for improving urban areas, citizen health, freight, and city life, as well as important considerations like exemptions for different categories, like emergency services, freight, and the disabled, as well as safe walkable areas for pedestrians and cyclists. Barriers to a car-free adapted logistics solution were identified, with urban rail, modal shift, and electric delivery vehicles, having slower comparative speed due to modal shift, limited flexibility, as well as limited capacity in some electric delivery vehicles.

Keywords: Car-free, urban logistics, city logistics, multimodal urban distribution centres, urban consolidation centres, walkability, group interviews, workshop, Barcelona, Oslo, Gothenburg.

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Sincerely,

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Elliot Moran

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1.0 Background

This chapter provides a brief introduction to the background of car-free cities, with the rapid growth of motor vehicle use and urbanisation, and their negative externalities. Followed by a problem discussion that delves further into these issues. The thesis purpose and research questions are presented, as well as the scope.

1.1 Introduction

The Transport White Paper issued by the European Commission in 2011 declared two specific urban goals to be achieved by 2030, essentially CO2-free logistics in major urban centres, and halving the use of conventionally fuelled cars in cities, phasing them out entirely in urban areas by 2050 (Siragusa et al, 2020; Ilin et al, 2023; Arvidsson & Browne, 2013; Arvidsson & Pazirandeh, 2017). The European Commission aims to decrease CO2 emissions as well as tackle air and noise pollution by encouraging the use of alternative fuels (Quak et al, 2016). These measures are primarily directed to private transport. However, one could expect that they would gradually be applied to other sectors as well (Ilin et al, 2023).

Despite numerous attempts to reduce the number of vehicles with internal combustion engines, the result is still negligible, which is in contradiction with EU directives (Iwan et al, 2021). Motorized traffic is rapidly growing, with the number of road vehicles globally expected to reach 2 billion by the year 2030 (Gundlach et al, 2018; Nieuwenhuijsen & Khreis, 2016). Traffic density tends to be high in cities because of economic and social activities and urban planning patterns, exacerbating the health concerns in urban areas (Nieuwenhuijsen & Khreis, 2016). Cities are places of intensive human activity, with them already accounting for 55 % of the world population (Pietrzak & Pietrzak, 2021). By 2050 68-86% of the world will be living in urban areas (Pelet et al, 2023; Pietrzak & Pietrzak, 2021). As a result of this progressing global urbanisation, sustainability will depend on effective management of these areas, with an increasing urban population also increasing cargo and passenger flows (Pietrzak & Pietrzak, 2021).

Urban freight is of particular interest to transportation planners due to its central role in the urban economy as well as the detrimental effects of road freight transport (Cochrane et al, 2017). Urban freight distribution is almost entirely performed by road vehicles, with congestion, lack of parking spaces, lack of appropriate loading and unloading areas, affecting its efficiency (Alessandrini et al, 2012; Pede et al, 2006; Vajihi & Ricci, 2021). The use of road-based vehicles for urban freight movement has resulted in several issues. Cities suffer from congestion, poor air quality and noise pollution, with urban deliveries being a major contributor (Regué & Bristow, 2013; Pelet et al, 2023; Pietrzak & Pietrzak, 2021; Ngoc et al, 2023; Pede et al, 2006; Vajihi & Ricci, 2021; Cochrane et al, 2017; Arvidsson & Browne, 2013; Deveci et al, 2022) through a quarter of transport emissions and more than two-thirds of road accidents (Arvidsson & Pazirandeh, 2017). This is a challenge for city authorities as balancing the need for mobility and its negative externalities is difficult (Iwan et al, 2021). Efficient urban freight movement is critical to the operation of transportation networks (Deveci et al, 2022). This challenge is increasing with the rise of e-commerce, where the size of individual shipments decreases further, as well as the expectation of speed for transport, leading to an increase in urban freight movement within cities (Regué & Bristow, 2013; Pelet et al, 2023; Pietrzak & Pietrzak, 2021) making the planning of last-mile delivery even more difficult. (Pelet et al, 2023; Ngoc et al, 2023).

1.2 Problem Discussion

Cities have become subservient to the needs of transport system development rather than the needs voiced by its residents (Pietrzak & Pietrzak, 2021). The ever-growing presence of motorised traffic in urban areas has caused public spaces to decay and will ultimately lead to a disturbance of urban social systems (Gundlach et al, 2018). Cities already have high congestion levels and limited space (Katsela et al, 2021), with parking and road space using up a large amount of this limited space in cities that could arguably be used for other purposes such as trees, parks, and other green space, which are often lacking in cities but are more beneficial to public health and well-being (Nieuwenhuijsen & Khreis, 2016).

Cities today are host to a myriad of public health problems related to transport, with traffic accidents resulting in pedestrian deaths, polluted air, and sedentary lifestyles, that can reduce economic productivity, and harm overall quality of life (Welle, 2017). Car use being sedentary is also associated with substantial increases in premature mortality and morbidity particularly in cities, with a reduction in active transport and physical activity lowering the likelihood of making and interacting with social contacts on a regular basis (Nieuwenhuijsen & Khreis, 2016). In addition to adverse health effects, car use is also related to externalities like inequality, road damage, congestion, and oil dependence (Gorrini et al, 2023; Nieuwenhuijsen & Khreis, 2016). Vehicle related accidents are a direct cause of many deaths globally, with millions of injuries. The total cost of traffic congestion, pollution, and accidents in the EU total 502 billion euro per year (Nieuwenhuijsen & Khreis, 2016), with road congestion specifically costing approximately 1% of GNP on an EU level (Arvidsson et al, 2013).

Urban freight is a significant problem, accounting for a disproportionate share of environmental externalities in urban areas, despite accounting for a fraction of total vehicle movements (Deveci et al, 2022). Freight vehicles are accountable for between 16-40% of urban traffic emissions while only accounting for 10-14% of urban road traffic (Alessandrini et al, 2012; Arvidsson & Browne, 2013; Ngoc et al, 2023; Deveci et al, 2022). Heavy freight vehicles are even worse, making up four percent of road traffic but accounting for more than half of the fatal cyclist and pedestrian accidents (Arvidsson & Pazirandeh, 2017).

Freight distribution systems in urban areas are impacting quality of life on an unsustainable level (Arvidsson & Browne, 2013), with urban freight movement being a detriment to living standards (Deveci et al, 2022). Excessive land consumption and need to share urban space between pedestrians and city transport is a considerable negative consequence resulting from the dynamic development of urban transport (Pietrzak & Pietrzak, 2021). Urban freight distribution is often provided in inefficient ways, and the industry is particularly resistant to change (Arvidsson et al, 2013). The urban space that is required to transport the same amount of people with bicycles or bus is much smaller than that with cars, the same is true if people are replaced with parcels and cars with delivery vans, representing today's urban freight distribution (Arvidsson & Pazirandeh, 2017).

This emphasis on urban freight transportation has resulted in attempts to expand transportation strategies in some cities (Deveci et al, 2022), with many cities experimenting with innovative policies for the reorganisation of urban freight distribution (Pede et al, 2006). Cities seek to develop their city centres to make them more attractive, vibrant, and accessible (Hagen & Tennøy, 2021). Several cities have introduced measures restricting car use, ranging from *car-free city centres*, to restricting car access in new residential areas, where parking is no longer adjacent to housing but rather organized in concentrated parking facilities (Gundlach et al, 2018).

Many cities have introduced special zones allowing vehicles with zero or low emission, i.e. *Low Emission Zones* (*LEZs*) and *Zero Emission Zones* (*ZEZs*) to enter (Pietrzak & Pietrzak, 2021). *LEZs* are areas which are closed to vehicles that do not meet certain emission standards. *LEZs* have been implemented in several urban areas (Cruz & Montenon, 2016; Sarmiento et al, 2023; Browne et al, 2005; Malina & Scheffler, 2015). *LEZs* can lead to major air quality improvements (Browne et al, 2005; Sarmiento et al, 2023), and become more effective in reducing pollution over time. Pollution is especially high in urban areas, where tailpipe emissions from motor vehicles are one of its primary sources (Sarmiento et al, 2023). Particulate matter (PM) emissions are one of the main concerns, with them contributing to premature mortality and morbidity, as they cause cardiovascular and respiratory diseases, leading to a decrease in average life expectancy. As cities are densely populated the number of people exposed to PM is high, which exacerbates the adverse health effects of PM emissions from road transport (Malina & Scheffler, 2015).

A *Zero Emission Zone (ZEZ)* would be requiring the replacement of all non-compliant cars with electric vehicles. A scenario which would eliminate tail-pipe emissions, leaving only contribution from other sources (Marner et al, 2023), like non-exhaust emissions from break and tire abrasion, and road wear (Malina & Scheffler, 2015; Marner et al, 2023). Introduction of *LEZs* or *ZEZs* requires the application of dedicated vehicles, such as *Electric Freight Vehicles (EFVs),* or *cargo-bikes* (Pietrzak & Pietrzak, 2021). *LEZs* consistently reduce emissions locally, inside their borders, potentially leading to air pollution spill over into adjacent areas (Browne et al, 2005; Sarmiento et al, 2023). This suggests that people living outside the *LEZs* bear the cost of restrictions without experiencing the benefits of improved air quality (Sarmiento et al, 2023).

Transportation requirement is strongly linked to economic development (Deveci et al, 2022), but people's health pay the cost in negative side effects (Arvidsson et al, 2013). Balancing the need for mobility with environmental and health concerns is one of the most pressing issues for the sustainability of urban centres. Reducing excessive dependence on motor vehicles is paramount in preserving the environment and ensuring urban liveability (Gundlach et al, 2018;

Paijmans & Pojani, 2021). Motor vehicles emit CO2 and other greenhouse gases and air pollutants such as particulate matter and nitrogen oxides. Motor vehicles and related infrastructure are related to other environmental externalities, like heat and noise, with air pollution and noise being particularly high near roadsides (Nieuwenhuijsen & Khreis, 2016). While it might be possible for the automobile industry to find technical solutions to reduce air pollution, neither better filters for diesel engines nor the replacement with electric cars can solve the urgent problems of urban centres caused in large part by individual motorized traffic (Gundlach et al, 2018). Electric vehicles can reduce some of the noise-, and air pollution, but not the space that they occupy (Rueda, 2018).

Encouraging the shift towards public transport, walking and cycling is a challenge for cities (Gorrini et al, 2023). While it is hard to imagine a world without cars, cities around the world are beginning to shift their mobility solutions away from private cars towards more sustainable modes, like the walkability of cities (Gorrini et al, 2023; Nieuwenhuijsen & Khreis, 2016). Walkability contributes to the quality of life of citizens by enhancing physical activity, road safety, well-being, air quality, and social inclusion (Gorrini et al, 2023).

1.3 Purpose

Today, there are several pedestrian zones, and a few select pedestrian only streets in central Gothenburg. Municipal politicians have proposed turning all the central area *Inom Vallgraven* into a *car-free city centre*, inspired by Barcelona's *"superblocks"* (Kommunstyrelsen, 2021), as well as the local transport authority's plans to create more pedestrian zones, removing parking spaces and road space for cars in large parts of *Inom Vallgraven* (Trafikkontoret, 2022). Both proposals raise concerns regarding urban freight and its need to not only continue to function, but to improve by addressing its negative externalities.

This thesis aims to investigate the *car-free city* phenomenon, urban logistics solutions to its restrictions, and the perceived opportunities and barriers to them by municipal agencies in Gothenburg, Sweden, that would likely be involved in its implementation. This is accomplished through qualitative *group interviews* with members of the Gothenburg municipal agencies, Stadsmiljöförvaltningen, and Stadsbyggnadsförvaltningen[1]. This thesis contributes to the literature by answering the research questions, which gives a greater understanding of municipal agencies view on the feasibility of *car-free initiatives*, as well as related *urban logistics solutions*. Freight is often neglected despite its fundamental importance for an area's economy with public policy rarely considering freight transport (Cruz & Montenon, 2016).

[1] Municipal agencies responsible for public spaces, accessibility, and the physical planning in and of Gothenburg (Göteborgs Stad, n.d).

Research Questions
RQ1: What opportunities & barriers do municipal agencies identify to the implementation of car-free initiatives in Gothenburg, Sweden?

RQ2: What opportunities & barriers do municipal agencies identify in urban logistics solutions to restrictions imposed by potential car-free city initiatives?

RQ3: Do the identified opportunities & barriers align or contrast those found in the literature?

1.3.1 Scope

This thesis will focus solely on *car-free city centres* that have a clear framework and available literature, and *urban logistics solutions* that are of particularly appropriate to city centre deliveries, as well as *primary data collection* solely focusing on Gothenburg, Sweden, as *group interviews* will be conducted exclusively with Gothenburg municipal agencies.

This concludes the thesis background which has presented an introduction, problem discussion as well as the thesis purpose, with research questions and scope. The following section will present the results from the literature review.

2.0 Literature Review & Theoretical Framework

This chapter presents a literature review & theoretical framework for car-free city centres, as well as urban logistics solutions.

2.1 Car-free Initiatives

This section presents a brief introduction to the car-free phenomenon, as well as two examples of car-free initiatives, Oslo, and Barcelona, which were selected based on both their popularity, and clear framework, as well as available literature. Additional cities were examined, like Brussels, Ghent, London, Zurich, but were ultimately excluded due to the lack of framework and/or available literature.

The *car free city* phenomenon is not new, with Toppi & Pharoah (1994) writing a foundational paper on it as early as 1994. The term "*car-free*" itself produces ambiguity and misunderstandings in the debate (Toppi & Pharoah, 1994). *"Car-free city*" does not mean the complete removal of cars, with cars having become an integral part of modern city life. There will always be exceptions for certain groups and stakeholders (Rydningen et al, 2017; Minh, 2016). The term "*car-free*" cannot be taken literally. It means the reduction of motor traffic to levels compatible with the environmental quality required by residents, visitors, and trade. The term is applied to initiatives by city governments to increase the attractiveness and economic vitality of their city centres by reducing parked and moving vehicles, while encouraging access by "urban compatible" means of travel. It implies greater intervention than in isolated pedestrian shopping streets but does not mean the complete removal of cars (Toppi & Pharoah, 1994). Nevertheless, there are concerns that hamper these initiatives. Mainly, that the negative impact of reduced car accessibility might be more substantial than the positive impacts of better accessibility by other transport modes and more pleasant environments (Hagen & Tennøy, 2021).

Car-free city centres have two comparable precedents, the pedestrian zone, and the traffic-calmed area. In both cases, retailers initially offered strong opposition. However, in nearly every pedestrian zone and traffic-calmed area the turnover of shops has increased. There is evidence of much wider and growing interest in policies which adapt the car to the city in place of the more usual destructive attempts to adapt the city to the car (Toppi & Pharoah, 1994). Surveys reveal that 60-85% of people support "drastic limitation of car traffic within big cities", keeping the current infrastructural services constant (Gundlach et al, 2018; Toppi & Pharoah, 1994). Among people who do not drive this figure was 91%, and even amongst drivers the figure was 82%. "Car-free centres in the big cities" were favoured by 53% overall, by 63% of non-drivers, and by 49% of car drivers (Toppi & Pharoah, 1994). This increases to above 90% once the bicycle infrastructure is improved and public transportation fees are reduced (Gundlach et al, 2018).

Car-free city centres can only develop its intended effect and avoid unintended side-effects when combined with other measures. The most important condition is attractive and efficient public transport, with a densification of the network of bus stops and train stations contributing to a higher acceptance of a *car-free city centre* (Toppi & Pharoah, 1994; Gundlach et al, 2018). A critical aspect of car-bans is having too many exemptions, and inadequate capacity and quality of the public transport alternative (Toppi & Pharoah, 1994). Both permanent and temporary interventions in city centres that favour pedestrians lead to greater use, with more people walking and biking, reduced traffic volumes, positive impacts on social interactions and health, and increased retail turnover (Hagen & Tennøy, 2021).

2.1.1 Oslo

About

Oslo is an often-cited example of a *car free city centre* since introducing and implementing an ambitious car-free model in 2017 (Rydningen et al, 2017; Tortosa, 2022; Hagen & Tennøy, 2021; City of Oslo, 2020). Oslo has set ambitious goals to prioritise pedestrians, cyclists, and public transport users, and to reduce private vehicle traffic. Aiming to create a greener and more pleasant city that is easier to move around in. Each one of these points are targets in the overall municipal plan for 2030 (City of Oslo, 2020; Oslo municipality, 2017). Oslo aims to reduce its greenhouse gas emissions by 50% by 2030, relative to 1991 levels. One of the pillars in achieving this is the aim to reduce all traffic in Oslo by one third by 2030. Oslo is predicted to grow by nearly 200,000 residents over the next 20 years, and if this population growth is not decoupled from private transport, it will lead to an increase in greenhouse gas emissions. These emissions are expected to increase by 15% by 2030. The only way to avoid this development, is to implement more sustainable measures for the transport sector (Rydningen et al, 2017).

The population of Oslo is ageing and are in increasingly good health after reaching retirement age. Facilitating accessibility is a primary goal, with making it safe and desirable for elderly people to walk or to cycle being an important public health measure (City of Oslo, 2020). Accessibility for all people must be a primary goal in a pedestrian city centre, it is therefore natural that some will be allowed to continue to drive in the city centre (Rydningen et al, 2017).

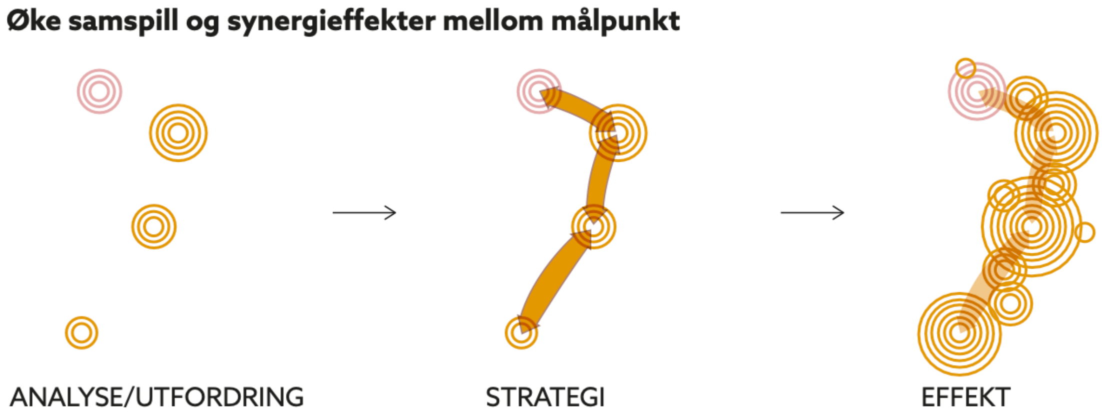
History

The move to restrict car use began in the 1990s. In 1994 a former six lane traffic artery going through the city centre was closed to motor vehicles, then opened to a new tram line in 1995. A new traffic plan 2002 proposed removing 300 surface parking spaces, continuing the pedestrianisation and introducing a 30 km/h speed limit in the city centre. In 2010, the municipality adopted another traffic plan for the city centre, proposing the pedestrianisation of new streets, the widening of pavements and the elimination of on-street parking (Tortosa, 2022).

In 2017, the *"Car-free Liveability Programme"* was introduced. The programme was created in response to a report that found the city centre to lack good connections to the fjord and surrounding neighbourhoods. The report found that Oslo is an obvious pedestrian city, but that the quality of pedestrian movement varies greatly. Car traffic was found to act as a powerful disruptive element, creating barriers for pedestrians and cyclists (Oslo municipality, 2017). The programme turned away from the traditional hierarchy of the road, taking away priority from motor vehicles and instead prioritising pedestrians (City of Oslo, 2020; Oslo municipality, 2017). This objective was motivated by the desire to offer inhabitants a pleasant city centre, to facilitate retail, services, and other commercial and non-commercial activities, to attract businesses and inhabitants to the city, and to shift urban mobility toward more sustainable modes (Hagen & Tennøy, 2021). The programmes formulating document states that the most important lesson learned was the importance of words and their meaning. *"Car-free"* became a slogan of its own, which people began to fill in for themselves (City of Oslo, 2020).

Framework

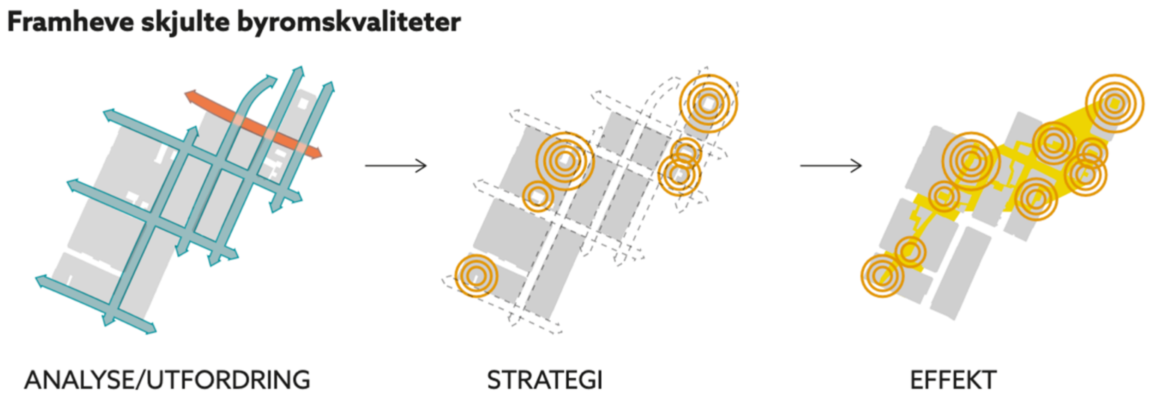
The programme divides central Oslo into 13 sub-areas that capture different issues and characteristics. The analysis of the individual sub-areas identified urban spaces and sub-areas that are considered particularly important to prioritise, in order to achieve a comprehensive strengthening of city life in the centre of Oslo. Each area has its own set of strategies and initiatives that contribute to increased city life (Oslo municipality, 2017; Oslo kommune, 2019). The main principle in redrawing the road network is connecting destinations by strengthening the connections between them and highlighting distinctive urban space qualities. By establishing better pedestrian connections between the target points, synergies beyond the intrinsic value of the target points are achieved (Oslo municipality, 2017).



English: Analysis - Strategy - Effect.

***Figure 1 - Oslo Framework 1**, from: Oslo Kommune (2017, p35).*

Most of the streets within the city centre are designed for car-based transport and parking. By expanding the pedestrian street network and shared use areas, and constructing wider pavements in several streets, the accessibility and experience for pedestrians becomes more attractive (Oslo kommune, 2019; Oslo municipality, 2017).



English: Analysis - Strategy - Effect.

Figure 2 - Oslo Framework 2*, from: Oslo Kommune (2017, p35).*

This new street layout is based on the principle of prioritising pedestrians and cyclists, and areas of activity. The design of each cross-section depends on the function of the street. For example, "collective street", i.e. main streets for trams and/or buses but in combination with soft road users, "pedestrian street" - prioritized pedestrian streets and "cooperative street" - streets with multi-use principles. (Oslo municipality, 2017).

Implementation

The area where private vehicles are restricted is an area of 1.3 km2, from Oslo Central Station in the east to the Royal Palace in the west, including Oslo's main commercial streets, shopping malls, and major nightlife districts. Roughly 1,000 people live in this area, but more than 100,000 travel in and out to work every day (Oslo municipality, 2019; Rydningen et al, 2017). Based on the price per square metre in central Oslo, a single parking space is worth roughly 1,000,000 Norwegian kroner. The city authority questioned whether this was the best use of this space. (Tortosa, 2022). The programme removed most municipal street parking, adding more seating and green areas in the city centre. Many of the reclaimed parking spaces have been made available for goods deliveries, tradesmen working in the city, and the disabled. The city also makes the reclaimed space available for concerts, courses, sporting events, festivals, theatre, seminars, gatherings, performances and more (Oslo municipality, 2019; City of Oslo, 2020).

Private use of vehicles was scaled down through a gradual restriction on where it was possible to drive and park (Oslo municipality, 2019), with the traffic pattern being changed (City of Oslo, 2020). Several goals were used as foundation when developing the new traffic pattern, such as a desire to restrict traffic going through the city centre west-east and north-south and to reduce the number of private cars on public transport routes (City of Oslo, 2020). This new traffic pattern makes it impossible to cross the city centre from east to west in a car, significantly reducing access to the road network without immediately closing the entire city centre to motorised traffic (Tortosa, 2022; Hagen & Tennøy, 2021).

It is still possible to deliver goods throughout the city centre, with accessibility to all properties by road being maintained. Goods must be delivered, maintenance must be carried out and the city needs to improve how it facilitates mobility for the disabled (Oslo kommune, 2019). Car driving is still allowed in most streets (Hagen & Tennøy, 2021), however driving a car in Oslo city centre has become less attractive (Oslo kommune, 2019). Traffic reduction was not the primary goal of the Car-Free Liveability Programme, but traffic reducing measures have played an important role in creating a better urban environment and increasing accessibility for more road users (City of Oslo, 2020).

The programme included a stepwise removal of approximately 760 out of 1,450 on-street parking spaces available in the area (Hagen & Tennøy, 2021). The removal of street parking for private cars was a major aesthetic victory, but it made accessing the city by car more difficult (City of Oslo, 2020). Surface parking requires a larger share of downtown area compared to other forms of transport. Additionally, travel surveys suggested that most journeys use other means of transportation (Rydningen et al, 2017). Analysis in the years following implementation revealed that on-street parking use decreased with parking garage use increasing. The use of private parking, and parking spaces offered by employers also increased dramatically, with the share of commuters reporting it easy to find parking near their workplace doubling. Although street space had been reallocated from driving and parking to other uses, many surveyed still felt that there was too much car traffic in the city centre and that parked cars took up too much space. However, this sentiment decreased each year (Hagen & Tennøy, 2021).

Results

When street space was reallocated in the Oslo city centre, the conditions for car usage worsened while other modes improved. These accessibility changes could be expected to result in modal changes toward lower proportions of commuters and city centre users traveling to and in the city centre by car (Hagen & Tennøy, 2021). At a municipal level, modal shift has been well underway before 2015 (Tortosa, 2022). When comparing survey data between from before and after implementation, only weak changes in modal choice could be observed. Most commuted by public transport, walking shares increased every year, with both being higher than car-driver shares. (Hagen & Tennøy, 2021; Stridh & Norgård, 2020). The share of car drivers was already low before the interventions were implemented (Hagen & Tennøy, 2021).

Despite the car restrictions, car usage on commutes increased, which the changed access to parking offered by employers may explain (Hagen & Tennøy, 2021). Commuters working in the city centre were generally satisfied with their commutes, with the share answering positively increasing yearly when comparing before and after restrictions. The same could be observed generally with car drivers, with drivers surveyed become more satisfied year on year, which is surprising given the reduced car accessibility. One explanation could be that those driving to work park in garages, not on the street, and would not be affected by removal of on-street-parking (Hagen & Tennøy, 2021).

There was hardly any variation in the frequency of visits to Oslo's city centre. City users continued to express that there was too much car traffic, parked cars, buses, and goods delivery at the same frequency each year following the measures. Opposite to this were responses disliking the car and parking restrictions that remained stable (Hagen & Tennøy, 2021). Oslo municipality's consultants found that car traffic volumes had been reduced, and people walking and cycling hade increased (Hagen & Tennøy, 2021). Overall, the results give a clear picture that the level of traffic in the city centre has decreased significantly during the period, but it is not possible to link this to individual measures (Stridh & Norgård, 2020).

The *Car-free Liveability Programme* has not been the only driver of traffic changes in central Oslo during period. In parallel, many other measures, individual projects and political guidelines have been initiated which may have influenced the traffic situation in the city centre. The traffic effect of traffic-reducing measures carried out in the *Car-free Liveability Programme* can therefore not be isolated (Stridh & Norgård, 2020).

Accessibility is crucial for businesses needing to attract employees from the larger urban region. Changes in actual and perceived accessibility could affect how often the city centre is visited, what is done when visiting, and how much money is spent (Hagen & Tennøy, 2021). Retailers were initially concerned that closing streets would hurt stores, criticising a perceived lack of long-term holistic view. There is no doubt that the retail industry would be affected by a traffic-free city centre. Revenues would likely be reduced during reconstruction but would be expected to increase once everything is in place (Rydningen et al, 2017).

Consultants investigating the issue for the municipality found a weak increase in turnover in the years following implementation, with the area having a higher turnover than reference areas. They also found that the city centre had become a more popular place to establish businesses (Hagen & Tennøy, 2021; City of Oslo, 2020). Important to note is that Oslo is the economic centre of Norwegian retail, which could also explain this (City of Oslo, 2020). A survey comparing before and implementation found that there was an increase in respondents who answered that it was very easy to access the city centre, which indicates that the perceived accessibility to the city improved. There were 14 percent more people on the streets and 43 percent more people at leisure in urban spaces (Hagen & Tennøy, 2021).

The reallocation of street space in the Oslo city centre contributed positively to factors relevant for attracting visitors to the city centre and businesses. It has improved the travel experience for those walking and biking in the city centre and worsened the for those driving their private car there, which could result in shifts toward more sustainable travel behaviour in the long run. (Hagen & Tennøy, 2021).

Summary & Criticism
The reallocation of street space in the city centre of Oslo did not cause significant change among commuters or city centre users. The interventions improved the walking and biking experience in the city centre. Even car drivers seemed less affected than many anticipated. There are several explanations for the lack of significant adverse impacts in Oslo. There was already low car use among commuters and city centre users prior to the restrictions. Car access to the central station and existing private and public parking garages in the area has been retained, meaning that about 90 percent of the city centre's parking capacity remained unchanged. Meaning that the existing parking-garage capacity was high enough to accommodate the new demand (Hagen & Tennøy, 2021).

Although the *Car-free Liveability Programme* is presented as a break in urban transport policy, it was in fact fuelled by major road-burial works designed to ease motorised traffic, with the construction of underground roads, and tunnels. Motorised traffic has not disappeared but has been buried for nearly 25 years. Most of the traffic passing the city centre had been moved from surface streets to underground motorway tunnels, meaning that banning through-traffic there did not have a large effect on traffic volumes (Hagen & Tennøy, 2021; Tortosa, 2022). It therefore became a question of erasing parts of the car network rather than its disappearance or drastic reduction as a result of the interventions (Tortosa, 2022).

By taking advantage of a project that was not initially intended for them, pedestrians, cyclists, and public transport users benefited from a desire to improve the flow of motorised traffic in the 1980s and 1990s, that led to a vast movement to restrict surface car use in the 2000s (Tortosa, 2022). Also, the project needs to be put into perspective. It only affects 1.3 km2, or 1% of the city's urbanised surface area, which has a very low residential density and population (Tortosa, 2022; Oslo municipality, 2019; Rydningen et al, 2017).

2.1.2 Barcelona

About
Barcelona's *superblocks* have attracted international attention and acclaim as a tool for reorganising public space and reducing the movement and dominance of motorised traffic (Amati et al, 2024; Anguelovski et al, 2023). *Superblocks* are an innovative urban and transport planning strategy that prioritizes pedestrians over motor vehicles, with the aim of improving environmental quality and liveability through reclaiming public space, reducing motorized transport, and promoting sustainable mobility (Anguelovski et al, 2023: Mueller et al, 2020; Lopéz et al, 2020). *Superblocks* not only modify a city's physical structure, but also its mental barriers, which are driven by car-centred city planning (Lopéz et al, 2020). Barcelona is the largest city to have adopted them as a guiding principle for the whole city (Amati et al, 2024). Barcelona dedicates more than 60% of public space and 85% of roads to traffic, with the use of public space being restricted by mobility (Rueda, 2018). One of the most radical aspects of *superblocks* is the conversion of the single function traffic streets to multiple uses in most urban spaces (Rueda, 2018; Amati et al, 2024).

The *superblock* is a cell of three by three, or nine, city blocks of Barcelona's grid system, in which traffic is diverted away from the centre block, transforming four vehicular intersections into public plazas. The cell is pedestrianised, and traffic is pushed to the surrounding streets (Rueda, 2018; Anguelovski et al, 2023). By eliminating through traffic, it aims to decrease noise and air pollution, convert car-related street space into green and walkable streets, while strengthening public transit and cycling infrastructure (Anguelovski et al, 2023). The formed cell is approximately 400m by 400m (Lopéz et al, 2020; Mueller et al, 2020). The dimensions are based on the speed of a car going around the cell at 20km/h, the average urban speed in Barcelona, being comparative to a person walking at 4km/h (Rueda, 2018; Amati et al, 2024). *Superblocks* allow the through traffic of cars, buses, and bicycles in its periphery, while prioritising movement on foot and bicycle on the inside (Rueda, 2018). The average number of inhabitants in a *superblock* in Barcelona is around 5000–6000 (Rueda, 2018; Lopéz et al, 2020).

In addition to reconfiguring transport, the *superblock* model consists of developing open public, and green space throughout the city, consisting of plazas, parks, green corridors, and green patches in and around the cells (Mueller et al, 2020), improving the health and quality of life of its inhabitants (Lopéz et al, 2020), as well as facilitating safe and independent child play. The implementation of *superblocks* is expected to decrease private motorized traffic considerably, while traffic flow on the basic road network remaining stable (Mueller et al, 2020).

History

The idea of *superblocks* in Barcelona is nothing new. Towards the end of the 19th century Catalan urban planner Ildelfons Cerdà devised the *"Cerdà plan"* which considered the human need for open space and greenery, and a transport network accommodating pedestrians, horse-drawn carriages, and public tram lines (Mueller et al, 2020; Amati et al, 2024). The plan is famous for its extension of Barcelona, creating its grid array of large blocks and wide streets to promote circulation. Each block was intended to have an area of open space in the centre for residents (Amati et al, 2024). Despite this, by the 1920s Barcelona's streets became filled with concrete structures, with the centre of the blocks being filled with buildings (Mueller et al, 2020; Amati et al, 2024). This has led to Barcelona today suffering from a chronic lack of open space, excess noise, and air pollution that exceeds European Union law (Amati et al, 2024).

The next major intervention proposed for Barcelona was the *"Macià plan"* in 1932. Where among other things, the creation of larger 400m by 400m blocks was proposed to facilitate the speed of automobile traffic. Although not fully implemented, it laid the foundations for development of today's *superblock*. (Lopéz et al, 2020; Amati et al, 2024) In 2000, a total of 503 Superblocks stretching across the city of Barcelona were proposed (Amati et al, 2024; Mueller et al, 2020; Anguelovski et al, 2023), aiming to create equalizing and redistributive benefits to all districts (Anguelovski et al, 2023). The proposed city-wide implementation of these blocks was driven by the need to reduce car movements and associated noise, nitrous oxide, and other pollutants (Amati et al, 2024).

Air pollution due to motorized traffic has an unacceptable impact on the health of Barcelona's metropolitan population. A study estimated that on a yearly basis air pollution causes 3,500 premature deaths 1,800 hospitalizations due to cardiovascular disease, 5,100 cases of chronic bronchitis in adults, 31,100 cases of children bronchitis, and 54,000 asthma attacks among both children and adults in Barcelona (Rueda, 2018). It is estimated that 20% of premature mortality and 13% of total of disease could be prevented if regulations regarding exposure to air pollution, noise, heat, and access to green space were complied with (Mueller et al, 2020). To address these serious problems, the Sustainable Urban Mobility Plan of Barcelona was approved by the city council in 2015. A plan which proposed to extend the *superblocks* throughout the city, aiming to reduce circulating vehicles by 21%. With this reduction, it is estimated that the levels of air pollution will fall below guideline values, while maintaining service levels for transport (Rueda, 2018).

Framework

As stated, a *superblock* is a cell of three by three, or nine, city blocks of Barcelona's grid system (Rueda, 2018; Anguelovski et al, 2023). The new cell is defined by the road network around the periphery, where through and connecting traffic circulate at a maximum speed of 50 km/h. This network accommodates motor vehicles, dedicated bike lanes that share street space with

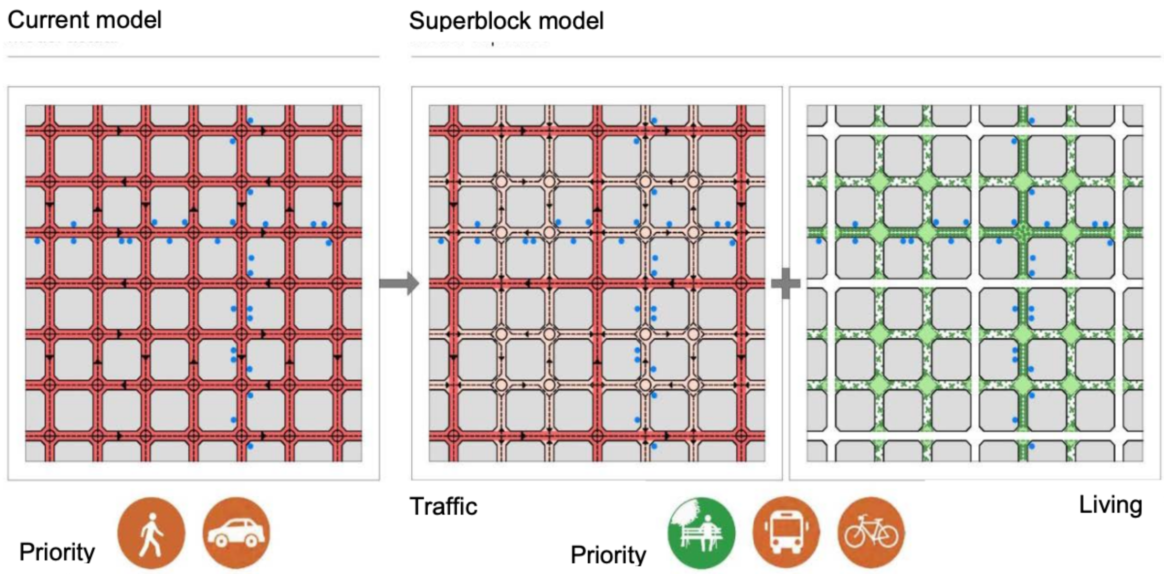


***Figure 3 - Barcelona framework**, from: Ajuntment de Barcelona (2016, p16).*

cars, being separated from pedestrian infrastructure, as well as a dedicated bus lane for rapid public transit (Mueller et al, 2020; Rueda, 2018). Bus stops are placed every 400m, at the main intersections, and buses circulate at a high frequency, making public transport an attractive transport alternative (Mueller et al, 2020). With main crossings every 400m, traffic light synchronization is much more efficient, as well as avoiding disruption of the main traffic flow due to turns, with two out of three turns being removed (Rueda, 2018).

The interior of the *superblock* provides a local road network that is accessible primarily to active transport, allowing bicycles to cross the superblock in both directions at either 10, or 20 km/h. Speed must be adjusted to the speed of pedestrians or the uses that are in place at that moment, with the rider being required to step off the bicycle, if necessary (Rueda, 2018; Mueller et al, 2020). Residential traffic with a maximum speed of 20 km/h is also allowed (Mueller et al, 2020). A superblock cannot be crossed, which means that movements into the interior only make sense if their origin or destination is in the interval (Rueda, 2018). Because of this, traffic inside the cells will almost be removed completely making streets more accessible for pedestrians (Lopéz et al, 2020), as well as little to no noise or pollution (Rueda, 2018). The implementation does not require investment in hard infrastructure, tearing down buildings or massive redevelopment (Lopéz et al, 2020).

Implementation

Three *superblocks* were implemented by 2019, and commitments have been made for six more (Mueller et al, 2020). What function the centre of the *superblock* has is decided through a participative process, where residents themselves get to define problems, challenges, and solutions, together (Lopéz et al, 2020). This process brings together civic groups and associations working together with city staff to collaboratively diagnose public space needs and to organise residents' proposals for specific interventions (Anguelovski et al, 2023). A steering group is set up in each district where the program is being implemented, to monitor the project. The steering group acts as a link between the technical team and residents, validating the different stages and helping to define the participation spaces, as well as the outcomes of the participation workshops and the technical work carried out (Lopéz et al, 2020). Although somewhat slow, this process has been key to the progress of *superblock* development in the city. Local acceptance of *superblocks* has grown over the years, with ongoing collaboration with residents being essential to dispel fears (Lopéz et al, 2020).

Results

The basic road network of *superblocks* reduces the total length of roads used by through traffic by 61%. This dramatic reduction does not lead to a proportional drop-off in the circulation of vehicles for the same level of service (Rueda, 2018), with 70% of urban mobility space used by motor vehicles being freed up by reducing the number of circulating cars by just 13% (Lopéz et al, 2020; Rueda, 2018). So far pedestrian space has been increased by 67% and will achieve a total increase of 270% once the total number of *superblocks* is implemented (Lopéz et al, 2020). This reduction of vehicles is expected to increase the percentage of people exposed to levels below the air pollution guidelines from today's 56%, to 94%, and from 54% to 73% for noise, as well as increasing the liveability index significantly (Rueda, 2018). The economic effect for Barcelona results in saving of €1.7 billion a year (Lopéz et al, 2020).

The Barcelona Public Health Agency evaluated the effects of the implementation in 2021 compared to 2019 (Anguelovski et al, 2023). The new green areas have become a well-used asset, by providing new local green and public areas for families and elderly residents living in the *superblocks* (Pérez et al, 2021; Anguelovski et al, 2023), as well as families living nearby. The creation of new open spaces removed from car traffic has provided safe spaces for socialisation, and rest. Among the most benefitted are the elderly, for which high quality urban spaces are essential as a place to socialise, as well as women with children who are more frequent users of proximity trips and reliant on active transportation (Anguelovski et al, 2023).

While traffic and noise increased in some streets over the short term, recent studies estimate that traffic levels on intervened streets have decreased by 15% while those in adjacent streets have seen insignificant changes. The traffic reduction achieved on intervened streets did not lead to a redistribution of traffic to adjacent streets, rather, some of the traffic seems to have disappeared, potentially because of drivers choosing other modes of transport or other routes. NO2 concentrations were found to have decreased by 25% at the central *superblock* intersection. Sound measurements showed that noise overall had remained somewhat stable (Anguelovski et al, 2023).

Benefits reported are emotional health, better rest, less noise, air pollution and greater socialization, a more relaxed environment, and a decrease in stress. The spaces facilitate walking and bring calm and improved mental health through interaction between neighbours (Pérez et al, 2021). *Superblocks* have the potential to reduce premature mortality, with reductions in air pollution, noise, and heat, as well as increased access to green space and public transport (Mueller et al, 2020; Lopéz et al, 2020). The estimated health impacts should make a case for a rapid implementation in Barcelona, and the scale-up to other cities, where similar health benefits could be found (Mueller et al, 2020).

In addition to these health benefits, other potential benefits are quality spaces with less disturbance helping provide security that positively affects a sense of community. These spatial improvements have greatly enhanced the quality and variety of the physical and social experiences that are available in the city, increasing mental and social as well as physical well-being (Amati et al, 2024; Mueller et al, 2020).

Summary & Criticism

While the project has received abundant attention, the *superblock* model has received some criticism. The project has not been scaled to its original ambition, demonstrating the financial, administrative, and practical difficulty in implementing such ambitious change. The original plan envisioned traffic reduction through a majority of streets in the city grid, with some streets remaining as arterials. In addition to this structural inequity, the plan’s partial implementation, with only a few *superblocks* being built, may also have pushed traffic flows to surrounding streets or specific areas (Anguelovski et al, 2023).

The pilot *superblock* areas were chosen out of convenience, as to minimize interruptions to city traffic, meaning that social and environmental equity considerations were not part of the selection process. The project has not been used to redress inequities, but rather as a marketable flagship program that needed to be implemented in an area where it was most likely to be successful (Anguelovski et al, 2023).

Therefore, the project has been unable to generate a city-wide change, failing to address complex mobility equity needs in Barcelona's marginalized neighbourhoods. While the project goals are noble, the urban design changes will likely have limited impacts on travel behaviour, especially among socially vulnerable population groups. *Superblocks* have increased accessibility and active travel infrastructure in areas that are already highly accessible. For instance, the Sant Antoni *superblock* is highly walkable and accessible and is inhabited by high- and middle-class groups. In contrast, the mobility needs of the working-class who live disproportionately in peripheral areas and commute longer distances remain unmet or unaddressed by Barcelona's *superblocks* (Anguelovski et al, 2023).

The new public spaces are mainly used by the elderly, and families with children, who consider it as a space that allows them to circulate comfortably, but also generates stress, with it giving a false sense of safety. Working people frequent the spaces for lunch or at the end of the day, while other groups use it mainly as a place to pass through, with young people feeling that the space is not designed for them. Some women consider the area deserted and perceive it to be unsafe, while others perceive the opposite (Pérez et al, 2021).

The implementation of *superblocks* could lead to increased regional traffic congestion in cities with both local and regional traffic, Complementary transport strategies need to be undertaken, such as design of public transportation in symbiosis with the design of *superblocks*. If urban residents are to give up their cars, they need to be able to access the rest of the city by other means (Lopéz et al, 2020).

Projects are not immune to market dynamics and land speculation that may burden or displace residents. Some of the equity concerns surrounding *superblocks* relate to if they constitute secluded islands of environmental. While most residents and families value the benefits of low-traffic streets and green spaces, residents surveyed in the *superblocks* report fear of displacement because of the urban greening agenda, relating this displacement to the attractiveness and the branding of the *superblock*. Most new real estate developments built around the *superblocks*, such as office buildings, luxury condos, and hotels are targeting high-income residents rather the district's long-term residents. The City of Barcelona is aware of this and is working to mitigate them through new social housing within the *superblocks* and other measures meant to mitigate gentrification (Anguelovski et al, 2023).

In 2021, the city announced that the project was pivoting away from the creation of nine block cells, and instead focusing on the creation of green axes. While not explicit, the city essentially abandoned the original nine block *superblock*, but retained its commitment to the core values of pedestrianisation that inspired the idea, creating considerable confusion within the city. The recent shift stems from a municipal vision to reach more residents and neighbourhoods rather than creating islands of privilege. The pivot aims to re-scale the original nine block cell to the entire city, meaning that city planners aim to transform the entire grid system into a pedestrian zone. Instead of pushing traffic to adjacent streets the goal is that traffic does not even enter the city. The green axes are meant to spread the benefits of greening throughout the city and avoid green gentrification (Anguelovski et al, 2023).

2.2 Urban Logistics Solutions

This section presents a brief introduction to issues in urban freight, as well as urban freight solutions, including modes, and nodes, which can be combined into a hypothetical solution that would allow freight to continue to function under the restrictions of a car-free city centre.

Increasing population density is a challenge for urban logistics because it results in traffic congestion and necessitates the use of irregular locations for logistics facilities (Pelet et al, 2023). Many countries have the same common goal, which is to optimize and organize urban freight transportation systems to decrease traffic congestion and air pollution in cities, but because freight transportation is primarily a business-to-business sector, communities' efforts to alleviate the results are typically limited to urban and traffic planning (Deveci et al, 2022).

A major problem is the inefficient use of vehicles in the last mile, or the final segment of the delivery process (Pelet et al, 2023), in urban areas, significantly contributing to congestion, emissions, and noise. This inefficiency stems from freight transport in urban areas often being uncoordinated, as shippers use different logistics service providers and carriers for delivery in the city centres. This results in non-optimised load factors of vehicles, multiple routes, and increased system costs (Katsela et al, 2021). There is a growing need to identify viable solutions to tackle these challenges through consolidation of goods distribution in cities (Björklund & Johansson, 2018).

Last-mile delivery is considered the most expensive, least efficient, and most complex part of the logistics chain (Toraman et al, 2023), with as much as 20-41% of supply chain cost being attributed to this last leg of distribution (Toraman et al, 2023; Arvidsson & Pazirandeh, 2017; Ilin et al, 2023). Last-mile deliveries are an increasingly important and costly component of supply chains, especially in urban centres, with the last meters of many deliveries being covered on foot (Pelet et al, 2023). The use of *electric delivery vehicles (EDV)* and different concepts of EVs, like *electric cargo-bikes*, can be appropriate solutions for last-mile deliveries in urban areas (Ilin et al, 2023; Vajihi & Ricci, 2021), with the use of environmentally friendly vehicles for last-mile delivery being one of the strongest ideas that pertain to the sustainable supply chain (Pelet et al, 2023).

Many urban logistics solutions have a clear potential to reduce environmental impacts. Unfortunately, they often become financially unsustainable without public subsidies (Katsela & Pålsson, 2019). The cost of externalities needs to be included in the economic evaluation of urban logistics solutions for them to become financially viable (Katsela et al, 2021). It is essential for the long-term success of urban logistics solutions to secure a sufficient flow of goods and enough customers to achieve economies of scale (Katsela & Pålsson, 2019).

2.2.1 Modes

This section presents two modes, urban rail, and electric delivery vehicles. These were chosen due to being especially relevant and appropriate to city deliveries. Other delivery modes were explored, like barges on inland waterways, but were determined to not be as relevant and ultimately left out.

2.2.1.1 Urban rail

In the past trams were often used to transport urban freight. These trams where taken out of operation in the 1950s (De Langhe et al, 2019), due to the rising popularity of the car and truck coupled with the extensive development of road infrastructure (De Langhe et al, 2019; Alessandrini et al, 2012). Today, rail is rarely used in urban freight transport (Alessandrini et al, 2012; Pietrzak & Pietrzak, 2021; Arvidsson & Browne, 2013; De Langhe et al, 2019).

Given the spatial overlap between the last mile in freight and passenger transport, and increasing demand, sharing of infrastructure needs to be considered in reducing land use requirements for transport (Arvidsson et al, 2016), and load on the road traffic network (De Langhe et al, 2019). Space in urban areas is becoming increasingly more expensive, giving potential to combining space. This would increase the efficiency of existing infrastructure and create a more integrated transportation system (Cochrane et al, 2017). One way of combining passenger and freight flows is to share the tram network (Arvidsson et al, 2016; Arvidsson & Browne, 2013; Regué & Bristow, 2013; Pietrzak & Pietrzak, 2021).

The idea of a freight tram involves using existing tramlines to deliver to micro depots instead of trucks (Vajihi & Ricci, 2021). Many urban areas possess rail infrastructure, that is often underutilized (De Langhe et al, 2019; Cochrane et al, 2017), opening the door for urban freight, particularly outside peak hours (Pietrzak & Pietrzak, 2021; Cochrane et al, 2017). Unlike road transport, rail transport is operated on fixed routes, and does not necessarily need to follow a predefined timetable, or to stop at all intermediate stops, like rail passenger transport. (Vajihi & Ricci, 2021). Using a freight tram to serve cargo flows in urban areas may be a competitive alternative to road transport (Pietrzak & Pietrzak, 2021), with it being resource efficient with or without electronically driven vehicles in the last mile delivery (Arvidsson & Browne, 2013).

There are several benefits to implementing an urban rail transport system. Most of them stemming from reduced externalities due to modal shift, like rail having a good weight/volume capacity, low energy and environmental impact, reducing congestion, and being less accident prone in comparison to road traffic flows (Arvidsson & Browne, 2013; Alessandrini et al, 2012; Regué & Bristow, 2013; Pietrzak & Pietrzak, 2021; Cochrane et al, 2017; Vajihi & Ricci, 2021; Deveci et al, 2022), as well as having good network linkages between cities (Arvidsson & Browne, 2013). It also brings with it the value-adding activities of both consolidation and urban consolidation, if implemented alongside (Regué & Bristow, 2013). Using passenger rail networks has the potential to generate revenue for the local transit agency (Cochrane et al, 2017).

Their low environmental impact, due to being electrically driven (Pietrzak & Pietrzak, 2021; Arvidsson & Browne, 2013), make them especially appropriate for *LEZs* and *ZEZs* (Pietrzak & Pietrzak, 2021). For a city distribution scenario one of the advantages of a delivery tram is avoiding the busy hours in the morning and in the afternoon, which a delivery truck does not since it usually makes one round trip per day (Arvidsson & Browne, 2013). Another benefit is the reduction in city congestion, especially at the motorways to and from the city, which makes it possible to reduce harmful environmental emissions (Arvidsson & Browne, 2013; Pietrzak & Pietrzak, 2021).

Barriers

The main barriers to urban rail freight distribution are the limited flexibility with lack of door-to-door capability (Alessandrini et al, 2012; Arvidsson & Browne, 2013; Vajihi & Ricci, 2021; Regué & Bristow, 2013), competition with passenger services for line capacity (Alessandrini et al, 2012; Vajihi & Ricci, 2021; Regué & Bristow, 2013), initial investment and operational costs perceived as being high (Alessandrini et al, 2012; De Langhe et al, 2019; Regué & Bristow, 2013; Vajihi & Ricci, 2021), and the comparative speed of current road transport (De Langhe et al, 2019). There is also a major challenge in the commitment of stakeholders involved, and the need for political backing (Regué & Bristow, 2013; Arvidsson & Browne, 2013).

A significant problem may be the potential conflict with the passenger service function, as new freight trips on existing public transit infrastructure operations have the potential to create passenger delays (Cochrane et al, 2017; Pietrzak & Pietrzak, 2021). This could make municipal transport companies hesitant to cooperate, and object to the use of municipal infrastructure (Arvidsson & Browne, 2013), and of qualified tram drivers, that may be in shortage (Pietrzak & Pietrzak, 2021). Transit users would be resistant to give up space in favour of cargo, especially if systems were to begin reaching capacity. As more cities struggle with congestion and environmental challenges, this is expected to change (Cochrane et al, 2017).

Despite the availability of tram infrastructure in many cities, a significant barrier is the infrastructural constraints in the lack of infrastructural elements that are relevant for freight transport, and the fact that the routes are adapted to the passengers' needs rather than the needs of freight. (Pietrzak & Pietrzak, 2021). The number of actors involved is greater in light rail freight than traditional freight, making the implementation and cooperation between multiple entities more complex (Arvidsson & Browne, 2013; Pietrzak & Pietrzak, 2021).

Building additional tracks for loading and unloading in the city centre is very expensive, costing upwards of one million Euros per kilometre. (Arvidsson & Browne, 2013). One way of reducing costs is the use of obsolete or existing surplus vehicles (Regué & Bristow, 2013; Alessandrini et al, 2012; Arvidsson & Browne, 2013). If old trams are used this means that the total tram park can be utilized for a longer period, which affects depreciation. (Arvidsson & Browne, 2013).

2.2.1.2 Electric delivery vehicles

Electric delivery vehicles (EDVs) are usually smaller, zero-emission vehicles (Ilin et al, 2023). The use of zero emission vehicles is one way to mitigate the negative externalities stemming from urban freight in cities while maintaining an efficient system (Quak et al, 2016), providing advantages such as no fossil fuel consumption, less carbon-, air- (Ilin et al, 2023), and noise pollution (Siragusa et al, 2020). Emissions and local pollutants may be significantly reduced if transport companies use cargo *EDVs* to transport goods in urban areas. (Ngoc et al, 2023; Siragusa et al, 2020). Smaller vehicles are generally operationally flexible, with accessibility to a wide variety of infrastructure like bicycle paths, pedestrian areas, bus lanes, easier flow through congestion, better parking possibilities, and limited structural impact in terms of noise and road damage (Arvidsson & Pazirandeh, 2017). Using *EDVs* for freight distribution in city centres also reduces noise pollution due to the near silent state at running speed (Kelly & Marinov, 2017). From the operations point of view *EDVs* are suited for urban logistics (Quak et al, 2016). Larger vehicles are better on long distances due to volume but have no real benefit to using them in city distribution (Arvidsson et al, 2013).

A *cargo-bike* (CB) is a popular type of *electric delivery vehicle*. The *CB* is a viable solution for urban logistics and the transportation of light goods in inner cities, where they are quicker than cars over short distances (Pelet et al, 2023). The advantages include easy access, no parking, sufficient speed and maneuver operations, emitting no greenhouse gases (Ilin et al, 2023; Pelet et al, 2023) and make little noise (Pelet et al, 2023). In addition, it promotes a healthier and more active workforce (Ilin et al, 2023). Unlike conventional bicycles, *CBs* have trunks. These trunks can be as large as 2 m3 and hold up to 250 kg of goods. *CBs* are equipped with electric motors (Pelet et al, 2023) moving at a speed of 15–20 km/h. *CBs* contribute to variety of solutions when multimodal transport is considered, with its last-mile access being a major advantage compared to other modes (Ilin et al, 2023). A very important aspect of last-mile delivery with *CBs* is the vulnerability of drivers, with crashes often resulting in severe injury (Ilin et al, 2023).

Smaller electric vehicles are found to be cheaper in initial cost, tax, insurance, storage, depreciation, and running costs, have no parking or congestion charges, have higher speed in congestion, do not need driver training, and have less environmental impact (Arvidsson & Pazirandeh, 2017). *EDVs* represent a feasible option for short-distance trips in urban areas as well as for entering restricted traffic areas (Siragusa et al, 2020).

Barriers

Although *EDVs* have several benefits when compared to conventional vehicles with internal combustion, they still have several limitations (Ilin et al, 2023). The cost of *EDVs* (Ilin et al, 2023; Iwan et al, 2021; Toraman et al, 2023; Siragusa et al, 2020), insufficient charging stations (Ngoc et al, 2023; Toraman et al, 2023; Pietrzak & Pietrzak, 2021; Siragusa et al, 2020), potential user biases, and inadequate incentive programs hinder the rapid development of *EDVs*, limiting the use of *EDVs* in last-mile delivery (Toraman et al, 2023; Siragusa et al, 2020). There is also a substantial issue in range, with it being significantly affected by weather conditions and terrain (Ilin et al, 2023; Alessandrini et al, 2012; Pietrzak & Pietrzak, 2021), making it difficult to select vehicles that adequately meet requirements (Iwan et al, 2021).

There are still limitations in battery technology (Arvidsson & Browne, 2013), with battery recharging being time consuming when compared to a relatively quick tank filling process, as well as a shortage of public and/or private *EDV* battery charging stations (Iwan et al, 2021). The case for solely using *EDVs* for freight and logistics services has its downfalls. The current logistics systems in many cities are set up for conventionally powered vehicles (Kelly & Marinov, 2017). One of the most frequently indicated obstacles to utilisation of electric delivery vehicles is their limited driving range resulting from the battery capacity and the need to recharge it. Iwan et al (2021) suggests that this argument has become illegitimate, as in their testing the vehicle was able to complete the work tasks stipulated for two working days before the battery needed recharging.

Electrically powered vehicles bring increased energy production, and when this energy is obtained from combustion of conventional fossil resources, it leads to an increase in air pollution (Iwan et al, 2021). Also, the production process of an electric vehicles and its use of lithium batteries is far more carbon intensive than the manufacturing of a combustion engine (Arvidsson & Browne, 2013; Siragusa et al, 2020). Despite their weaknesses, electric vehicles appear to be the future of both passenger and freight transport systems in cities, with further development increasingly improving their performance and practicality (Iwan et al, 2021).

2.2.2 Nodes

This section presents three nodes, urban consolidation centres, micro-consolidation centres, and multimodal urban distribution centres. These were chosen due to being especially relevant and appropriate to city deliveries.

2.2.2.1 Urban Consolidation Centres

An *urban consolidation centre* (*UCC*) is a logistics facility that is situated on the outskirts of the urban area that it serves. Goods are delivered to the *UCC*, where they are consolidated and transported to their final destination (Browne et al, 2011). *UCCs* have the potential to both reduce environmental and make the delivery and collection of goods in the cities more efficient and enable the use of environmentally friendly vehicles (Deveci et al, 2022; Browne et al, 2011; Katsela et al, 2021).

Even a supply that is highly consolidated has the potential to achieve further benefits in terms of reductions in total distance travelled and emissions through additional consolidation efforts and the use of electric vehicles. *UCCs* reduce the total distance travelled by delivery vehicles in urban areas (Browne et al, 2011; Björklund & Johansson, 2018; Katsela et al, 2021). The implementation of a *UCC* can be used to improve the attractiveness of a city, with reduced emission, congestion, and noise. *UCCs* can serve entire cities, or part of a city, and are commonly located at the city boundary (Katsela et al, 2021; Björklund & Johansson, 2018).

UCCs might increase consignment costs but increase consolidation and pave the way for the use of more environmentally efficient vehicles (Arvidsson et al, 2013).

2.2.2.2 Micro-consolidation centres

Micro-consolidation centres, or *micro-hubs*, are distribution nodes located in or close to urban areas. When *micro-hub* implementations use low-emission vehicles for last mile deliveries it reduces delivery emissions and congestion (University of Washington, 2020; Katsela et al, 2022). Consolidating freight close to the city centre enables a high load factor when entering the city, reducing the number of vehicles needed. It also enables the use of smaller, more environmentally friendly electric vehicles, due to shorter delivery distances (Katsela et al, 2021; Björklund & Johansson, 2018).

Micro-hub implementation has the potential to increase efficiency in terms of speed, distance travelled, and cost (University of Washington, 2020). It also contributes to reducing the number of vehicles entering cities by approximately 80% as deliveries are done by smaller electric trucks and cargo bikes, lowering emissions, and noise. Differences in delivery speeds between commercial bikes and vans are negligible when adequate delivery density is met (Katsela et al, 2022). *Micro-hubs* offer a secure unloading area close to the city centre, where there is heightened competition for limited curbside space (University of Washington, 2020).

Combining UCC & Micro-hubs

UCCs can be combined with *micro-hubs* in urban areas (Katsela et al, 2022). When a *UCC* is combined with *micro-hubs* the costs of externalities are reduced by up to 70%. Including this cost reduction in a business model increases the likelihood of it becoming financially viable. The cost of externalities is a critical factor for viable business model representing 60-70% of the overall transportation cost. Any implementation of a combined *UCC* and *micro-hub* needs to consider the challenge of collaboration between transport providers and their competitors. Competing transport providers may be reluctant to share a *UCC* (Katsela et al, 2021).

Despite the potential benefits, many implementations fail to operate in the long term because of low volumes, and the inability to operate without financial support from government (Björklund & Johansson, 2018; University of Washington, 2020). The cost of an additional transhipment points often prevents facilities from being cost-effective when governmental subsidies are removed, with many *UCCs* struggling to generate profits or break even once subsidies are reduced or lifted (University of Washington, 2020; Katsela et al, 2022). Despite that many *UCCs* have been unsuccessful does not mean that the idea of an additional transhipment point is a bad one, or that it should be avoided (University of Washington, 2020).

Transport providers can perceive the *UCC* transhipments as increasing costs and risk, and delaying delivery, which retailers are unwilling to pay for (Katsela et al, 2021). Highlighting the environmental and social benefits for each stakeholder is important, as some retailers are willing to pay a premium for green deliveries (Katsela et al, 2022). Especially to the local authorities, who have the most to gain through a more attractive city with fewer freight vehicles

(Björklund & Johansson, 2018). There are several policies that are appropriate to implement together with *UCCs* and *micro-hubs*. For instance, *Low/Zero Emission Zones* that restrict access for polluting vehicles in urban centres (Katsela et al, 2022), or restricted traffic conditions like pedestrian zones (University of Washington, 2020).

2.2.2.3 Multi-modal Urban Distribution Centres

A *multi-modal urban distribution centre (MUDC)* utilises light rail for the urban penetration leg of freight trips. Goods are consolidated outside the city centre, and transported by rail to a *MUDC* located in the city centre and from there are distributed to their final destinations. The vehicles will consequently cover an overall shorter distance because of only transporting within the city centre, which further enables the use of zero-emission vehicles (Alessandrini et al, 2012; Vajihi & Ricci, 2021; Pede et al, 2006: Pietrzak & Pietrzak, 2021), like *EFVs* and *cargo-bikes* (Vajihi & Ricci, 2021; Enthoven et al, 2020). This could be integrated with *urban consolidation centres (UCCs),* where modal shift can occur (Regué & Bristow, 2013). A multimodal system utilising light rail is an important concept that should be considered (Kelly & Marinov, 2017).

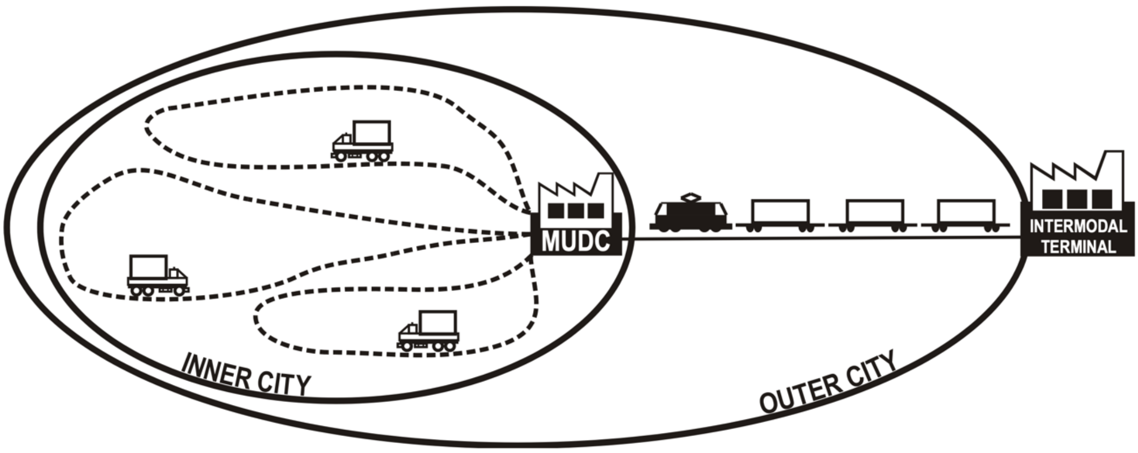


Figure 4 - Illustration of a MUDC operation*, from: Alessandrini et al (2012, p10).*

Alessandrini et al (2012), found that railway capacity is saturated by passenger rail traffic in daytime, meaning that a train shuttle between two terminals should operate during the night. Connecting this with *micro-hubs*, or *urban consolidation centres* leads to a reduction in urban rail weaknesses of accessibility, flexibility, and limited line capacity (Vajihi & Ricci, 2021).

A *MUDC* implemented in Rome found a reduction in emissions of 50-57% when using conventional vehicles, and 65-77% with hybrid vehicles (De Langhe, 2017; Alessandrini et al, 2012). The use of low/no-emission vehicles has the potential to eliminate these emissions entirely. The *MUDC* was found to reduce the social cost of emissions from nearly 40 €/tonne to 25 €/tonne with conventional vehicles. The use of hybrid vehicles for the final delivery would reduce the remaining 25 €/tonne to as low as 2 €/tonne (Alessandrini et al, 2012). Alessandrini et al (2012) suggests that these savings in social costs should be used as an incentive to hauliers through subsidies.

Barriers

Co-operation between actors within and outside the supply chain is required for this type of initiative to be implemented, and to achieve energy efficiency and cost reduction (Arvidsson et al, 2013). It's typical for each logistics operators to have their own clients, vehicles, and storage areas (Pede et al, 2006). Consolidating different types of consignments and increasing cooperation between competitors can lead to considerable gains in efficiency, with higher load factors being possible when deliveries are coordinated in a network (Arvidsson et al, 2013). However, there is seldom cooperation between operators to rationalise the distribution trips (Pede et al, 2006). Road hauliers and forwarders often show signs of resistance to cooperating with competitors (Arvidsson et al, 2013).

This concludes the literature review, which has presented the car free concept, and examples of car-free cities, as well as urban logistics solutions to the restrictions imposed by potential car-free city initiatives. The following section will detail the thesis methodology.

3.0 Methodology

This chapter presents the research approach and methods used for the thesis. It explains what and how information has been collected and analysed, as well as the rationale behind it.

3.1 Research Approach

This thesis uses a qualitative research method. Qualitative research utilizes interpretive techniques to understand meaning, rather than the frequency. These techniques are applied in both data collection and analysis stages of a research project (Cooper & Schindler, 2014; Collis & Hussey, 2021). Despite its benefits, qualitative methods face scepticism. Concerns about subjectivity, human error, and bias in data collection and interpretation lead some to view qualitative research as an unstable foundation for critical business decisions. The inability to generalize results to a larger population is considered a fundamental weakness (Cooper & Schindler, 2014).

This thesis is classified as a case study, as it investigates applicability of a car-free city framework, as well as alternative delivery methods on Gothenburg, Sweden. Case studies place more emphasis on a full contextual analysis of fewer events or conditions and their interrelations. Although hypotheses are commonly used, the reliance on qualitative data introduces challenges in supporting or refuting them. The focus on detail, however, provides valuable insights for problem-solving (Cooper & Schindler, 2014). The process of writing up case study material can be difficult, requiring a well-structured approach to demonstrate the connection between analysis, conclusions, and the extensive data collected (Collis & Hussey, 2021). Despite criticism suggesting case studies lack scientific value due to design limitations, they play a crucial role. A well-designed case study can effectively challenge a theory and generate new hypotheses simultaneously (Cooper & Schindler, 2014).

Case studies are a powerful research methodology where researchers extract information from reports, newspapers, and articles, along with direct observation and combine it with interview data from participants. The objective is to obtain multiple perspectives of a single organization, situation, or event (Cooper & Schindler, 2014). Although a case study methodology has many advantages, securing access to a suitable case can be challenging, and the research itself is time-consuming. Determining the study's scope poses difficulties, as the chosen organization or group interacts within the broader societal context. Additionally, understanding events within a specific timeframe requires knowledge of the case's history and future developments (Collis & Hussey, 2021).

3.2 Data Collection

A study may be based on an analysis of data collected from an existing source; secondary data, or from data generated by collecting them from an original source; primary data (Collis & Hussey, 2021). This thesis involves the collection of both secondary data from academic articles, reports, and primary data from expert focus groups through meetings, as well as a workshop.

3.2.1 Secondary Sources

Secondary data are data collected from an existing source such as publications, databases, and other records (Collis & Hussey, 2021). Secondary sources are interpretations of primary data. Encyclopaedias, textbooks, handbooks, magazine and newspaper articles, and most newscasts are considered secondary information sources. Nearly all reference materials fall into this category (Cooper & Schindler, 2014). This thesis has utilised the University of Gothenburg's library search engine, which has provided access to journals and databases for peer-reviewed academic research papers and articles. Additionally, some papers have been sourced from course material from the master's program, as well as articles provided directly to the author from the thesis supervisor, or other academics.

3.2.2 Primary Sources

The primary sources for this thesis consists of meetings, and a workshop, with a group of experts. Both the meetings, and the workshop, can be considered forms of group interviews, or focus group interviews. A group interview is a data collection method using a single interviewer, also known as a moderator, with more than one research participant (Cooper & Schindler, 2014). Focus groups are subset of group interviews where selected participants discuss their reactions and feelings about a situation or concept, under the guidance of a moderator (Collis & Hussey, 2021). The moderator uses group dynamics principles to focus or guide the group in an exchange of ideas, feelings, and experiences on a specific topic (Cooper & Schindler, 2014).

Group interviews are one of the few research techniques in which participants are encouraged to interact, as it is believed that the data extracted will be richer because of the interaction (Cooper & Schindler, 2014). Listening to other group members' views stimulates participants to voice their own opinions and encourages the participants to interact with one an another when responding to questions (Collis & Hussey, 2021).

Given time constraints, group interviews spend only a limited amount of time gathering information from each participant. This problem is magnified when a group interview covers numerous questions or topics. (Cooper & Schindler, 2014). The results are sometimes nothing more than the opinions of a small group of people and offer little in the way of deep insights or illumination of the issues under study. (Collis & Hussey, 2021). Another drawback of the group interview is the increased difficulty in arranging and coordinating group discussions. Although this is considered a small price to pay for the insights that can be revealed by group interaction. (Cooper & Schindler, 2014).

Managing a group's conversation while avoiding interjecting is a challenge for the moderator. It is also important for a moderator to control extrovert or dominant personalities as to ensure meaningful contributions from all members. Some members' opinions may be suppressed, and valuable insights lost if this control is not maintained. Also, some individuals might not be as honest in front of a group of peers, as they would be with a neutral interviewer. (Cooper & Schindler, 2014).

A group interview’s structure and process include moderator interaction with the group and probing of the group to clarify responses. As a result, the moderator may create bias in the results by sending verbal and nonverbal signals that some responses are more favourable than others, or direct discussion down specific paths (Cooper & Schindler, 2014).

Choice of Participants

This thesis gathered its participants through snowball sampling, which consists of participants being referred to the researcher by each other. Snowball sampling is used in studies where it is essential to include people with experience of the phenomenon being studied (Cooper & Schindler, 2014; Collis & Hussey, 2021). As research data will not be analysed statistically when using an interpretivist approach, a random sample is not necessary (Collis & Hussey, 2021).

The gathering of participants began with the thesis supervisor referring a representative to the author, that then in turn connected appropriate members from the municipal agencies Stadsmiljöförvaltningen, and Stadsbyggnadsförvaltningen in Gothenburg, Sweden. These municipal agencies are responsible for public spaces, accessibility, and the physical planning in and of Gothenburg (Göteborgs Stad, n.d). That these agencies would be partly responsible for and highly involved in the implementation of the initiatives and measures explored in this thesis make them well-qualified to identify barriers in their application.

Meetings

Initially two meetings took place with representatives from the agencies. The first meeting was used as a way of establishing contact with the group, with help from the thesis supervisor. The second meeting was conducted without the thesis supervisor. Both meetings were unstructured, and with limited recording, as they took place early in the research process. The aim of these meetings was to discuss the concepts in a free form setting with experts on the area, as to assist the author in the research process, as well as form the foundation of the following workshop.

Date: 30/1/2024	**Participants:**	**Agency**
Duration: 120min	Ann-Sofi Karlsson	Stadsbyggnadsförvaltningen
	Peter Hagby	Stadsmiljöförvaltningen
	Alexandra Bakosch	Stadsmiljöförvaltningen
	Michael Browne	Gothenburg University
	Per Bratthammar	Stadsbyggnadsförvaltningen

Table 1 – Meeting 1

Date: 7/2/2024	**Participants:**	**Agency**
Duration: 120min	Ann-Sofi Karlsson	Stadsbyggnadsförvaltningen
	Peter Hagby	Stadsmiljöförvaltningen
	Alexandra Bakosch	Stadsmiljöförvaltningen
	Andrea Hulting Gustafsson	Stadsbyggnadsförvaltningen

Table 2 – Meeting 2

Workshop
Workshops can be used as a tool to discuss the implementation of emerging topics that are not well known or established (Valença et al, 2023). A workshop can be considered a type of focus group interview. When conducting this type of interview, it is important to prepare a list of issues you want to cover (Collis & Hussey, 2021). Collin & Hussey (2021) suggests starting the session with a broad, open question and if possible, giving a visual explanations or examples. The moderator should allow the group to discuss the issues as they are introduced, without intervention, except to ensure that all members have an opportunity to contribute to the discussion and all the issues are covered.

Some moderators use large sheets of paper to record participants responses, while others use a personal notepad. The verbal portion of the group interview can be transcribed along with moderator debriefing sessions and added to moderator notes. (Cooper & Schindler, 2014). Valença et al (2023), and Castrellon, et al (2024) both utilise this method in their workshops Allowing the participants to record their own responses by writing on post-it notes, and papers to record responses throughout the workshop. These responses are prompted through questions provided by the moderator, and through discussion with the group. This allows for qualitative data to be extracted from the workshop without the need for the moderator to record responses throughout.

The main primary source for this thesis is a workshop conducted with a group of representatives from the municipal agencies Stadsmiljöförvaltningen, and Stadsbyggnadsförvaltningen on the 28th of May 2024. Although the workshop was planned to be two hours, it ended after three and a half hours.

Name	**Agency**	**Area**
Suzanne Falk	Stadsbyggnadsförvaltningen	Traffic Safety
Ann-Sofi Karlsson	Stadsbyggnadsförvaltningen	Urban Freight
Alexandra Bakosch	Stadsmiljöförvaltningen	Urban Freight
Peter Hagby	Stadsmiljöförvaltningen	Urban Freight
Maria Bernström Printz	Stadsbyggnadsförvaltningen	Accessibility
Andrea Hulting Gustafsson	Stadsbyggnadsförvaltningen	City Development
Hanna Ljungblad	Stadsmiljöförvaltningen	Bicycle Development

Table 3 – Participants workshop

The workshop was conducted exclusively in Swedish. Participants were not sent material or questions in advance but were informed about the workshop topic. The workshop was semi-structured, consisting mainly of open-ended questions. In a semi-structured interview, the researcher prepares some questions to encourage the interviewees to talk about the main topics of interest and develops other questions during the interview. The researcher might not need to ask all pre-prepared questions because the interviewees may have provided the relevant information when answering another question. An open question requires a longer, developed answer, as opposed to “yes” or “no” (Collin & Hussey, 2021).

Qualitative data was collected as suggested by Cooper & Schindler (2014), Valença et al (2023), and Castrellon et al (2024), through participants recording their own responses to questions on post it notes, and through marking on a printed physical map of central Gothenburg. The moderator also took notes of key points during discussion.

This concludes the methodology, which has presented the research approach, and data collection methods. The following section will detail the results of the research approach and subsequent data collection.

4.0 Results

This chapter presents the results from the conducted workshop. The results are presented in the same order as the workshop, categorised into relevant sections.

4.1 Workshop

The workshop consisted of four parts. The first part consisted of discussions regarding the concept of car-free cities, as well as defining what Gothenburg's city centre is. The second part consisted of presenting the frameworks used by *Oslo*, and *Barcelona* in their car-free initiatives. This part set the foundation for part three, which consisted of hypothetical *Scenario 1*, which would be applying a similar framework to Gothenburg. This was done through group discussions surrounding a physical map of Gothenburg, as well as questions being posed in connection to a reduced traffic network, reduced parking, as well as a parallel increase in pedestrian only roads, and zones. The fourth and final part of the workshop consisted of hypothetical *Scenario 2*, which would entail the complete ban of motor vehicles entering the city centre, which could be compared to further developing the current *low-emission zone* in Gothenburg by adding an extreme version of a *no-emission zone* in the city centre. This was discussed through the presentation of a logistics solution utilising *urban rail, electric delivery vehicles, cargo-bikes, multi-modal urban distribution centres, urban consolidation centres,* and *micro-hubs,* that would curtail the need to enter the city by truck.

***Figure 5 - Part of workshop results**, with post-it notes placed on top of the Gothenburg map.*

4.1.1 Car-free Concept & Gothenburg City Centre

There was a strong consensus in the group regarding what car-free entailed, with most participants describing it as an area which restricts private car use. Some participants also mentioned the removal of parking to a certain extent. It was regarded as having the potential to make urban spaces more attractive, with more green areas, leading to both healthier streets and citizens, with more city life, and being safer for children. Several participants highlighted the need for exceptions to the rule, although what should be exempted varied. These exemptions came in a couple different categories. The need for unhindered access for emergency services like police, fire trucks, and ambulances, both road access and parking exemptions for the elderly and disabled, as well as for transportation services for these groups, and access for freight vehicles as well as busses in public transport. One participant made the point that it is important for this type of initiative to be both wide reaching, and definitive, as *"dabbling"* in car restrictions would result in the system quickly falling back to what it used to be.

What constitutes Gothenburg's city centre was discussed, as there are several definitions with different names when examining municipal maps. It became apparent that defining the city centre by geographical areas is difficult, with only certain areas being regarded unanimously. Areas like *Inom Vallgraven, Vasastaden, Lorensberg, Haga, Olivedal* were widely cited as parts of the city centre, although not in their entirety, with some floating the idea of the city centre being defined by the movement of people rather than geographical areas. Several participants brought up areas north of the river, like *Lindholmen* and *Backaplan*, areas that might get overlooked when discussing Gothenburg. Some included these areas outright, while others made the point that these areas have a potential to be part of the city centre, and that with a longer time perspective should be included.

One participant questioned why car-free initiatives should begin and end in the city-centre, especially in Gothenburg, as it has several *"cores"* throughout the city that would be suitable, while the areas in-between might not be. This sparked a discussion, which brought up points like that car-free ideas should rather be applied when building new areas, as it is easier to *"do it right from the beginning"*.

One point of discussion was a concern expressed about car-free initiatives potentially worsening segregation, with vulnerable areas that are farther away from the city centre having reduced access to it by car. This was met with two points, one being that car ownership is low in these areas, as well as cars themselves potentially having this effect on segregation by creating both physical and financial barriers between sections of the city.

Participants expressed peoples need for cars for certain situations, like when public transport isn't quick enough, when a trip has multiple stops, when purchasing heavy or large products, or for parents with young children. This was met with the counter argument that the idea of taking the car being a quicker option often being wrong, because of traffic and limited accessibility to the city-centre. Several mental barriers were identified and discussed connected to this. With one participant stating:

"Sometimes people complain that public transport is slower than walking when you're in the city centre. Why not walk then?"

Central Gothenburg is not a particularly large area, and a ten-minute walk goes a lot farther than people might perceive. Another mental barrier discussed is in relation to *Hisingen*, the area north of the river, a place that can often be perceived as far away because of the need to cross the river. This point sparked a wider discussion regarding the need of cars with some participants highlighting that this is rather a city design issue, where if people had access to their needs within a reasonable proximity to their home that they would not need a car. This brought up a key issue with Gothenburg, its density. Gothenburg was stated as not being densely populated enough to carry the necessities of fifteen-minute city, for example. Although one participant suggested that this density issue is caused in part by the city being adapted to the car.

4.1.2 Scenario 1

Recurring barriers for Gothenburg are its topography, history as a fortress, and later industrial city. This has led to the city having several different "*cores"* with residential areas outside the historical city core *Inom Vallgraven* growing in connection to industry along the river.

When examining a physical map of the city, barriers to pedestrian movement, as well as areas with potential for increased pedestrianisation were identified. Although there is an extensive area of pedestrian zones, with few select pedestrian only streets *Inom Vallgraven,* the whole area was identified as an area with potential for increased pedestrianisation, with some participants going so far as to say that the area could be made entirely car-free without much issue. Especially the former squares *Grönsakstorget,* and *Kungstorget*, that are used as parking lots today, but also the western parts of the island, as well as the pedestrian zone heavy areas in the centre.

Several barriers for movement were identified. Among them was the road, and parking that cover the entire outline of the islands channel walls, creating both a physical and mental barrier to the walkway along the channel. Another barrier was the areas of the centre with particularly high public transport and car throughput, *Brunnsparken,* and *Grönsaktstorget*, as well as their intersections like at *Lilla Torget*. Both the roads *Norra Hamngatan* and *Södra Hamngatan* that follow the central channel walls carry quite a bit of car traffic. These areas are difficult and sometimes dangerous to cross on foot. This, coupled with the fact that the channel wall along *Brunnsparken* not being able to carry the weight of the public transport vehicles, led to the suggestion that this node might have to be moved, for instance to the northern part of *Nordstan* instead.

Another physical barrier is the road *Nya Allén*, which is built through the city centres' park *Kungsparken* that separates the denser residential areas *Lorensberg, Vasastaden, Haga, and Olivedal,* from the retail and office dense historical city centre *Inom Vallgraven*. It was suggested that this road was no longer a necessity, and could be removed without much issue, through this route being replaceable with using underground tunnels like *Götatunneln*, as well as making the parallel road *Parkgatan* into a two-way street instead of one.

There was some discourse regarding bike lanes in central Gothenburg. Specifically, the lack of bike lanes *Inom Vallgraven.* This was seen as a barrier to accessing the city centre by other modes by some, while others expressed that bike lanes themselves can create a barrier to walkability. There was a wider discussion regarding the sharing of road space between motor vehicles, bikes, and pedestrians, with opinions varying between the need for streets to be accessible by all modes, and the separation of modes, prioritising certain modes for certain streets.

Reduced private parking was seen as an opportunity for freight vehicles, as this would allow for larger and more accessible loading zones, as well as removing the *"competition"* for road space with private car users. The removal of above ground parking *Inom Vallgraven* was widely regarded as a non-issue. Some participants citied the available space in parking garages, while others brought up the issue of car users simply being pushed to parking spaces in adjacent areas instead. Although few people live within this area, some participants mentioned the need for those that do, to have parking exemptions, as well as the concern for reduced access for disabled people. There was also a concern for retail businesses potential opposition to the initiative, due to potential loss of business, as the loss of car access to shops would make it difficult, or even impossible to move some larger and heavier goods. The idea of removing above ground parking in other central areas was seen as beneficial to some streets and areas, while removing parking from non-busy residential streets being regarded as unnecessary.

4.1.3 Scenario 2

The groups' reaction to the logistics solution was mostly critical. Although the idea of utilising *urban rail* through the tram network to transport urban freight was regarded as potentially positive, it was not seen as applicable to all types of freight. It was suggested that this type of transport might be suitable for large bulky transport, like construction material, but not for normal parcel, or pallet deliveries. The solution was thought to require longer delivery times, because of the added steps and modal shifts in the delivery process that would require both consumers and retailers to change their consumption habits. There was a concern that this increased lead time could affect retailers to the extent that shelves could be empty, and retail death being expedited. This could be used as a driver for changed consumption habits but would lead to a radical change in the system that would not work in today's context.

Another key criticism was aimed at the *last-mile delivery* use of *cargo-bikes*, and/or smaller *electric delivery vehicles*. There was a concern that the increased number of transport vehicles, while still smaller in size, would take up more road space, create more traffic and congestion, and ultimately lead to an increase of accidents in the city centre. Several retail locations require larger deliveries, especially grocery stores, with participants highlighting that larger freight vehicles fill an important function in this context. It would require a clear structure in the allocation of street space, of which vehicles can go where, and when, compared to pedestrians and cyclists. There was also a questioning of a complete ban of motor vehicles. Participants circled back to the reasoning behind restricting car-access, with healthy streets and street space reallocation, and questioned whether this extreme measure would improve these points, or rather worsen them.

This concludes the thesis results, which has presented results obtained through the conducted workshop. The following chapter will analyse these results in connection to the literature review, and research questions.

5.0 Discussion

This chapter connects the results to information gathered in the literature review in connection to the research problem and question. This discussion builds the foundation for answering the research question and drawing conclusions.

The discussion organises results by their relevance to *RQ1*, and *RQ2*, as well as connecting each part to the literature review, thereby connecting to *RQ3*.

RQ1: What barriers & opportunities do municipal agencies identify to the implementation of car-free initiatives in Gothenburg, Sweden?

RQ2: What barriers & opportunities do municipal agencies identify in urban logistics solutions to restrictions imposed by potential car-free city initiatives?

RQ3: Do the identified barriers & opportunities align or contrast those found in the literature?

5.1 Implementation of Car-free Initiatives

5.1.1 Opportunities

*There was a strong consensus in the group regarding what car-free entailed, with most participants describing it as an area which **restricts private car use**. Some participants also mentioned the **removal of parking** to a certain extent. It was regarded as having the potential to **make urban spaces more attractive**, with **more green areas**, leading to both **healthier streets** and **citizens**, with **more city life,** and **being safer for children**.*

The points identified by the group regarding the concept of a car-free city centre have strong connections to the literature. The idea of a car-free area restricting private car-use is a fundamental pillar of the concept. Although, the literature is more inclined to state it as the prioritisation of pedestrians and cyclists over car-users (City of Oslo, 2020; Oslo municipality, 2017; Anguelovski et al, 2023: Mueller et al, 2020; Lopéz et al, 2020). When Toppi & Pharoah (1994) defined the concept, it was stated as, among other things, reducing parked and moving vehicles. The same can be said for both Oslo and Barcelona.

Although the City of Oslo (2020) state that traffic reduction was not the primary goal of the Car-Free Liveability Programme, the basis for the program revolves around reducing a third of all traffic in the city by 2030, outlined in the overall municipal plan (Rydningen et al, 2017; City of Oslo, 2020; Oslo municipality, 2017). The program involved a gradual restriction of where it was possible to drive and park (Oslo municipality, 2019), with the traffic pattern being changed (City of Oslo, 2020), making it impossible to cross the city centre from east to west in a car (Tortosa, 2022; Hagen & Tennøy, 2021). Barcelona's *superblocks* also revolve around reducing motorised transport (Anguelovski et al, 2023: Mueller et al, 2020; Lopéz et al, 2020), with the implementation being expected to decrease private motorized traffic considerably (Mueller et al, 2020). Although the basic road network of *superblocks* reduces the total length of roads used by through traffic by 61% (Rueda, 2018), it reduces the number of circulating cars by just 13% (Lopéz et al, 2020; Rueda, 2018).

The removal of parking is prevalent in car-free initiatives, especially in Oslo, where all municipal above ground parking was removed in the city centre (Oslo municipality, 2019; City of Oslo, 2020). The removal of street parking in Oslo was a major aesthetic victory, but it made accessing the city by car more difficult (City of Oslo, 2020). That the group identified this point is not surprising, as parking uses up a large amount of already limited space in cities (Nieuwenhuijsen & Khreis, 2016; Rydningen et al, 2017), especially when compared to other forms of transport, which makes up most journeys (Rydningen et al, 2017).

Making urban areas more attractive, healthier, greener, and safer for its citizens is the core of the car-free concept. Green space in cities is beneficial to public health and well-being (Nieuwenhuijsen & Khreis, 2016). Oslo's program aims to create a greener and more pleasant city (City of Oslo, 2020; Oslo municipality, 2017), and Barcelona's *superblock* model develops open public, and green space throughout the city, with plazas, parks, green corridors, and green patches (Mueller et al, 2020). For Barcelona these new green areas have become a well-used asset, by providing new public green areas for families and elderly residents living in the *superblock* (Pérez et al, 2021; Anguelovski et al, 2023), as well as families living nearby (Anguelovski et al, 2023). The main goal of this is improving the health and quality of life of residents (Lopéz et al, 2020), as well as facilitating safe and independent child play (Mueller et al, 2020) However, the new public spaces are mainly used by the elderly, and families with children, who consider it as a safe space, giving a false sense of safety. Most other groups use the area mainly as a place to pass through, with some women considering the area deserted and unsafe (Pérez et al, 2021).

Benefits reported are emotional health, better rest, less noise, air pollution and greater socialization (Pérez et al, 2021). Air pollution due to motorized traffic has a significant impact on the health of city residents (Mueller et al, 2020). Motor vehicles emit CO2 and other greenhouse gases and air pollutants such as particulate matter and nitrogen oxides (Nieuwenhuijsen & Khreis, 2016). Particulates contribute to premature mortality and morbidity, as they cause cardiovascular and respiratory diseases, leading to a decrease in average life (Malina & Scheffler, 2015). Several urban areas in the European Union have implemented low-, and no-emission zones to combat this (Cruz & Montenon, 2016; Sarmiento et al, 2023; Browne et al, 2005; Malina & Scheffler, 2015). Car-free initiatives are comparative to low-, and no-emission zones, in that they restrict car access to specific areas. Therefore, the initiatives could be expected to overlap in both benefits and issues. The local benefits delivered by *LEZs* and *ZEZs* are appreciable, leading to major air quality improvements (Marner et al, 2023 Browne et al, 2005; Sarmiento et al, 2023).

LEZs consistently reduce emissions inside their borders but may lead to air pollution spill over into adjacent areas (Sarmiento et al, 2023; Browne et al, 2005). Results from studies examining the effect of Barcelona's *superblocks* contradict this notion, finding that while traffic and noise increased in some streets over the short term, traffic levels on intervened streets decreased by

15%, with insignificant changes being found in adjacent streets. The traffic reduction achieved on intervened streets did not lead to a redistribution of traffic to adjacent streets. The same study found that NO2 concentrations were found to have decreased by 25% at the central *superblock* intersection (Anguelovski et al, 2023).

Both Barcelona and Oslo target healthy streets with city life. Oslo does this by identifying an individual set of strategies and initiatives that contribute to increased city life in that specific area (Oslo municipality, 2017; Oslo kommune, 2019). In Barcelona, residents themselves get to define problems, challenges, and solutions, through a participative process where they decide together what function the centre of their *superblock* should have (Lopéz et al, 2020; Anguelovski et al, 2023). This collaboration with residents has been essential for local acceptance and dispelling fears (Lopéz et al, 2020).

Reduced private parking *was seen as an* ***opportunity for freight vehicles****, as this* ***would allow for larger and more accessible loading zones,*** *as well as* ***removing the "competition" for road space*** *with private car users.*

The opportunity for improved delivery conditions for freight vehicles is present in the literature. Urban freight distribution is almost entirely performed by road vehicles, and congestion, lack of parking and appropriate loading and unloading areas affect its efficiency (et al, 2012; Pede et al, 2006; Vajihi & Ricci, 2021). Many of the reclaimed parking spaces in Oslo have been made available for goods deliveries (Oslo municipality, 2019; City of Oslo, 2020). This coupled with car restrictions could be argued to have improved delivery conditions, as well as removing the competition for road space.

Although there is ***an extensive area of pedestrian zones****, with* ***few select pedestrian only streets Inom Vallgraven****, the* ***whole area was identified as an area with potential for increased pedestrianisation****, with some participants going so far as to say that* ***the area could be made entirely car-free without much issue.***

There are proposals for turning *Inom Vallgraven* into a car-free zone inspired by Barcelona's "Superblocks" (Kommunstyrelsen, 2021). One issue with this proposal is that it can be argues that the area *Inom Vallgraven* already fills most of the criteria outlined for creating *superblocks*, with a peripheral road network going around blocks of pedestrian areas, and streets. The same can be said for the internal road network, where cars are allowed to drive in pedestrian zones at walking pace. The main differences would be the ability to cross the areas, as well as the lack of a centre square that is naturally formed by Barcelona's hexagon grid network. The author would suggest that the Barcelona approach appears more suited for residential areas, or areas that do not already have pedestrian zones. The author also suggests that it might be of interest to pilot this in areas like *Olivedal, Vasa* and *Lorensberg* for instance, as these areas are denser and more residential and could therefore reap more benefits for residents' health.

The measures applied in Oslo might be more applicable for *Inom Vallgraven*, as both are comparable in size, population, and street layout (Tortosa, 2022; Oslo municipality, 2019;

Rydningen et al, 2017). Especially the removal of above ground parking, which falls in line with initiatives like the local transport authority's plans to create more pedestrian zones, removing parking spaces and road space for cars in large parts of *Inom Vallgraven*, more specifically along the channel (Trafikkontoret, 2022).

The idea of transforming the area into a car-free zone could be compared to Anguelovski et als (2023) criticism of Barcelona choosing pilot areas for superblocks out of convivence rather than social and environmental equity factors. As stated, *Inom Vallgraven* already has an extensive area of pedestrian zones, and would therefore also be a marketable flagship area where it is most likely successful (Anguelovski et al, 2023).

The ***removal of above ground parking Inom Vallgraven was widely regarded as a non-issue.*** *Some participants citied the* ***available space in parking garages****, while others brought up the issue of car users simply being pushed to parking spaces in adjacent areas instead.*

Several parallels can be drawn between the sentiment expressed by the group here and Oslo's experience. A big part of Oslo's interventions was the removal of most municipal street parking parking (Oslo municipality, 2019; City of Oslo, 2020). This included a stepwise removal of approximately 760 out of 1,450 on-street parking spaces available in the area. Analysis in the years following implementation revealed that on-street parking use decreased with parking garage use increasing. (Hagen & Tennøy, 2021). The removal of street parking for private cars was a major aesthetic victory (City of Oslo, 2020), but did not adversely affect the parking situation in Oslo. Hagen & Tennøy (2021) suggest that this could be due to car access being retained to existing private and public parking garages in the area, meaning that about 90 percent of the city centre's parking capacity remained unchanged. This suggested that the existing parking-garage capacity was high enough to accommodate the new demand (Hagen & Tennøy, 2021). The reallocation of road space was preceded, and therefore compensated by the construction of underground car spaces (Tortosa, 2022).

The idea of ***removing above ground parking in other central areas was seen as beneficial*** *to some streets and areas, while* ***removing parking from non-busy residential streets being regarded as unnecessary.***

While the excessive removal of parking in residential areas might be unnecessary, the author would argue that a reduction in residential areas could also lead to benefits. Surface parking requires a larger share of city area compared to other forms of transport (Rydningen et al, 2017), using a large amount of already limited space in cities that could be used for other purposes such as trees, parks, and other green space, which is more beneficial to residents' health (Nieuwenhuijsen & Khreis, 2016). Several European cities restrict both car access and parking to residential areas, where parking instead is moved to concentrated parking facilities rather than adjacent to housing (Gundlach et al, 2018). The author would suggest that restricting access to car-infrastructure might encourage modal shift to other modes, as was observed in Barcelona, where traffic reductions achieved on intervened streets did not lead to a redistribution of traffic to adjacent streets, but rather to other modes of transport or other routes (Anguelovski et al, 2023).

5.1.2 Barriers

*Several participants highlighted the **need for exceptions** to the rule, although what should be exempted varied. These **exemptions** came in a couple different categories. The need for **unhindered access** for **emergency services** like **police, fire trucks**, and **ambulances**, both **road access** and **parking exemptions** for the **elderly and disabled**, as well as for transportation services for these groups, and **access for freight vehicles** as well as **busses** in public transport.*

The need for exemptions that the group expressed is echoed in the literature. Accessibility for all people must be a primary goal in a pedestrian city centre (Rydningen et al, 2017). The City of Oslo (2020) state that making it safe and desirable for elderly people to walk or to cycle is an important public health measure, and in Barcelona the elderly are more frequent users of proximity trips and reliant on active transportation (Anguelovski et al, 2023). However, the Oslo city council has stated that mobility impaired people should be provided for, and that the city needs to improve how it facilitates mobility for the disabled, meaning that some will be allowed to continue to drive in the city centre (Rydningen et al, 2017; Oslo kommune, 2019). It is also important to note that although it is less attractive, car driving is still allowed in most streets (Hagen & Tennøy, 2021; Oslo kommune, 2019). The same is true for Barcelona, with residential traffic still being allowed, albeit with a maximum speed of 10-20km/h (Mueller et al, 2020), but movements into the interior only make sense if their origin or destination is in the interval, as *superblocks* cannot be crossed (Rueda, 2018).

The same rules apply to freight and public transport, with goods still being delivered throughout the city centre, and accessibility to all properties by road being maintained (Oslo kommune, 2019). In Barcelona buses don't cross the superblocks, but are placed every 400m, at the main intersections, and buses circulate at a high frequency, making public transport an attractive transport alternative (Mueller et al, 2020). A critical aspect of *car-free city centres* is having too many exemptions, and inadequate capacity and quality of the public transport alternative (Toppi & Pharoah, 1994).

*Another **barrier** was the **areas** of the centre with particularly **high public transport** and **car throughput**, Brunnsparken, and Grönsaktstorget, as well as their intersections like at Lilla Torget. Both the roads Norra Hamngatan and Södra Hamngatan that follow the central channel walls carry quite a bit of car traffic. **These areas are difficult and sometimes dangerous to cross on foot.***

Walkability is an important aspect of car-free initiatives. Encouraging the shift towards active modes of travel such us walking and cycling is a challenge for cities, but important, as walkability contributes to the quality of life of citizens by enhancing physical activity, road safety, well-being, air quality, and social inclusion (Gorrini et al, 2023). Both permanent and temporary interventions in city centres that favour pedestrians have been found to lead to more people walking and biking, reduced traffic volumes, positive impacts on social interactions and health (Hagen & Tennøy, 2021).

Oslo identified traffic as creating barriers for both for pedestrians and cyclists (Oslo municipality, 2017). Making it safe and desirable to walk or to cycle was identified as an important public health measure (City of Oslo, 2020). The interventions in Oslo improved the walking and biking experience in the city centre, and worsened for those driving, which could result in shifts toward more sustainable travel behaviour. Although car drivers seemed less affected than anticipated (Hagen & Tennøy, 2021).

One aim for eliminating through traffic in *superblocks* was making streets more walkable. The new open spaces removed from car traffic have provided safe spaces for pedestrian movement, especially for the elderly, and families with children (Anguelovski et al, 2023; Pérez et al, 2021). Although it has been argued that they give a false sense of safety (Pérez et al, 2021).

*Another **physical barrier is the road Nya Allén**, which is built through the city centres' park Kungsparken that separates the denser residential areas Lorensberg, Vasastaden, Haga, and Olivedal, from the retail and office dense historical city centre Inom Vallgraven. It was suggested that **this road was no longer a necessity**, and could be removed without much issue, through **this route being replaceable** with using **underground tunnels** like Götatunneln, as well as making the parallel road Parkgatan into a two-way street instead of one.*

The removal of city traffic through underground motorways is cited as prerequisite and explanation as to why the wide-reaching and definitive interventions in Oslo did not have a large effect on traffic volumes. Motorised traffic did not disappear in Oslo, but had been buried (Hagen & Tennøy, 2021; Tortosa, 2022). Therefore, it became a question of removing parts of the road network rather than the disappearance or drastic reduction of traffic because of restrictions (Tortosa, 2022).

*Some expressed that **bike lanes themselves can create a barrier to walkability.** There was a wider discussion regarding the sharing of road space between motor vehicles, bikes, and pedestrians, with opinions varying between the need for streets to be accessible by all modes, and **the separation of modes, prioritising certain modes for certain streets.***

Cities have high congestion levels and limited space (Katsela et al, 2021), which makes encouraging the shift towards cycling attractive, as the urban space that is required to transport the same amount of people with bicycles is much smaller than with cars (Arvidsson & Pazirandeha, 2017). The separation of modes is an interesting point, and is not found in Oslo's approach, where pedestrians and cyclists goals are grouped together (City of Oslo, 2020; Oslo municipality, 2017). In Barcelona however, this separation is found, with the periphery network around the *superblock* including dedicated bike lanes that share street space with cars, separated from pedestrians. In the interior road network bicycles are required to adjust their speed to 10-20km/h, or even to step off the bicycle if necessary (Rueda, 2018; Mueller et al, 2020). These requirements could allude to the issue of bike lanes potentially creating barriers for pedestrians that was voiced by some participants.

*There was also a **concern for retail businesses** potential opposition to the initiative, due to **potential loss of business**, as the loss of car access to shops would make it difficult, or even impossible to move some larger and heavier goods.*

The concern for retail business as well as their resistance in connection to car and parking restrictions is as old as the concept itself. Toppi & Pharoah (1994) stated already 30 years ago that retailers offered strong opposition to pedestrian areas due to fear of loss of business. However, in nearly every pedestrian zone and traffic-calmed area the turnover of shops has increased. (Toppi & Pharoah, 1994). Both permanent and temporary interventions in city centres that favour pedestrians are connected to an increase in retail turnover (Hagen & Tennøy, 2021). In Oslo retailers were initially concerned that closing streets would hurt stores, criticising a perceived lack of long-term holistic view (Rydningen et al, 2017). Rydningen et al (2017) suggested that revenues would likely be reduced during the reconstruction of streets but would increase once everything is in place. Consultants investigating the issue for the municipality found a weak increase in turnover in the city centre in 2017 and 2018, with the area having a higher turnover than reference areas. They also found that the city centre had become a more popular place to establish businesses (Hagen & Tennøy, 2021; City of Oslo, 2020). Important to note though, is that Oslo is the economic centre of Norwegian retail (City of Oslo, 2020).

*One point of discussion was a **concern** expressed about **car-free** initiatives **potentially worsening segregation**, with **vulnerable areas** that are **farther away** from the **city centre** having **reduced access** to it by car. This was met with two points, one being that **car ownership** is low in these areas, as well as **cars themselves potentially** having this **effect on segregation** by **creating** both **physical** and **financial barriers** between sections of the city.*

The literature doesn't directly address segregation, but does address accessibility as well as social equity, which is relevant to the issue. In Oslo, for instance surveys found that there was an increase in respondents who answered that it was very easy to access the city centre after implementation, indicating that the perceived accessibility to the city improved (Hagen & Tennøy, 2021). Although, the surveys were not presented as separating respondents geographically or socioeconomically, making it unable to answer for segregation. Balancing the need for mobility and its negative externalities is difficult for city authorities (Iwan et al, 2021).

Anguelovski et al (2023) argues a couple key criticisms regarding social equity in Barcelona's *superblocks*. It was criticised for failing to address complex mobility equity needs in marginalised neighbourhoods, with the urban design changes likely having a limited impact on travel behaviour, especially among socially vulnerable population groups (Anguelovski et al, 2023). Anguelovski et al (2023) further argues that *Superblocks* have increased accessibility levels and active travel infrastructure in already high accessible areas. Exemplified by the Sant

Antoni *superblock*, which is highly walkable and accessible, and is inhabited by high- and middle-class groups. In contrast, the mobility needs of the working-class who live disproportionately in peripheral areas and commute longer distances remain unmet or unaddressed. Pérez et al (2021), argues for an issue stemming from age demographics, where elderly, families, and people working use the public spaces regularly, while young people feel that the space is not designed for them.

Another key issue argued is gentrification, where most residents and families value the benefits of low-traffic streets and green spaces, but when surveyed report fear of displacement because of the urban greening. Projects are not immune to market dynamics and land speculation that may burden or displace residents. Some of the equity concerns surrounding *superblocks* relate to if they constitute secluded islands of environmental privilege. The City of Barcelona is aware this and is working to mitigate them through new social housing within the *superblocks* (Anguelovski et al, 2023) Car's effect on segregation has not been encountered in the literature review, but car use has been found to be associated with inequality (Gorrini et al, 2023; Nieuwenhuijsen & Khreis, 2016), as well as acting as a powerful disruptive element, creating barriers for pedestrians and cyclists (Oslo municipality, 2017).

*One participant made the point that it is **important** for **this type** of **initiative** to be both **wide reaching**, and **definitive**, as **"dabbling"** in car restrictions would **result** in the system quickly **falling back** to what it used to be.*

While this point is not addressed directly in the literature, its consequences can be seen when reading between the lines. One criticism of Barcelona's *superblocks* is the fact that the project has not been scaled to its original ambition, demonstrating the financial, administrative, and practical difficulty in implementing such ambitious change (Anguelovski et al, 2023). This is exemplified by the fact that although 503 Superblocks were proposed in the year 2000 (Amati et al, 2024; Mueller et al, 2020; Anguelovski et al, 2023), only three were implemented by 2019 (Mueller et al, 2020). Couple this with the city's pivot away from the conventional *superblock* in 2021 to an even more ambitious project (Anguelovski et al, 2023), adds to this issue, demonstrating in some part the issue of *"dabbling"* expressed by the participant.

In Oslo private use of vehicles was scaled down gradually (Oslo municipality, 2019). Gradually in this case refers to only a couple years, with the traffic pattern being changed in just one (City of Oslo, 2020). The new traffic pattern made it impossible to cross the city centre from east to west in a car, significantly reducing access to the road network (Tortosa, 2022; Hagen & Tennøy, 2021). This, along with the removal of most municipal street parking (Oslo municipality, 2019; City of Oslo, 2020) demonstrates that the project is both wide reaching, and definitive. Contrasting these two approaches, and the difference in how far the projects have come highlights the importance of the point expressed by the participant.

*One participant **questioned why car-free initiatives should begin and end in the city-centre**, especially in **Gothenburg**, as it **has** several **"cores" throughout** the **city** that would be suitable,* *while the areas in-between might not be. This sparked a discussion, which brought up points like that **car-free ideas** should rather be **applied when building new areas**, as it is easier to "**do it right from the beginning**".*

These two points are very interesting and can be connected to the literature in a couple ways. In Oslo, the initiative covers only central areas with the main commercial streets, shopping malls, and major nightlife districts. Only 1,000 people live in this area, but more than 100,000 travel in and out to work every day (Oslo municipality, 2019; Rydningen et al, 2017). The rationale behind this could be connected to what was observed in Barcelona, where pilot *superblock* areas were chosen out of convenience, as to minimize disruption, and where it was most likely to be successful (Anguelovski et al, 2023). Barcelona has however developed their *superblocks* as to stretch across the entire city (Amati et al, 2024; Mueller et al, 2020; Anguelovski et al, 2023) with each cell containing roughly 5-6000 residents (Rueda, 2018; Lopéz et al, 2020). This approach would line up with the what the participant is expressing for Gothenburg, with the initiative not growing from the centre, but rather wherever it would be suitable. However, it is important to note the tremendous difference in population density between Barcelona and Gothenburg, an issue expressed by participants during the workshop.

Applying car-free concepts when constructing new areas is observed in several European cities that have introduced measures restricting car use, where car-free city centres, or the restriction of car access being applied to new residential areas, where parking is no longer adjacent to housing but rather organized in concentrated parking facilities (Gundlach et al, 2018). The idea is also present, but not implemented, in Barcelona. The original *"Cerdà plan"* for Barcelona's city grid network considered the human need for open space and greenery, and a transport network accommodating pedestrians, horse-drawn carriages, and public tram lines (Mueller et al, 2020; Amati et al, 2024), with each block intended to have an area of open space in the centre for residents (Amati et al, 2024). However, this area was ultimately lost, with the centre of the blocks being filled with buildings (Mueller et al, 2020; Amati et al, 2024), becoming an example of both *"doing it right from the beginning"*, and *"dabbling"* by not being definitive, with the system quickly falling back to what it used to be.

5.2 Implementation of Urban Logistics Solution

The groups' reaction to the logistics solution was mostly critical*. Although the idea of utilising urban rail through the tram network to transport urban freight was regarded as potentially positive, it was not seen as applicable to all types of freight. It was suggested that this type of transport might be suitable for large bulky transport, like construction material, but not for normal parcel, or pallet deliveries. The solution was thought* ***to require longer delivery times****, because of the* ***added steps and modal shifts*** *in the delivery process that would require both consumers and retailers to change their consumption habits. There was a concern that this increased lead time could affect retailers to the extent that shelves could be empty, and retail death being expedited. This* ***could be used as a driver for changed consumption*** *habits but would lead to a radical change in the system that would not work in today's context.*

The weaknesses of the transport solution expressed by the participants are present in the literature. The main barriers to urban rail freight distribution are the comparative speed of current road transport (De Langhe et al, 2019), and the limited flexibility due to lack of door-to-door capability (Alessandrini et al, 2012; Arvidsson & Browne, 2013; Vajihi & Ricci, 2021; Regué & Bristow, 2013). Without taking negative externalities, and the slowing of traffic into account road transport is undoubtably faster than urban rail with the added steps of consolidation and modal shift.

Transportation requirement is strongly linked to economic development (Deveci et al, 2022), but we pay the cost in negative side effects (Arvidsson et al, 2013). Freight distribution systems in urban areas are impacting quality of life on an unsustainable level (Arvidsson & Browne, 2013), with urban freight movement being a detriment to living standards (Deveci et al, 2022). Cities suffer from congestion, poor air quality and noise pollution, with urban deliveries being a major contributor (Regué & Bristow, 2013; Pelet et al, 2023; Pietrzak & Pietrzak, 2021; Ngoc et al, 2023; Pede et al, 2006; Vajihi & Ricci, 2021; Cochrane et al, 2017; Arvidsson & Browne, 2013; Deveci et al, 2022).

Although the concerns raised by the participants are clearly valid, the author would like to stress that urban rail has the potential to alleviate these negative externalities. Rail has a good weight/volume capacity, low energy and environmental impact, reducing congestion, and being less accident prone in comparison to road traffic flows (Arvidsson & Browne, 2013; Alessandrini et al, 2012; Regué & Bristow, 2013; Pietrzak & Pietrzak, 2021; Cochrane et al, 2017; Vajihi & Ricci, 2021; Deveci et al, 2022), as well as having good network linkages between cities (Arvidsson & Browne, 2013). When connected to micro-hubs in the city centre it leads to vehicles covering an overall shorter distance because of only transporting within the city centre, which further enables the use of zero-emission vehicles (Alessandrini et al, 2012; Vajihi & Ricci, 2021; Pede et al, 2006: Pietrzak & Pietrzak, 2021)

In order to have more sustainable cities, logistics companies should be encouraged to shift from road transport (Vajihi & Ricci, 2021). Rail is an under-used modality in urban freight distribution (Alessandrini et al, 2012), and is rarely used in urban freight transport

(Alessandrini et al, 2012; Pietrzak & Pietrzak, 2021; Arvidsson & Browne, 2013; De Langhe et al, 2019). It could be argued that this is due to the inherent weaknesses of the mode, especially with the alternative cost of road transport not being affected by its negative externalities. Alessandrini et al (2012) suggests that the potential social savings achieved through the use of a MUDC be used as an incentive to hauliers through subsidies, as to even the playing field for modes economically, and to indirectly penalise road transport for its negative externalities, using it as a driver for changed consumption as suggested by participants. The idea of including the cost of negative externalities for urban logistic solutions is reiterated by Katsela et al, (2021).

Another ***key criticism was aimed at the last-mile delivery use of cargo-bikes, and/or smaller electric delivery vehicles.*** *There was a concern that the increased number of transport vehicles, while still smaller in size,* ***would take up more road space, create more traffic and congestion, and ultimately lead to an increase of accidents*** *in the city centre.*

The concerns raised by the group are mainly regarding the use of cargo-bikes, which is one alternative for last-mile delivery. The author agrees that replacing all transport with cargo-bikes is both infeasible and undesirable, with an excessive number of vehicles crowding the city centre. Cargo-bikes have a relatively small capacity but are suitable for dense inner-city zones with narrow and crowed streets in city centres (Kelly & Marinov, 2017). They are a viable solution for the transportation of light goods in inner cities, where they are quicker than cars over short distances (Pelet et al, 2023). The advantages include easy access, no parking, sufficient speed and manoeuvre operations, emitting no greenhouse gases (Ilin et al, 2023; Pelet et al, 2023) and make little noise (Pelet et al, 2023). In addition, it promotes a healthier and more active workforce. The risk of accidents however is reiterated in the literature, with crashes often resulting in severe injury (Ilin et al, 2023).

The use of smaller *electric delivery vehicles* (*EDVs*) would not require excessive numbers when compared to regular road transport. Arvidsson et al (2013) argues that larger vehicles are better on long distances because of volume, but that they lack benefits when used in city distribution. Smaller vehicles are operationally flexible, with accessibility to a wide variety of infrastructure like bicycle paths, pedestrian areas, bus lanes, easier flow through congestion, better parking possibilities, and limited structural impact in terms of noise and road damage. (Arvidsson & Pazirandeha, 2017). Emissions and local pollutants may be significantly reduced if transport companies use cargo *EDVs* to transport goods in urban areas. (Ngoc et al, 2023; Siragusa et al, 2020). *EDVs* represent a feasible option for short-distance trips in urban areas as well as for entering restricted traffic areas (Siragusa et al, 2020). The concern for accidents is of course valid for *EDVs* as well, but this risk would arguably be lower as heavy freight vehicles, while only making up four percent of road traffic, account for more than half of the fatal cyclist and pedestrian accidents (Arvidsson & Pazirandeha, 2017).

*There was also a **questioning of a complete ban of motor vehicles.** Participants circled back to the reasoning behind restricting car-access, with healthy streets and street space reallocation, and questioned whether this extreme measure would improve these points, or rather worsen them.*

The reasoning behind a complete ban on motor vehicles is two-fold. Firstly, even electric vehicles that lack tail-pipe emissions still emit non-exhaust emissions from break and tire abrasion, and road wear (Malina & Scheffler, 2015; Marner et al, 2023), which make up almost half of the particulates emitted. Secondly, they cannot reduce the space that they occupy in the city (Rueda, 2018) where urgent problems are caused in large part by individual motorized traffic (Gundlach et al, 2018). Cities already have high congestion levels and limited space (Katsela et al, 2021). Excessive land consumption and need to share urban space between pedestrians and city transport is a considerable negative consequence resulting from the dynamic development of urban transport (Pietrzak & Pietrzak, 2021). The ever-growing presence of motorised traffic in urban areas has caused public spaces to decay (Gundlach et al, 2018), with parking and road space using up large amounts of already limited space in cities that could arguably be used for other purposes (Nieuwenhuijsen & Khreis, 2016).

This concludes the discussion, which has analysed the thesis results in connection to the literature review and research questions. The following chapter is the conclusion, which will summarise the thesis and answer the research questions.

6.0 Conclusion

This chapter summarises the thesis, as well as key findings in connection to the research questions, as well as proposals for future research.

This thesis has explored the car-free city phenomenon, urban logistics solutions to its restrictions, and the perceived opportunities and barriers to them by the municipal agencies that would likely be responsible for its implementation. This was achieved through an extensive research process, which resulted in the literature review presented, as well as through group interviews with said municipal agencies. The results from said group interviews were subsequently compared to the literature, as to identify overlap, as well as novel ideas in the gap in between.

RQ1: What opportunities & barriers do municipal agencies identify to the implementation of car-free initiatives in Gothenburg, Sweden?

The key opportunities identified were potentially making urban areas more attractive, with more green areas. This was expected to result in both healthier streets, and healthier citizens, where streets have more city life and are safer for children. The historical city centre area *Inom Vallgraven* was identified as particularly appropriate for applying car-free principles, with some participants going as far as to say that the area could be made almost entirely car-free, including the removal of above-ground parking, without adverse practical implications, citing ample access to concentrated parking garages. However, it would be crucial that exemptions be made for emergency vehicles, freight, public transport, and for the elderly and disabled as well as transportation services for these groups. Reduced private parking was seen as an opportunity for freight vehicles, as this would allow for larger and more accessible loading zones, as well as removing the "competition" for road space with private car users. The further removal of above ground parking in other central areas was seen as beneficial to some streets and areas, while removing parking from non-busy residential streets being regarded as unnecessary.

Barriers identified included retail businesses potential opposition to the initiative, as well as concern for potential loss of business. There was also a concern that car-free initiatives could potentially worsen segregation, with vulnerable areas that are farther away from the city centre having reduced access to it by car. Physical barriers were also identified, like the road *Nya Allen* which separates the city's denser residential areas from the central shopping area *Inom Vallgraven*.

RQ2: What opportunities & barriers do municipal agencies identify in urban logistics solutions to restrictions imposed by potential car-free city initiatives?

The urban logistics solution presented utilised *urban rail, electric delivery vehicles, cargo-bikes, multi-modal urban distribution centres, urban consolidation centres,* and *micro-hubs,* that would curtail the need to enter the city by truck. The municipal agencies were mostly critical to the urban logistics solution presented. The solution was thought to require longer delivery times, because of the added steps and modal shifts in the delivery process that would require both consumers and retailers to change their consumption habits. While this was identified as a potential driver for a change in consumption habits, it would lead to a radical change in the system that would not work in today's context. There was a concern that this increased lead time could affect retailers to the extent that shelves could be empty, and retail death being expedited. Another key barrier was aimed at the last-mile delivery use of cargo-bikes, and/or smaller electric delivery vehicles. There was a concern that the increased number of transport vehicles, while still smaller in size, would take up more road space, create more traffic and congestion, and ultimately lead to an increase of accidents in the city centre.

RQ3: Do the identified opportunities & barriers align or contrast those found in the literature?

There was a considerable overlap in alignment between identified opportunities & barriers and those found in the literature for both preceding research questions. Key points were the opportunities for improving urban areas, and citizen health aligned with both Barcelona and Oslo, and remaining literature. The importance of exemptions for different categories, like emergency services, freight, and the disabled was echoed in the literature, as well as the importance of safe walkable areas, with roads and vehicles constituting barriers for both pedestrians and cyclists. The opportunity for both freight and city life in the removal of above ground parking, as well as the identified sufficiency of consolidated underground parking, aligned also. The concern for retail businesses is prevalent for these types of initiatives, but is consistently contradicted by research, which argues that retail turnover instead increases.

Although identified opportunities for the urban logistics were few, the barriers identified aligned well with the literature. The group identified the key weaknesses of both urban rail, modal shift, and electric delivery vehicles, with slower comparative speed due to modal shift, limited flexibility, as well as limited capacity in some electric delivery vehicles, all of which are frequently cited in the literature.

The group made interesting points that could be argued to be novel as they were not found in the literature examined. The idea the of bike-lanes evolving, with increased traffic and speed potentially creating a barrier for pedestrian movement is indirectly addressed in some literature. While socioeconomic considerations are addressed in the literature, like gentrification, and accessibility for all, the potential issue of segregation, which is highly relevant for Gothenburg, is not. The questioning of car-free concepts starting and ending in the centre is of particular interest, as the few car-free initiatives' that exist are implemented solely in the denser city centre, but in cities like Gothenburg were density is spread out, this approach might not be as appropriate. This coupled with the idea of implementing car-free principles in the building of new areas constitute important areas of consideration, especially for Gothenburg.

6.1 Future Research

Through the process of writing this thesis several topics for future research were encountered. A couple are presented here.

Bike-lanes of the future.

Exploring and analysing the effect on road-space allocation considerations through bike-lanes evolving with increased traffic, due to increased popularity, and speed, due to the rise of electric bikes. This could be done through both qualitative and quantitative studies, or ideally a combination of both, with group interviews with municipal agencies, city residents, as well as analysis of speed, and its connection to injury.

Car-free for all.

Delving deeper into socioeconomic considerations in the implementation of car-free principles. Exploring its effect on issues like segregation and gentrification, and if negative, how it could be mitigated. This could also be achieved through both qualitative and quantitative studies, either through discussions and surveys of residents' sentiment and experiences, or through the analysis of home pricing, and demographics before and after implementation.

Car free "centre"?

Exploring benefits of decentralising car-free principles as to develop a framework for wider application to sparser areas that consist of several smaller core areas, and squares. This could be done qualitatively, deriving principles from existing car-free city plans, and applying them to either multiple, or single cities that have this issue. This would be followed by refinement of the framework through collaboration with government agencies and experts.

This concludes the thesis, thank you for taking the time to read it.

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