The Cargo Bike in Dutch Zero Emission Zones for Logistics

Final report

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Colophon

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Executive Summary

In 2025, at least 18 Dutch cities will see the introduction of Zero Emission Zones (ZEZ) for logistics which aim to clean up the urban freight distribution sector. This vital activity, in which goods are transported within the urban area, maintains the functioning of cities and is growing year on year. With the growth in transport movements comes a growth in emissions, which the ZEZ aim to address through a transition period in which polluting vehicles are phased out until only zero emission vehicles can enter the ZEZ in city centers.

To help achieve this transition to a clean urban freight distribution sector, the cargo bike is increasingly being recognized as a mode of transport that can offer a solution to actors moving goods through the ZEZ for logistics. These users of cargo bikes can be categorized as those making deliveries of fresh produce, specialized retail products, express parcels or those moving to provide a facility and service or working in construction. It is expected that by 2025 more than 9,500 cargo bikes will be used in Dutch logistics, whilst demand is expected to quadruple across the EU, helping to bring the global market value for cargo bikes to € 2.4 billion in 2031. With this it is anticipated that there will be an increase in demand for knowledge regarding cargo bikes in Dutch ZEZ from both the Netherlands and from international actors, which is of direct relevance to the Dutch Cycling Embassy (DCE) who aim to share and connect people to Dutch knowledge and expertise on cycling.

This report was conducted to make recommendations to the DCE concerning problems and opportunities that exist regarding the use of cargo bikes as an urban distribution solution, by providing insights into the opinions of the stakeholders in the Dutch freight distribution sector with regards to cargo bikes in zero emission zones. Through the conduction of interviews with stakeholders and supplemented by literature, six problems and opportunities were identified.

It was found that concerns have and still exist regarding the total cost of ownership of the cargo bike, predominantly due to the long-term durability. However, as different user needs and behaviours are being understood this is beginning to change with the incorporation of automobile technology. The high quality and vast quantity of cycling infrastructure already present in the Netherlands means the cargo bike can offer fast, efficient and reliable deliveries which has allowed certain users to benefit and offer customers time critical and flexible delivery. These success stories are beginning to be shared. The lack of and inconsistent institutional arrangements has also led to fragmented collaboration and poor knowledge sharing on the subject of cargo bikes and logistics. Greater awareness on the benefits that cargo bikes can provide to municipalities, beyond logistics, is required and can be achieved by integrating the subject across departments. A major concern is the problem of the perceived level of safety which is creating uncertainty and could be attributed to hindering the establishment of institutional factors, as well as providing cargo bike suitable network facilities. It is felt that current infrastructure, such as the width of cycling paths, is not suitable for a rise in use of larger and heavy cargo bikes, for the risk in conflict this could create. A debate regarding what space cargo bikes can use is delaying regulation and creating uncertainty. More research is needed to provide clarity on safety, whilst the creation of training standards for cargo bike riders could help improve safety, whilst also addressing the durability concerns of the technology.

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Introduction

In 2025, at least 18 Dutch cities will see the introduction of zero emission zones for logistics which aim to clean up the urban freight distribution sector. The Dutch Cycling Embassy (DCE) wishes to understand the potential for cargo bikes to increasingly be used to achieve successful implementation of this policy. Traditional focus of the DCE and its participants has been utility cycling for citizens, and so knowledge regarding cycling in urban freight distribution is not well established. However, with increasing number of DCE network participants having direct and indirect involvement with cargo bikes in urban freight distribution and an expected increase in international interest in the subject, the topic of cargo bikes in urban freight distribution is likely to become an increasingly important one. With this in mind, the research object is the current cargo bike's use in urban city centres and soon to be established zero emission zones.

Urban freight distribution

Urban Freight distribution, also referred to as urban logistics, is defined as the system, process and movements by which goods are collected and transported within the urban area (Alice, 2022). This is a vital activity that maintains the functioning of a city and demand is growing year on year, due to the rise of e-commerce and changing customer demands such as the need for faster delivery (Ploos van Amstel W. , et al., 2018; Van Buren, Demmers, Van der Heijden, & Witlox, 2016).

In the Netherlands, this has resulted in delivery vans accounting for more than 80% of urban freight traffic. In cities urban freight traffic accounts for 20 -25% of all road traffic. (Ploos van Amstel W. , et al., 2018). For context, 8,000 – 10,000 delivery vans travel to and within Utrecht's Environmental Zone (Milieuzones) per day. This has impact on all transport movements within a city, as well as on space, livability and pollution, including noise and emissions. Indeed, vehicles in urban freight distribution account for 30 - 50% of all road transport-related air pollution and 35% of road transport-related CO_2 emissions. Of emissions from transported goods in the Netherlands, 34% of emissions comes from vans (Delft, 2016).

Figure 1: Vans in a busy Dutch city street (Hansadrone, n.d.).

The continuation of these emissions is not compatible with the national government's international commitments to the Paris Agreement or with national commitments to the Climate Agreement. The national Climate Agreement includes the goal to halve total CO_2 emissions by 2030. With the total number of kilometers driven by vehicles in logistics expected to rise by 19% in 2035 (Quak, et al., 2024), policy is required to increase the sustainability of urban freight distribution. One such way the Climate Agreement looks to achieve this is that from 2025 at least thirty Dutch cities (currently twenty-eight cities) need to implement zero emission zone for vehicles in urban freight distribution.

Zero emission zones

A zero-emission zone (ZEZ) for logistics aims to achieve emission free deliveries in order to meet the goals of the Climate Agreement. Set out in the Urban logistics implementation agenda (Uitvoeringsagenda Stadslogistiek), the ZEZ will achieve this by excluding freight transported by lorries and vans that run on petrol, diesel, biodiesel or LPG, in particular zones within city centers. This is to reduce particulate matter and carbon dioxide emissions, whilst trying to keep cities livable and attractive. These differ from the established Environmental Zones (Milieuzones), that aim to improve air quality by restricting entrant to older diesel vehicles including passenger cars. At the time of writing, 29 cities have confirmed their decision to introduce a ZEZ, with 15 commencing from 1st January 2025 (Figure 2). Full list of cities can be found in the Appendix. From the commencement date, all new vans and trucks in the ZEZ must be emission-free.

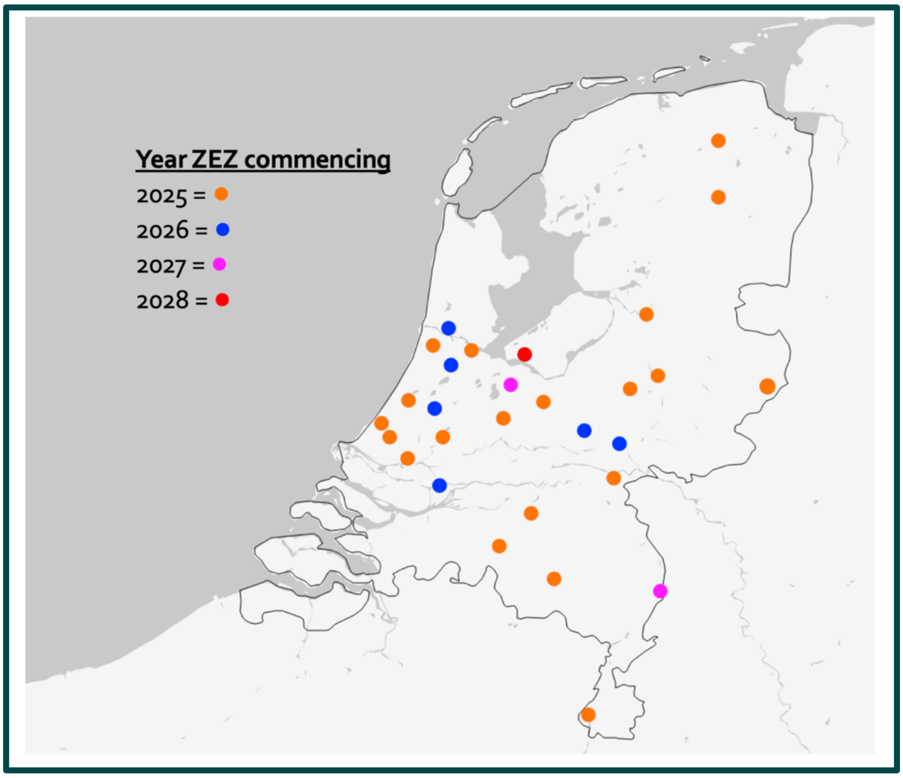

Figure 2: Map of the Municipalities within the Netherlands where Zero Emission Zones have been announced

It is on individual municipalities to design the zones, which includes the zone size and date that the zone is effective from. Whilst each city will see variations, they will each follow a similar pattern of including the city centre and surrounding neighbourhoods as well as experiencing a gradual exclusion of access for lorries and vans of particular Euro emission standards during a transition period (Kloostra & Godoy, 2024). These transitional arrangements will vary on the city, with difference in start date, depending on the van emission standard and date of registration (Table 1). These differences exist as the agreements want to ensure affordability and feasibility for businesses and actors in urban freight distribution, in order that they can maintain this vital function within the city.

Each zone is formalized via a traffic decision (Verkeersbesluiten) that outlines exemptions, which include vintage vans that are more than 40 years old. Through the use of licensing and exemptions not all organisations will be impacted (Kloostra & Godoy, 2024). Municipalities are then responsible to create project plans for the zones, manage budgets, enforce, communicate about the zone and develop flanking policy (ZES, 2023). Flanking policy is needed to stimulate the transition to zero emission urban logistics, and can work towards improving city access, better integrate logistic infrastructure into urban design, promoting bundling of goods in vehicles, enhancing the use of smart technology and promoting a modal shift. A modal shift can include switching to electric alternatives such as EV Vans, boats, light electric vehicles (LEVs) or cargo bikes. This report focuses on the modal shift to the cargo bike.

Table 1: Example of different transition period for vans in Utrecht and Venlo

Utrecht	Venlo
From 2025 All new registered freight and vans in ZE areas must have ZE drive. **2025-2026** Euro 5 vans have access to the ZE zones until 31-12-2026. **2025-2027** Euro 6 vans have access to the ZE zones until 31-12-2027. **2025-2029** Existing Euro 6 box trucks that are up to 5 years old on 1-1-2025 will have access to the ZE zones until 1-1-2030. Existing Euro 6 tractors who are up to 8 years old on 1-1-2025 will have access to the ZE zones until 1-1-2030.	**January 1, 2025** Vans (N1) registered after this date will only have access to the zone from January 1, 2027 if they are emission-free. For example, if they drive electric or on hydrogen. **January 1 2027.** Vans (N1) with emission class 5 or lower are no longer allowed into the zone. **January 1, 2028** Vans (N1) with emission class 6 are still allowed into the zone until January 1, 2028. From then, all vans in Venlo-centrum must be emission-free.

The cargo bike

In Dutch law, electric and normal cargo bikes fall under the category of bicycles, as a difference is not currently recognised. The law outlines that a bicycle with two wheels may have a maximum width of 0.75 meters, whilst with three or more wheels a maximum width of 1.50 meters (Regeling voertuigen, Artikel 5.9.6). There is currently no maximum length, height or mass. However, this is expected to change with the approval of the Dutch framework for Light Electric Vehicle (LEV), which includes cargo bikes, and is expected to be formalized in 2025.

The framework is the result of a collaborative effort between the Ministry of Transport, road safety research (SWOV) and Road Traffic Service (Kloostra & Godoy, 2024). In the framework, electric cargo bikes are within the category 2a which will define specifications, and is expected to introduce a minimum age of 18years, need to register, have insurance and an AM driving license (Janssen, 2024).Although a draft version exists, once formally finalized "*the goal of the framework is to ensure that LEVs authorized for use are technically safe, and that they are used safely on the road. Consumers will know which LEVs they are allowed to use on the road, manufacturers will know what technical requirements vehicles must meet, and road management authorities will know what vehicles they can expect to see on the roads"* (Ministry of Infrastructure and Water Managment, 2022, p. 2). Draft categorizations of LEV's, which include electric cargo bikes are outlined in Figure 3.

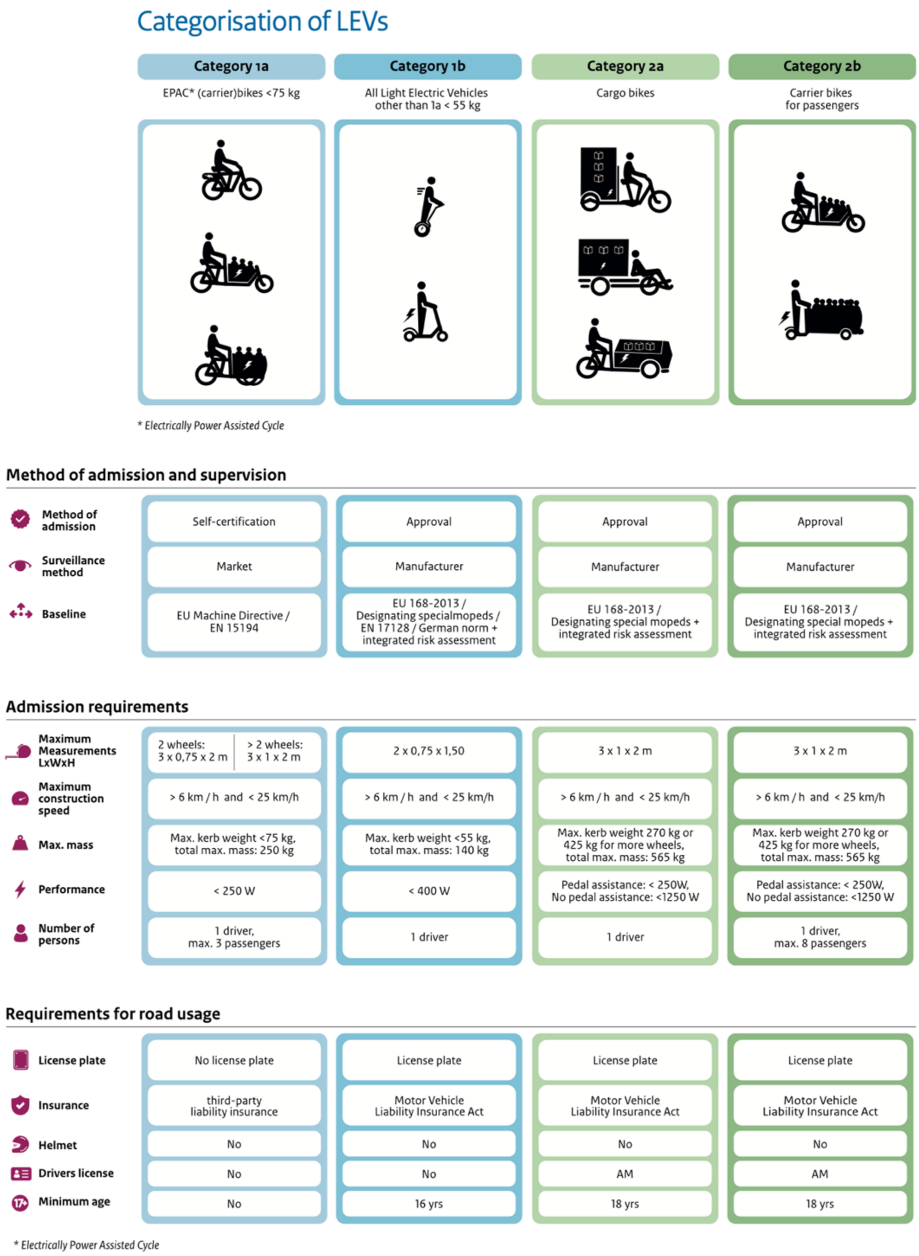

Figure 3: Detail information of LEV, including electric cargo bike in the Dutch Framework for LEV (Ministry of Infrastructure and Water Managment, 2022).

Currently several alternative designs for cargo bikes exist with cargo storage placed either in-front or behind the rider, potentially with additional load on a trailer (Figure 4).
The typical loading capacity of a cargo bike depends on the model, but ranges from 50-350 kg, with the vehicle weight accounting for 20-170 kg. This capacity means that the cargo bike provides an opportunity to transport freight, as the average cargo weight carried by commercial vehicles in the Netherlands is between 130 – 420 kg per trip (Connekt/Topsector Logistiek, 2017; Ploos van Amstel W. , et al., 2018). Specifically, it has been estimated that 10 - 15 % of delivery vehicle trips could be replaced by LEV's which would include cargo bikes (Ploos van Amstel W. , et al., 2018).

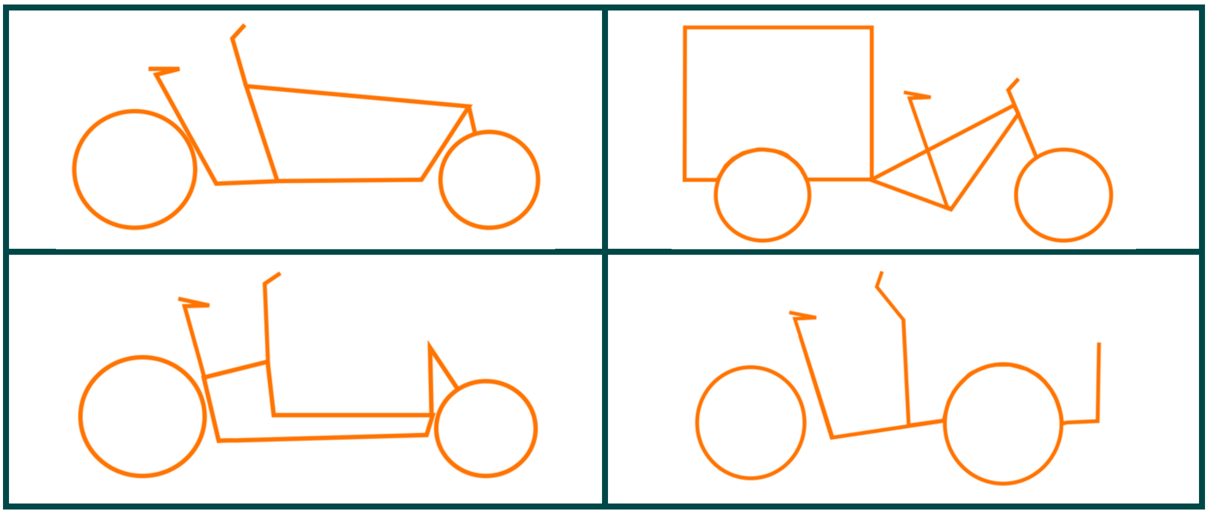

Figure 4: Simple schematic of 4 types of cargo bikes

Due to the smaller capacity compared to vans and lorries, cargo bikes offer a solution for last mile deliveries, which can be defined as the distribution of goods or series to homes or drop off points in neighborhoods (Van Buren, Demmers, Van der Heijden, & Witlox, 2016). However other options are also possible which is why the focus of the report will be on the broader term of urban freight distribution.

In 2021 it was estimated that 3,500 Dutch produced freight bicycles were in use in the Netherlands. This estimate is now likely to be higher now, and a conservative forecast expects the number to grow beyond 9,500 by 2025 (Janssen, 2024; de Wolff, Knigge, & Zweers, 2021). This quadrupling in demand is not just a Dutch phenomenon, as it is being replicated across the EU (Kloostra & Godoy, 2024). By 2031, the global market value for cargo bikes is expected to be worth € 2.4 billion (van Duin, Ploos van Amstel, & Quak, 2022).

Research objective and question

The DCE aims to share and connect people to Dutch knowledge on cycling expertise. A large part of this work is to collaborate both with Dutch network participants as well as interested international actors. It is hoped that the information gathered would be valued by the team, participants of the network and international observers, because in order to enable this work, opportunities first need to be identified in the urban freight distribution sector in order to incentivize collaboration (Morel, Balma, Berdena, & van Amstel, 2019).

To achieve this the research objective to is to make recommendations to the DCE concerning problems and opportunities that exist regarding the use of cargo bikes as an urban distribution solution, by providing insights into the opinions of the stakeholders in the Dutch freight distribution sector with regards to cargo bikes in zero emission zones. To fulfil this objective, the following research question will be answered:

What problems and opportunities in policy and technology do stakeholders in Dutch urban freight distribution experience when looking to utilize cargo bikes in zero emission zones?

In literature, different classifications and grouping for stakeholders exist (Taniguchi & Tamagawa, 2005; Connekt/Topsector Logistiek, 2017; Bauwens, 2015; Ploos van Amstel W. , et al., 2018; Sanchez & O'Brien, 2024). Each stakeholder has an array of complex and different needs, which can often be conflicting (Figure 5). For this research, frequently mentioned actors in literature were grouped into four actor groups in urban freight distribution were classified: Users, the cargo bike value chain, administration and knowledge institutes. The roles and subdivisions of these actor groups are defined and explored below.

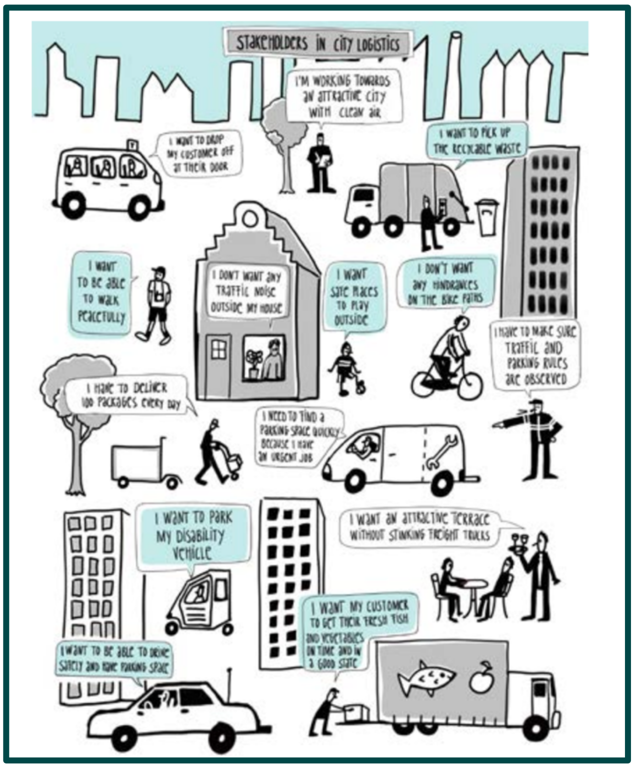

Figure 5: Different stakeholder needs in city logistics as illustrated by Ploos van Amstel W., et al., (2018).

User

In freight distribution literature, shippers and carriers are often referred to as key stakeholders (Bauwens, 2015). Shippers are responsible for providing, packing and preparing goods that are then given to a carrier who distribute the good. To distribute goods, carriers own/loan and operate transportation equipment (Approved forwarders, n.d.). The transportation equipment of focus being cargo bikes in this research.

Shippers, whether an online retailer or local store, wish for their good to be delivered fast, reliable and at a low cost (Ploos van Amstel W. , et al., 2018). Both the shipper and the carrier are also required to meet the needs of the end customer, who want same/next day delivery, the option to make last minute adjustments to an order and again low costs of delivery (Ploos van Amstel W. , et al., 2018). Whilst citizens don't have a direct influence on urban distribution, by being an end customer in some situations they have indirect influence through their consumer choices (Bauwens, 2015; Sanchez & O'Brien, 2024).

Toplogistiek has identified six different streams within the Dutch urban freight distribution sector (SPES, 2020). The largest streams transport products linked to hospitality, construction, retail and facility which account for > 50% of the freight vehicles in the city (Delft, 2016; Ploos van Amstel W. , et al., 2018). The six streams are outlined in Table 2 along with the subsegment which have different needs, behaviours and requirements when it comes to how freight is loaded, transported and unloaded. This includes considerations about whether goods can be stacked, needs to be temperature cooled, or if it needs to be handled with caution. These different needs determine the vehicle type chosen to distribute freight.

Table 2: The six streams of urban freight distribution ((SPES, 2020).)

Stream	Subsegment	Most common vehicle types
1. fresh produce (conditioned)	Retail (fresh)	Tractor trailer unit
		Truck
	Specialists	Truck
		Large delivery van
	Home deliveries of fresh food (groceries and meals)	Delivery van
		Moped/bicycle
2. Individual packed goods	Retail chains (not fresh)	Tractor trailer unit
		Truck
	Specialists retail	Truck
		Large delivery van
		Moped/bicycle
	Two man home deliveries (furniture, white goods)	Truck
3. Waste	Household waste collection	Heavy goods vehicles
	Business waste collection	Heavy goods vehicles
4. Express deliveries and parcels	Express deliveries and parcels	(Large) Delivery van
5. Facility/service logistics	Maintenance and service	Delivery van
		Moped/bicycle
	Deliveries of stocks and supplies to offices, public departments and hospitals	Diverse vehicles
6. Construction	Infrastructure	Heavy goods vehicles
	Construction site preparation	Heavy goods vehicles
		Heavy goods vehicles
	Building shell construction	Truck
		Delivery van
	New building fitout	Delivery van

Considering the size and weight specification of a cargo bike compared to all the common vehicle types, the most relevant users are the subsegments that currently use a van, as well as moped and bicycle. This is due to a similar size and weight restrictions. The most common vehicle type aligns with other research that users in Dutch cities that mainly use vans come from those supplying food (25%), providing a service (25%) or in construction (25%) (Balm, Moolenburgh, Anand, & Ploos van Amstel, 2017). Through this process, 5 streams were identified as the focus for the study: Home deliveries of fresh food, individual packed goods from specialist retail, express deliveries and parcels, facility & service and finally construction.

These streams have been identified as users, which is a broad term used in this research, as they also account for some shippers who provide goods. With some retail stores using cargo bikes themselves to send and then carry goods, they could also be defined as shippers. Thus, the broader term users has been chosen in this research. All streams have to include the needs and requirements of shippers, users of cargo bikes and end customer, which thus impacts the decision of whether to use a cargo bike. These 5 user streams are defined and different requirements identified below.

Fresh produce

The user stream 'fresh produce' are responsible for the delivery of food to people's homes, as well as to businesses including hospitality, shops and offices (Ploos van Amstel W. , et al., 2018). The produce could include fresh food, groceries, ready-made meals, includes flash delivery from dark stores, supermarkets and takeaway. This means that the user can be both a shipper and a carrier. For grocery deliveries, supermarkets, such as Albert Heijn and Picnic use LEV's for home deliveries, due to their ability to stack multiple order (Ploos van Amstel W. , et al., 2018). For this function cargo bike is not suitable. However, they are useful for other functions, where orders are small, time-critical and parking can be short. This is particularly relevant to individual deliveries to homes.

Figure 6: Cool Blue retail delivery

Retail

The user stream 'retail' sees city shops such as non-food retail and fashion stores act as carrier and shipper. Currently this is the smallest stream within urban freight distribution, as less than 5% of delivery vehicles in the sector can be attributed to retail. The small representation is because the retail stores, particularly large retail chains, are supplied with full trucks that travel long distances, limiting the likelihood of cargo bikes replacing this delivery (Ploos van Amstel W. , et al., 2018). However, for retailer's cargo bikes offer a good solution to deliver to local consumers from their store inventory. This includes Cool Blue (Figure 6) and Hive, whilst specialist stores such as a wine merchant have their own cargo bike or share with nearby stores.

Express deliveries and parcels

The user stream 'Express deliveries and parcels' are shippers as they distribute goods for consumers (B2C) and for businesses (B2B). In the Netherlands, this includes organsiastions such as Post.nl, DHL, DPD, Cycloon and Fietskoeriers.nl. The user group is experiencing a rapid growth in demand, due to digitalisation increasing the ease of online ordering and it is anticipated that the number of shipments will increase twofold within the decade (Boer, Kok, Ploos van Amstel, Quak, & Wagter, 2017). Currently between 5 and 10% of freight traffic in cities can be attributed to this user. Letters and parcel shipments are generally small and their delivery destinations have a high network density offering a lot of potential for cargo bikes (Ploos van Amstel W. , et al., 2018). This is a key user for the transition in urban freight distribution, as it has been

Figure 7: DHL cargo bike delivery

estimated to account for 43% market share cargo bike sales in the future (van Duin, Ploos van Amstel, & Quak, 2022).

Facility and Service

This user provides installation, repair, cleaning and maintenance work in offices, homes and public spaces, such as energy meter technicians and plumbers. Due to the need to carry material and tools for the service, a van is the most common use of vehicle for this stream and this is one of the major contributors to kilometres driven in the Netherlands as 35% of the kilometres driven by vans in the Netherlands are in order to deliver a service (Connekt/Topsector Logistiek, 2017; Ploos van Amstel W. , et al., 2021). This service occurs throughout the Netherlands, but a cargo bike is not a realistic option to replace a user working at a national scale. The factors to be considered when choosing whether to use a cargo bike include the network density, as compared to express deliveries and parcels, fewer stops are made per day, and possibly over a wider geographic area with unpredictable routes, lowering the network density (Ploos van Amstel W. , et al., 2021).

Figure 8: Mobian & Dockr P+R for services (van Amstel)

Construction

The final user stream construction is also a major contributor to vehicle freight traffic in urban areas, but not all is suitable for cargo bikes. However, some potential for cargo bikes exists where shipments are small and time-critical, such as in the maintenance phases of projects and for the transportation of materials on the construction site itself, as well as between a wholesaler or hub. For example, in Utrecht an electric cargo bike has been used by construction wholesaler Stiho to transport paint, nails and insulation materials to building sites (Ploos van Amstel W. , et al., 2018).

The cargo bike value chain

For this research, the actors in the cargo bike value chain are those responsible to supply and maintain cargo bikes for users. This is achieved through a value chain, which are the connected stages required to bring a cargo bike to the logistics market, including the sourcing of material, manufacturing, and marketing (Tardi, 2024).

Different functions within the value chain exist. This includes those actors responsible for the inbound logistics which means receiving, warehousing, and managing cargo bike inventories (Tardi, 2024). The function of operations is more relevant for this research, as it encompasses those actors responsible for converting raw materials into a finished product, whether cargo bike components such as batteries or the full cargo bike, as done by manufacturers including Cargo Cycling (Figure 9) and Fulpra.

Distributing the cargo bike to the final consumer, known as outbound logistics, can be done by the manufacture or by a third party fleet operators such as leasing by Dockr or as a service such as by Cargoroo. In cases such as Dockr, Pon is a supportive original equipment manufacturer (van Duin, Ploos van Amstel, & Quak, 2022). A fleet operator enables users to have access to a bike fleet whilst being responsible for cargo bike maintenance and insurance, as well as enhancing consumer experience through customer services (van Scheijndel, van der Veeken, Schoevaars, & Bosma, 2017).

Figure 9: Unveiling of Cargo Cycling's new Chariot SF2 at ICBF 2023.

Administrative

Administrative actors can be defined as those whose role it is to provide regulation and policy to the Netherlands. This includes international actors such as the European Union (EU), national government, as well as local provincial and municipal governments. The roles of administration specifically include stimulation, regulatory, facilitative, coordination and experimentation (ROB, 2012).

Table 3. Levels of administration in the Netherlands

Level	Location	Regulation and Policy	Function
International	EU	LEV regulation European regulation EU 168/2013	Determines cargo bike speed, mass, power, dimensions, number of riders
National	the Netherlands	Light Electric Vehicle Framework (Under discussion, expected 2025)	
Municipal		Zero emission zones logistics (from 2025), low emission zones (Milieuzone), other access restrictions	Enforcement, exemptions and licensing

Variation in cargo bikes specifications is seen across EU member states but this level was not within the scope of research. In the Netherlands, the national government has more influence regarding road and vehicle safety and thus manufacturing, and less influence regarding what vehicle users choose. This influence is seen by the previously mentioned Framework for LEV (Table 3). The new coalition that formed the national government in 2024 has also expressed interest in exploring options to postpone ZEZ and opportunities to create nation-wide exemptions (van Amstel, 2024).

The new coalitions exploration comes because the more important regulatory stakeholder on urban freight distribution in relation to decision making within the local urban system is for now the local provincial and municipal governments (Bauwens, 2015). The most noticeable way that municipalities have influenced the urban freight distribution is through regulatory enforcement of previously mentioned ZEZ, which includes the vehicle licensing and exemptions (Kloostra & Godoy, 2024). Accommodating different actors can lead to conflicting interests. This is because they need to represent residents, who are both consumers and constituents, as well as encouraging business and investment, whilst trying to avoid competition with the private sector (Bauwens, 2015; Starr, 2020). City planners, policy makers and regulators thus need to satisfy their residents as well as commercial, transport, safety and distribution interests (Ploos van Amstel W. , et al., 2018).

Knowledge institutions

In this research, knowledge institutes are defined as those actors that are responsible for providing and facilitating expertise and knowledge sharing related to cargo bikes in urban distribution. This could include such subjects as urban freight distribution, consumer behavior, transportation, cycling or cargo bikes.

Specific actors include universities, research institutes and consultants, who provide knowledge required for cargo bikes as a solution to be better understood, whether evaluative regarding technical or functional information. It also includes advisors and advocates including citizen advocate groups who look to represent the needs of citizens. From the cycling and cargo bike perspective, actors that facilitate knowledge sharing and production can include Tour de Force, International Cargo Bike Festival and the Fietsersbond. It could even include the DCE. From the freight distribution sector this could include national actors such as Topsector logistiek, connect.nl and local actors such as Utrecht Logistic Platform. These look to represent the varying and unique needs of their given sectors, such as enhancing knowledge production, sharing and collaboration.

Theoretical perspective

The theoretical perspective chosen to provide insights from the opinions of the stakeholders in the Dutch freight distribution sector with regards to cargo bikes in zero emission zones is outlined here. Critical success factors that had been identified in literature to assess the effectiveness of policy for utility cycling in the Netherlands were used as the basis of our framework. These factors are outlined below and adapted in relation to urban freight distribution literature, for the theoretical framework.

Policy inputs, outputs and outcomes in cycling

Critical success factors were identified in the hardware, software and orgware components of Dutch cycling policy. These three different components combine with exogenous factors to produce policy outcomes in relation to cycling modal share, perceived safety and perceived satisfaction (Harms, Bertolini, & Brömmelstroet, 2016). In this study, policy outcome can be the intention to achieve modal shift to cargo bikes in urban freight distribution, whilst also improving the perceived perceptions of stakeholders regarding cargo bike safety and perceived level of satisfaction for using cargo bikes (Figure 10).

Orgware refers to the policy input that results from the institutional and governance factors that provide foundation for a policy to function, such as collaboration and resources (Harms, Bertolini, & Brömmelstroet, 2016; Tieghi, 2017). In this report, this policy input being to increase modal share of cargo bikes in urban freight distribution. Hardware and software components are the immediate outputs and effects of a policy which would be the rise of cargo bikes used in ZEZ (Harms, Bertolini, & Brömmelstroet, 2016; Tieghi, 2017). Hardware refers to the physical material and infrastructure, whilst software refers to the and the immaterial features (Harms, Bertolini, & Brömmelstroet, 2016).

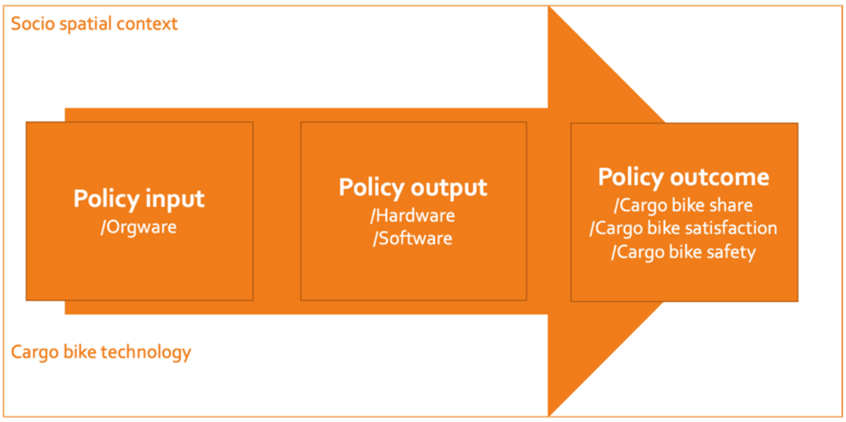

Figure 10: Conceptual diagram

The critical factors for each component are explored below.

Hardware

The built physical environment can help achieve a desirable policy outcome by improving the quantity and quality of cycling infrastructure for cargo bikes, whilst also making alternatives less attractive (Harms, Bertolini, & Brömmelstroet, 2016). The first factors (Table 4) works by create attractive benefits that pull users to utilise a cargo bike, and the second pushes users to choose a cargo bike due to the creation of inconvenience for alternatives.

When looking at pull factors, the quantity of cycling network is the first factor identified in literature. Through the provision of segregated cycling paths, the perceived level of safety of using a cargo bike increases as people on bikes are not mixing with vehicles of a larger mass. If there is a high network quantity, indicated by the length of segregated paths in a city, then interactions are less common, again increasing safety (Harms, Bertolini, & Brömmelstroet, 2016). The segregated infrastructure also means that cargo bikes are not stuck in congestion, which makes delivery times more reliable. This ensures that time critical shipments are possible (Balm, Moolenburgh, Anand, & Ploos van Amstel, 2017; van Duin, Ploos van Amstel, & Quak, 2022; Ploos van Amstel W. , et al., 2018). This allows users to meet the demands and expectations of customers, whilst delivering in a prompt manner (Logistics, 2023), which increases the satisfaction of cargo bikes as a solution.

The quality of this network is also important (Harms, Bertolini, & Brömmelstroet, 2016). This can come through the design of the cycling infrastructure, such as bicycle streets and also the surface material used for cycling paths, as smooth asphalt typically provides more comfort and ease to cyclists (Hull & O'Holleran, 2014; Narayanan & Antoniou, 2022). Effective road maintenance also impacts the long-term quality, as potholes can lead decrease rider comfort and damage to cycles. The higher mass of cargo bikes compared to regular bikes means that smooth surface and a design that accommodates the larger specifications of cargo bikes is critical for cargo bikes to be satisfactory solution for users who want to avoid damage to cargo and bike.

Weather proofing infrastructure can increase the satisfaction for riders of cargo bikes (Kong & Pojani, 2022). This factor may be particularly necessary due to the loss of a dry 'office' space that a van cockpit provided. Compared to vans and some LEV's, cargo bikes typically don't have weather protection. Weather proofing could include heated cycle path, shorter red lights for cyclists when raining or shaded cycling paths for hot weather and even porous asphalt which improves drainage (SWOV, 2023; Boffey, 2018; Easy Path, 2014), helping minimise aquaplaning and road spray. Poor weather protection could be expected to decrease the satisfaction of cargo bikes and cycling share.

Network safety highlights the importance of safe intersections and the need for crossings giving the right of way to cyclists. Giving priority to cyclists on safety grounds, increases perceived cycling safety for cargo bike riders (Harms, Bertolini, & Brömmelstroet, 2016). Although not the intention of the original policy, this indirectly is important for reliable delivery times, increasing the satisfaction of a cargo bike for users, as well as safety. Due to cargo bikes being wider than traditional bicycles, width of cycling lanes is also an important factor in network safety, particularly for other cyclists.

Network facilities focuses on the number of parking spaces and impacts perceived safety and satisfaction (Harms, Bertolini, & Brömmelstroet, 2016). For parking, cargo bikes have a different requirement to regular cycling (Kloostra & Godoy, 2024). One, a larger area is needed for a parking space, with width being crucial to satisfaction for users. Two, the bikes higher value means that more secure facilities with surveillance may be needed. Three, cargo bikes are often electric assisted, so charging facilities are needed. Four, different cargo bike users have different behaviours such as in stay length, so a diverse range of parking facilities is needed throughout a city. Cities need to understand the different groups of cargo bike users in their area and provide needed facilities in the appropriate geographical spaces, such as near stores in a shopping area (van Oosten, Godoy, & Kloostra, 2024). These facilities include city hubs, who's use is integral for users to deem cargo bikes as a last mile solution (van Duin, Ploos van Amstel, & Quak, 2022). Hub facilities can be used for loading, unloading, as deliveries are made to final destinations and returns to the hub.

The first example of push factors is the network speed, which is the travel time for a cargo bike in relative to alternatives such as a car or van (Harms, Bertolini, & Brömmelstroet, 2016). This can be faster for a cargo bike due to the existence of narrow historical streets or filtered permeability in roads, such as bollards (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). However, bollards and other obstructions may be a safety risk with cargo bikes, due to their width and longer turning circles, and so in some places have been removed (Wagenbuur, 2018). Depending on the bike size and weight the ability to get on the pavement also aids speed. This flexibility means users are less impacted by road works and congestion, so delivery times remain reliable. This factor has been identified as a key requirement for cargo bikes to be seen as a possible solution, as the network speed ensures that time critical shipments are possible (Balm, Moolenburgh, Anand, & Ploos van Amstel, 2017; Ploos van Amstel W. , et al., 2018; van Duin, Ploos van Amstel, & Quak, 2022). The reliability of delivery time and speed of cargo bikes allows users to meet the demands and expectations of customers, whilst delivering in a prompt manner (Logistics, 2023). This can be identified by comparing the travel time of cycling compared to car/van for local trips.

When administrators limit access to certain vehicles with urban governance such as environmental zones, then this can also push users to a cargo bike (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). If cars and vans physically cannot enter certain zones, due to the creation ZEZ for logistics, then this creates urgency and makes alternatives more attractive (Balm, Moolenburgh, Anand, & Ploos van Amstel, 2017; Ploos van Amstel W. , et al., 2018). Sometimes exemptions exist, such as for EV vans or particular businesses. Restrictions also exist in historic centres and vulnerable bridges where heavy vehicles are prohibited. Policy that restricts motoring and emissions expected to drive people to use cargo bikes (Amstel et al., 2022).

Beyond access, vehicle parking can also be limited (Harms, Bertolini, & Brömmelstroet, 2016). The area size where parking restrictions exist and number of parking spots, makes it harder for cars and vans to find parking spaces in urban distribution. Means more time lost looking for parking spots, and in walking to the destination, if forced to park further away. The smaller size of cargo bikes can make parking easier and they can park for a short term right in front of destination, saving time looking for a parking sport and walking to delivery destination (van Duin, Ploos van Amstel, & Quak, 2022). All of which increases the satisfaction for users and riders of cargo bikes.

The final hardware factor is the tariff value of on and off-street parking itself (Harms, Bertolini, & Brömmelstroet, 2016). If present, with appropriate values and better enforcement, then this will add an expense to delivery to automobiles, increasing the chance that users chose to utilise a cargo bike because they are not affected (Narayanan & Antoniou, 2022). This increases modal share for cargo bike.

Table 4. Critical factors that make up the component for hardware, with regular font pull and italics push factors.

Success Factor	Description
Network quantity	Segregated cycling path and alternative cycling routes
Network quality	Paved cycling path and improvements to existing paths quality and maintenance such as weather proofing
Network safety	Safe intersections and crossings where cyclists have right of way, bike paths with recommended minimum width
Network facilities	Variety in parking and charging facility in urban areas, including city hubs
Network speed	Travel time of cycling compared to car/van for local trips
Environmental zones	Urban area with complete or partial restrictions for vans and cars
Automobile parking tariffs	On street automobile parking tariffs with high rate increases
Area size parking regulation	Urban area with on street parking tariffs with increased area

Software

The software component is made up of factors (Table 5) related to mental and virtual elements, as a way to promote and publicise ideas, plans, policies, and laws for cargo bikes.

Education can be used to improve the skills and habits of cyclists, and awareness of traffic rules and logic for all road users (Harms, Bertolini, & Brömmelstroet, 2016). The focus of the original framework was on administrators such as local government and knowledge institutions, educating children in schools. This training helps to raise the skill level and knowledge of younger people which can then increases general road safety of an area, but effects on confidence and behaviour change are not seen and require a different approach (Goodman, van Sluijs, & Ogilvie, 2016; Ducheyne, De Bourdeaudhui, Lenoir, & Cardon, 2014). This is not immediately relevant to cargo bike users, unlike education for adults, specifically training for cargo bike riders. Educating, particularly novice cyclists or people from immigrational background, is not uncommon as it is important to educate motorists and cyclists in the Netherlands (Harms, Bertolini, & Brömmelstroet, 2016; Kong & Pojani, 2022). Actors from the cargo bike value chain, users, administrators and knowledge institutes can all have input into this. Training is needed for cargo bike riders because the usability of cargo bikes differs from traditional cycling, due to the longer and wider dimensions, heavier weight and different handling characteristics such as longer turning circles (Ploos van Amstel W. , et al., 2021; Ploos van Amstel W. , et al., 2018). This would increase the perceived level of safety for all actors.

Marketing campaigns can also be used by all actors, which aim to stimulate cargo bike use either with an incentive or without (Harms, Bertolini, & Brömmelstroet, 2016). Non-incentivised includes increasing awareness such as promoting the benefits of cargo bikes to small and medium enterprises who may not be aware of them or the changing policy. Barriers to using cargo bikes can also come from the perceived complexity of the technology when there is a lack of consistent language (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). Campaigns can help increase language and policy coherence. This may increase the modal share and perceived satisfaction level of using a cargo bike in urban freight delivery. Promotion can also be achieved through positive media coverage, articles in local or national newspapers and social media.

Table 5 Critical factors that make up the component for software

Success Factor	Description
Educating children	Large role of local government in learning or improving cycling skills and habits, and awareness rules and logic of traffic
Educating & training adults	Large role of actors in educating motorists and cyclists on cargo bikes in last mile delivery
Marketing campaigns with incentive	Targeted campaigns aiming to stimulate cargo bike use in last mile delivery with incentive
Marketing campaigns without incentives	Targeted campaigns aiming to stimulate cargo bike use in last mile delivery without incentive

Orgware

The focus of orgware components in relation to cargo bike policy for urban freight distribution identifies if institutions factors (Table 6) are present to achieve a desired outcome of ZEZ.

The first orgware factor is the formulation of policy goals by administrators. This looks at whether or not policy goals have been formulated in relation to modal shift to cargo bike and whether they are measurable and have been monitored (Harms, Bertolini, & Brömmelstroet, 2016). Monitoring and data can be collected by administrators as well as knowledge institutes. This will help improve perceptions of cargo bikes.

The next orgware factor is to look whether or not policy measures related to cargo bike modal shift has been implemented (Harms, Bertolini, & Brömmelstroet, 2016). Greater implementation by administration improves perceptions of cycling, as it reduces uncertainty and clearly signals to other actors, particularly users, that administrators are serious about a modal shift. If implementation is higher, then this should also increase modal share.

In order for the implementation and goals to be achieved, sustainable financial sources in relation to policy for cycling and for last mile cargo bike delivery are required. Finances for general cycling policy is required in order to continually improve the hardware and software factors. Additionally, budget can also be available specifically for enticing modal shift in urban freight distribution to incentivise sustainable last mile delivery (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). Sources of budget for these include both specific and general infrastructural and construction and maintenance, as well as investment budgets for different scales (Harms, Bertolini, & Brömmelstroet, 2016).

The ability to provide opportunities for experimental measures have been hugely successful in helping increase the modal share of cycling and perceptions of cycling in general in the

Netherlands (Bruntlett & Bruntlett, 2018; Harms, Bertolini, & Brömmelstroet, 2016). Experimental trial schemes include temporary closures of main streets to motorized traffic, which would have a knock-on effect to users (Narayanan & Antoniou, 2022). Fostering living labs is similar recommended to find solutions for urban freight distribution (Morel, Balma, Berdena, & van Amstel, 2019).

Policy consistency and comprehensive long-term planning is a critical factor for cycling and sustainable urban distribution policy to be established (Harms, Bertolini, & Brömmelstroet, 2016). This needs consistent language and goals to help guide strategy regarding the type of cities administrators want to create, which gives certainty and finance, and ultimately enhance satisfaction of cargo bike and lead to modal shift (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). However, some level of flexibility and adaptability is also important (Buehle & Pucher, 2011).

The institutional arrangement identifies the level of integration, coordination and collaboration on the topic of cargo bikes in ZEZ between policy domains (Harms, Bertolini, & Brömmelstroet, 2016). For improved outcomes, it is important that this policy is organised integrally and not siloed in different administrational departments. This strengthens the policy development, and maintains consistency. To avoid departments working in silo's, interdependence of actors needs to be recognised in order to establish a holistic view of what different actors manage at different stages of a project (Morel, Balma, Berdena, & van Amstel, 2019).

It is also important to collaborate and involve actors outside of the administration policy arena (Harms, Bertolini, & Brömmelstroet, 2016). The specific focus of cargo bikes as a solution for urban freight distribution creates a complex group of stakeholders with different needs, motivations and expertise. External to these other actors in different policy areas also have an interest in logistics including urban planners and transport organizations (Shrestha, Haarstad, & Rosales, 2024). A great diversity of actors involved in the policy development is desirable but to achieve this in construction logistics, consequential incentives are required in order to drive collaborative action which is not easy to establish. These incentives include organisations having internal resource needs, problems or interest, as well as being connected via external situations, threats and opportunities (Morel, Balma, Berdena, & van Amstel, 2019).

The relationship in and between all actors inside and outside policy arena can impact both the previous factors. Having actors with clear clarity of roles and tasks is vital, particularly to help define communication and collaboration structures between actors (Harms, Bertolini, & Brömmelstroet, 2016). With better relationship, comes improved data sharing and development of knowledge and innovation between public and private actors (Morel, Balma, Berdena, & van Amstel, 2019). This can improve perceived safety and satisfaction ultimately helping improve modal share.

For utility cycling literature refers to the levels of citizen participation, with the aim for it to be broad and inclusive in policy formulation and implementation phase (Harms, Bertolini, & Brömmelstroet, 2016). This could help improve the perceptions of cargo bike safety. More important for urban last mile delivery is the level of business participation, particularly potential users and the end customer within ZEZ's. However, negative consequences can also result from participation, such as increased costs, sub-optimal implementation and counterproductive outcomes (Irvin & Stansbury, 2004).

Strong, charismatic and powerful leadership is required in the implementation of policy (Harms, Bertolini, & Brömmelstroet, 2016). In urban freight distribution this leadership role can help provide direction and urgency to the different and multiple actors involved in the policy arena and external to (Morel, Balma, Berdena, & van Amstel, 2019). Leaders can include authoritative actors in administrators such as Mayors, or they could set up an independent body, whilst knowledge institutes could fulfil the role through advocacy, which have been vital to promote pro cycling policies (Schneider, 2005).

Table 6: Critical factors that make up the component for Orgware.

Success Factor	Description
Formulation of policy goals	Whether or not policy goals for cargo bike in last mile delivery have been formulated which are measurable and have been monitored
Implementation of policy measures	Whether or not policy for cargo bike in last mile delivery has been implemented
Financial sources for cycling and cargo bike policy	Sources of budget for policy on cargo bike for last mile delivery: structural budgets, maintenance budgets, general infrastructure budgets, neighborhood budgets, national or regional budgets, free budgets, other
Opportunities for experimental measures	Living lab opportunities such as temporary closures of main streets to motorized traffic, or pop up logistics hub
Policy consistency and adaptability	Few adaptations in (goals/measures of) in cargo bike in last mile delivery policy
Institutional arrangement of cycling policy	Policy on cargo bike as last mile solution is organised integrally with other policy domains, with collaboration
Involvement of actors outside policy arena	Much involvement of actors with policy: employees, schools and educational institutions; sport and recreational organizations; retailers; (public) transport organizations; cycling advocacy organizations; residents' groups, others
Relationship between actors inside and outside policy arena	Good communication between actors, with clarity of roles and tasks in collaboration
Levels of participation	Often or always participation of civilians and businesses in policy formulation and implementation
Strong leadership	Often or always role for authoritative actors (like mayors)

Exogenous factors

Exogenous factors are those that are out of the immediate control of policy makers yet still have influence on policy outcomes (Table 7).

Literature highlights the influence of a populations socio-demographics on the modal share and cycling rates in a city (Harms, Bertolini, & Brömmelstroet, 2016). Particular impact depends on the percentage share of students, elderly, single homes and immigrants of a population (Harms, Bertolini, & Brömmelstroet, 2016). For the modal share of cargo bikes this is likely to be less relevant, but could influence the socio-demographics of a workforce for cargo bike users, which impacts whether people want to cycle for work. Narayanan & Antoniou (2022) found that a lower educated workforce was less likely to want to use a cargo bike. If a workforce has to use their own vehicle, then car ownership of a workforce with also become a factor.

The composition of user refers to the characteristics of the organisation looking to utilise the cargo bike in last mile delivery. This can be determined by the managerial support, how innovative a potential user is and what their attitude are towards the soft perception benefits provided by promoting sustainability (Narayanan & Antoniou, 2022). Achieving these could be restricted by financial resources. Opportunities for growth and innovation aid LEV's (such as cargo bikes) potential as a solution (Ploos van Amstel W. , et al., 2018).

Urban spatial factors influence the level of cycling share for urban areas. The popularity to cycle increases where urban density increases because the distance and time between destinations decrease. On top of this, a built environment with a greater diversity of functions in an area also sees an increase in cycling popularity (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015; Harms, Bertolini, & Brömmelstroet, 2016). High network density has been shown to increase the potential and satisfaction for LEV's in urban freight delivery (Balm, Moolenburgh, Anand, & Ploos van Amstel, 2017; Ploos van Amstel W. , et al., 2018). Shorter trips for riders increase the chance of small businesses to use cargo bike. The larger the catchment areas for cargo bike users, the less attractive they become, with 20 km per trip proposed as a limit (Narayanan & Antoniou, 2022). One reason is that as the time of trips increases, weather factors (rain and low temperatures) play more of a role and decrease chance that cargo bike is used (Malik, Egan, Dowling, & Caulfield, 2023). Low temperatures demotivate riders but also increase the speed that hot food loses its warmth (Blazejewski, Sherriff, & Davies, 2020).

Technological factors were not included in the original framework of Hams et al., (2016). The integrated policy model on utility cycling may not have deemed it necessary to include it as it assumed that the bicycle technology was reliable, due to the historic use of the reliable Dutch grandma and grandpa bike. However, with the introduction of e-bikes and cargo bikes in logistics, with more manufactures, and more variety in cycles, this has changed. In this study it is chosen to add technological factors, total cost of ownership and the usability of cargo bikes, due to the difficulty in assessing the level of maturity of a technology (Narayanan & Antoniou, 2022).

TNO and HVA research found costs to be very important when selecting vehicle type, yet can be hard to assess (Morel, Balma, Berdena, & van Amstel, 2019). Total cost of ownership includes all the resource costs required to own and operate a cargo bike. This includes the upfront costs, which could be the purchase price, supplier costs and product development costs. Additional costs are found in the operation of cargo bikes, such as maintenance and repair work, which along with the availability of components in the supply chain, can impact the downtime. Operational costs also include the personnel costs and training for riders and other employees such as service providers.

Usability factors relate to the ease of use of the entire cargo bike solution to last mile delivery, including physical and processes. The physical limitations of the technology refer to distances travelled, volume and adaptability to meet different user needs now and in the future. This includes providing for containerisation, staking, the use of pallets, or temperature-controlled capabilities. Physically characteristics also impact the driveability, which refers to the ease to use for riders. The usability is also impact by the processes and software for fleet management. This determines things such as the ease that request repairs can be made and the level of data availability.

Table 7: Critical exogenous success factors

Success Factor	**Description**
Socio-demographic composition of the workforce	Share of students, non-western minorities, car owners in workforce
Composition of user	Characteristics and values of users
Urban density of destinations	High number of destinations within 3 km
Total cost of ownership of cargo bike	Upfront and operational costs
Usability of cargo bike	Physical specifications, drivability and processes

Method

The method section outlines the steps followed to answer the research question through the collection and analysis of data.

Data collection

To identify presence of critical success factors insights were sought from literature and interviews. In total 9 interviews were conducted, in a semi structured way in order to identify critical success factors outlined in theoretical approach. Attempts were made for further interviews with different stakeholders and whilst these were unsuccessful, some provided literature that was then used in this report. References to cargo bikes were also identified in other policy documents, such as city mobility plans & visions, as well as spatial strategies, in order to get a sense of policy integration.

Table 8: List of interviewed stakeholders

Stakeholder group	Stakeholder interviewed
User	Cycloon
Administration	Municipality of Amsterdam Municipality of Utrecht
Value chain	Cargo Cycling Dockr
Knowledge institution	Fietsersbond ARUP APPM Logistiek Platform Utrecht

Data analysis

To identify critical success factors from the interviews, the operationalisation of a factor is simply the presence if referenced. Unlike the Harms et al (2016) study, which the theoretical framework of this report was based on, the level of presence was not measured with indicators and neither was the direct effect on policy outcomes. Instead, critical factors were identified as a strength or as a hindrance by reflecting the stakeholder's opinions from interviews. The identified hindrances and strengths were then inferred and amalgamated to produce problems as well as opportunities that stem from these problems with a theoretical link to policy outcomes; modal shift, satisfaction and safety.

Interview transcripts were coded with the critical success factors from the analytical framework (Figure 11). The validity of the codes was justified in the theoretical section. By using the analytical framework with fixed conditions, this allowed for the use of the same codes throughout all of the source documents, providing consistency and stability to the analysis (Campbell, Quincy, Osserman, & Pedersen, 2013).

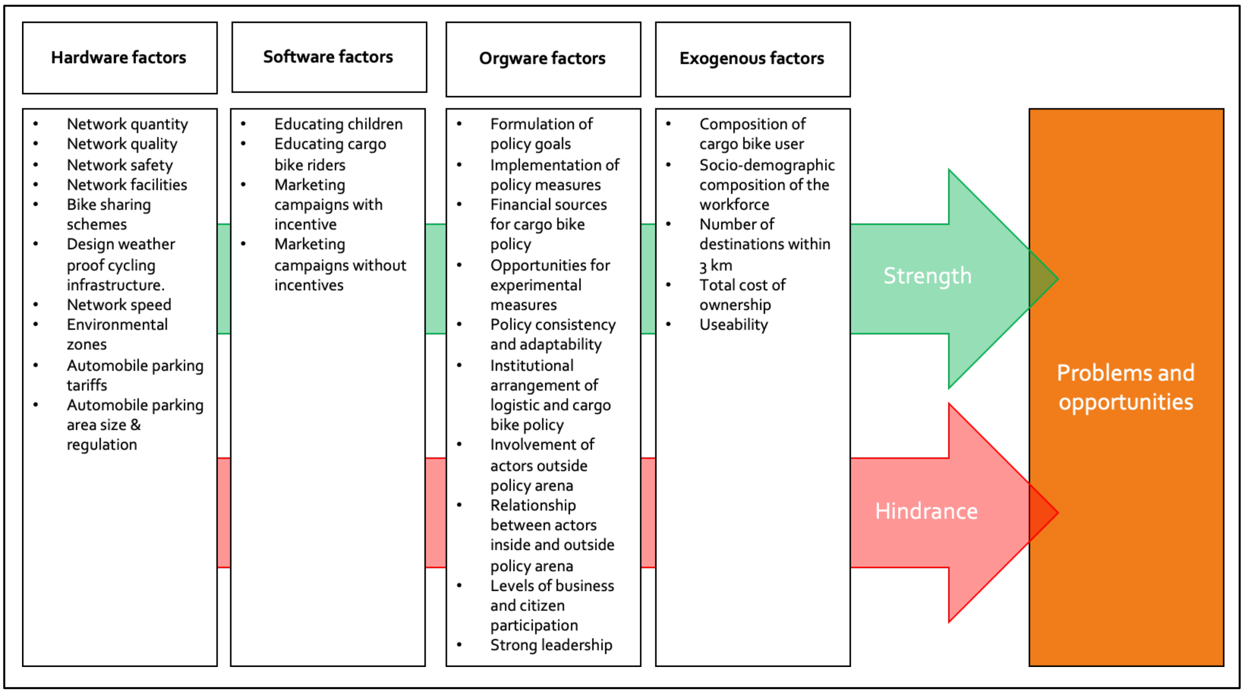

Figure 11: Analytical framework.

Problem 1. Uncertain costs meant cargo bike stayed a niche technology

The individual factor that was most identified as a hindrance to the use of cargo bike as solution to last mile urban delivery was the technology's total cost of ownership which resulted from concerns around the long-term durability of the technology.

Interviewees had mixed opinions on cost effectiveness of the cargo bike compared to alternatives. With lower purchasing costs, lower insurance and no need for road tax, upfront costs for cargo bikes compared to a delivery van are lower, but still a slow modal shift has been seen. According to interviewees, this was due to uncertainties around cost in the long run, due to operational costs such as maintenance and personnel. The highest cost to a user in delivery, whether utilising a van, a LEV or a cargo bike is the personal costs of employing somebody to drive the vehicle and delivery the good. This means that the lower volume of a cargo bikes compared to a van often means that more cargo bikes and thus more riders may be needed to replace a van, meaning higher personal costs, and higher cost of operation.

Durability issues have also seen this total cost of operation increase for users. Cargo bikes were originally manufactured with components from regular bikes, which were not durable enough for daily use on heavy bikes that need to survive high impacts such as jumping curbs. This is particularly important if the weight of the bike does not decrease during a full working day unlike express deliveries when the total weight of a cargo bike decreases in the day as packages are delivered. For instance, a service user may utilise a cargo bike to transport and swap charged batteries to bicycles around the city. This cargo bike could be running at maximum recommended load (sometimes more than) every minute and day of use, severely increasing risk of damage. Poor durability led to a high maintenance rate and frequent downtime, meaning larger cargo bike fleets are needed. Down time for cargo bikes could then be compounded by uncertainty that exists in the operational supply chain of components, which are not mature yet (van Duin, Ploos van Amstel, & Quak, 2022). The constrained supply of both components and maintenance workers, limits the geographical reach and size of cargo bike fleets. This uncertainty added to concerns for users and fleet managers. According to interviewees, the durability varied depending on the user, rider of the cargo bike and city. If treated with more care, which could be aided by designating a bike to a particular rider, then durability improved but the reason for geographical variation were less known. Actors in the value chain were unsure if this was to do with the user or network quality. The high maintenance, uncertain lifespan and low residual value of a cargo bike helps explains the slow uptake in use and limited modal share.

This has meant that the cargo bike has remained a niche technology, and it has also been a deliberate policy for administrators to leave decision making to the market. This has then meant other actors outside of logistics environment have not been aware of the potential for the cargo bike. This reluctance could also be due to the urban freight distribution sector being a large commercial environment, meaning non-commercial and smaller knowledge institutes have been reluctant to join debate and policy arena. This has led to at best mixed knowledge regarding the sector in administration and knowledge institutes from outside the policy arena and sector of urban freight distribution.

Opportunity 1: Benefits and knowledge can be shared as market is forming

Uncertainty about cargo bike technology has delayed policy makers and users from fully utilising cargo bikes (Narayanan & Antoniou, 2022). However, despite the concerns mentioned in problem 1, the last few years have seen the technology improve as lessons were learnt, as seen by an increased use of motorised technology to improve durability.

Due to the Netherlands historic promotion of cycling infrastructure within transport policy, a number of well-established hardware factors, including network quality, quantity and speed, as well as the high urban density of destinations in Dutch cities, create immediate benefits in utilizing a cargo bike. This saw hardware being the most frequently mentioned policy factor. These benefits to users include the reduced cost per delivery (Narayanan & Antoniou, 2022). According to interviews, cycling routes in cities are on average 15-20 % shorter than car routes, making cargo bikes faster whilst they can handle road works, go on pavement and bike paths. Less time is also lost looking for parking and then walking to the delivery destination allowing for many more stops per hour in a high-density location. Not being affected by congestion also means you can provide customers with reliable delivery times. This enabled flash delivery to boom, but the market remains uncertain. Flexibility to deliveries can also be provided to customers by cargo bike users, as they also provide the opportunity to make last-minute changes to orders or additional orders (Ploos van Amstel W. , et al., 2018).

Whilst hardware was the most mentioned factor, the highest mentioned individual strength was the composition of users as particular actors have been benefiting from the hardware factors and improved technology. Large express deliveries and parcel actors have had the resources and the time to invest in experimental trials and now are increasing the roll-out. Additionally, new and innovative users, such as Cycloon, that are intrinsically motivated by their own identity and values or that of particular customer segment have also benefited from using the cargo bike in order to promote and market their sustainability credentials. Even without sustainability credentials, the cargo bike offers physical advertisement space which some retail and service users benefit from, particularly if they can no longer park a van (with advertisement on) in the street.

Identifying and valuing these benefits have not been achieved by all. Such as smaller businesses, who have less resources to be innovative or have different priorities and motivations. The lack of reference to software factors in interviews shows that there are opportunities to promote and target these different compositions of users in order to show the benefits, through incentivised and non-incentivised marketing. Actors in the value chain, administrators and knowledge institutes can highlight the use of cargo bike as solution for last mile delivery, that helps make benefits more obvious for businesses. Administrators can also show how they reduce issues that affect people and liveability of their neighbourhood, whilst connecting to individuals core values such as wellbeing, health and sustainability (Kong & Pojani, 2022). This promotion of success stories is beginning to be seen, the Netherlands Enterprise Agency (RVO) in cooperation with APPM, has recently published 'Chances for cargo bikes in city logistics' report that outlines positive case studies (Rijksdienst voor Ondernemend Nederland, 2024). This demonstrates the collaboration of administrators and knowledge institutions, as well as actors that could be deemed to have a good reach to potential users in the Netherlands. Actors such as the DCE could publicise this information to raise awareness for international actors. Actors in the value chain such as Cargo Cycling have also recently published success stories of users utilising their cargo bikes. The availability of these stories should increase in time.

For employees of users, notably delivery riders, many physical and mental health benefits were raised by interviewees. They stated that riders often enjoy their job due to the greater possibilities to interact with people, whilst the smaller vehicle meant that riders don't feel guilty about blocking the road, avoid being shouted at for parking on the road/pavement, and reduce personal anger after not getting stuck in congestion when you have concerns about being paid per delivery. More could be done to raise this benefits and perceptions of satisfaction of cargo bikes for SME's and riders. This could include education for employees (particularly if not traditionally cyclists or they own a car) on cycling as an alternative mode of transport, as well as marketing regarding alternative routes, facilities, environmental zones and parking regulation changes that are to come. This could unlock new potential employees for organizations in urban distribution but may be tricky to many potential users, whose have many employees that are van drivers, and may not wish to cycle.

With more success stories being published, there are signs that the market for cargo bikes in urban freight distribution is forming, with the growth of fleets for certain users. The market is expected to grow, with the potential market share now more than the originally predicted 10 to 15 per cent of urban freight routes (van Duin, Ploos van Amstel, & Quak, 2022). For this potential to be realized, fleet managers are pushing the 'Internet of things' as they want improved access and quality data, as well as more user-friendly management software to improve usability. With better data and software, durability can be improved as worn components could be spotted earlier in data or more easily reported by riders. Currently this isn't always done meaning that damage is not known until the next shift, which adds delays and costs. This data would also be able to further understand efficiencies, demonstrate positive case studies that may make it easier to attract other users and demonstrate benefits to administrators.

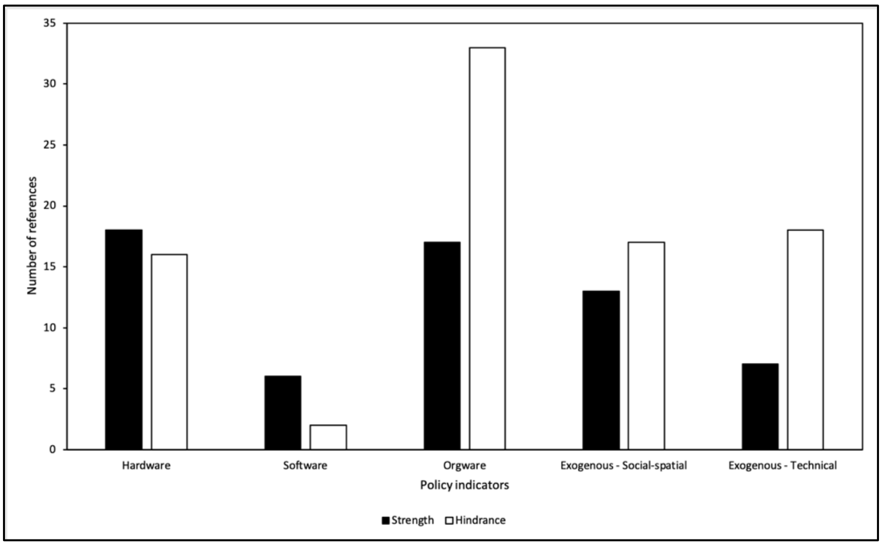

Figure 12: Frequency of reference to the grouping of critical success factors

Problem 2: Embedded logistics processes difficult to change

In order for cargo bikes to be cost effective it requires more than a direct modal shift from vans. Instead the logistics systems of users' need to be reconfigured, meaning new habits need to be acquired.

The need to learn new logistic processes is linked to why the second most mentioned hindrance was the composition of user. Whilst the first opportunity highlighted that certain users who already thought with a cargo bikes in mind are benefiting from the technology, the majority of users in urban freight distribution have only ever delivered goods to customers in a vehicle, van or lorry. However, the cargo bike offers different usability characteristics would need to devise completely new processes and perspective for deliveries. These processes would include the planning, sorting, loading and invoicing of goods (Ploos van Amstel W. , et al., 2018), which is not straight forward, especially if the composition of the workforce is made up of people used to driving goods and not cycling. This difficulty makes focusing a modal shift to electric vans and LEV's more desirable as it is more in line to the existing processes and behaviour.

The usability of cargo bikes compounds the reluctance to reconfigure. The limited volume a cargo bike could carry in comparison to a van is compounded by the fact that different users have different operational needs. When actors in the value chain started manufacturing cargo bikes they were originally unaware of the present and future demand for different market segments, so were unable to provide tailor-made cargo bikes to different users (Ploos van Amstel W. , et al., 2018). This put them at a competitive disadvantage compared to the well-established, trusted and mass-produced van which was well adapted to different storage hardware used in logistics, whether pallets, crates, roll containers or portable boxes (Ploos van Amstel W. , et al., 2018). For goods stored in such hardware, this made cargo bikes inconvenient and usability more restrictive. Factor in the ability of a van to provide flexibility to drive short and long distances and anywhere in the country, it meant that the purchasing cost of one van could be justified on the basis that it would provide solutions to most if not all tasks. This means that a van has been a vital tool for small medium enterprises (SME's) in the sector and is reflected by the fact that 55% of the 1 million vans in the Netherlands are owned by companies with less than 10 employees. This jumps to 75% owned by companies with less than 100 employees (Connekt/Topsector Logistiek, 2017). Thus, until the ZEZ becomes active a cargo bike cannot compete with the flexibility a van provides to small and less financially resourceful users.

This means that for a modal shift to occur in ZEZ's, more processes than simply transportation should be looked at.

Opportunity 2: Administrators should push for more than technological fix

To achieve a modal shift to cargo bikes in ZEZ, the focus should be broader than a simple technological substation. Promoting only a technological fix allows users to carry on as before and larger operational changes are easier forgo.

The focus of ZEZ's is currently on narrow technology substitution which recommends switching to an EV van, because it is easier to achieve and prevents the harder yet needed transition to institutional operations (Shrestha, Haarstad, & Rosales, 2024). One interviewee noted that in city ZEZ meetings, the focus and successes highlighted were often on a simple achievement of switching to EV vans and not on the more strategic and behavioural changes that could be achieved. It is stressed by van Amstel et al (2021) that efforts to achieve the goal of zero emissions transportation should not start by looking at the vehicle of choice. Instead it requires a transition at a greater strategic, tactical and operational level, with efforts being made around transportation systems such as in route planning, charging infrastructure and financing of vehicle fleets, as well as efforts beyond including on the organisation of inventories, the recruitment of staff and to customer service. If broader goals exist, that target users who are reluctant to change or switch, this could make cargo bike more attractive. This is a huge undertaking, a topic that is a lot wider in scope then this research but demonstrates how switching to cargo bikes is a small part of the logistic puzzle.

If achieved, these different urban freight distribution systems and operations will help identify the users most appropriate to achieve a modal shift to cargo bikes. In recent years, cargo bike value chain actors, such as manufacturers, have been able to supply more specialised bikes, allowing different needs in urban freight distribution to be met. A few years ago, it was believed that they could not provide tailor-made solutions for every logistics operator (Ploos van Amstel W. , et al., 2018). However, as demand for different market sectors is better understood and technology has improved, so too has the usability. It has yet to be seen if this production can be replicated to scale.

Another factor that could make cargo bikes more attractive in ZEZ's is that there is low EV availability and supply. Whilst helping the demand for cargo bike, it also highlights that goals to get to zero emission vehicles by just replacing vans is unfeasible. Instead it is likely to best be achieved by using a diverse range of vehicles (InnoEnergy, 2024), including LEV's and boats. An urban freight distribution system of entirely cargo bikes is not realistic (Narayanan & Antoniou, 2022), instead a mixed fleet would help address weaknesses of the cargo bike and improve the resilience of the urban distribution system (Starr, 2020). Research by EIT InnoEnergy (2024) found that by 2030, express delivery users delivering 2 billion parcels a year could save annual costs of around €554 million and reduce emissions by 80% if they used a mixed fleet of 80% cargo bikes and 20% EV van, compared to a 100% EV van fleet. This won't be possible if a like for like switch to EV vans is the only focus.

For this, a more comprehensive vision for cities and urban freight distribution is needed, which the policy environment is not currently enabling. This is due to hindrances in administration, such as a lack of knowledge on urban freight distribution and cargo bikes.

Problem 3: Fragmented governance decreased knowledge sharing and collaboration

Leaving the development of the policy arena to the market has allowed time for the cargo bike costs to fall and usability to improve, but has meant that orgware factors have not been developed. Regarding hindrances identified by interviewees, orgware components occurred the most frequently.

A lack of institutional arrangement and defined roles has meant that collaboration has been lacking and is seen by the fact that the critical success factor 'relationship between actors inside and outside' was the third highest mentioned hindrance. This has not just impacted cargo bikes, as it has been highlighted that the implementation of LEV's has also been hindered by unclear roles and poor communication within administration actors, such as the Ministry of Transport and the Netherlands Vehicle Authority (van Duin, Ploos van Amstel, & Quak, 2022). Beyond transport, the fragmented nature of the logistics sector has also been raised in previous research, particularly urban construction logistics (Morel, Balma, Berdena, & van Amstel, 2019).

There is evidence of collaboration between certain cities in the Netherlands, notably the 4G municipalities who advise the government. This is the largest 4 cities in the Randstad: Amsterdam, The Hague, Rotterdam and Utrecht. However, despite this collection of large Dutch cities, the fragmented nature of administration has meant that some actors believe there is a lack of leadership for stakeholders in the cargo bike sector.

A lack of collaboration has meant that even if the benefits of cargo bikes were beginning to be understood these were not communicated and shared with all actors, whether administration or knowledge institutions. With cargo bike technologies still developing it is understandable if private companies in value chain and users are reluctant to share data and lose competitive advantage, but it has unfortunate effect of administrators and knowledge institutes being unable to understand their benefits and promote their use. A lack of knowledge regarding both the subjects of urban freight distribution and specifically cargo bikes was noted by some actors in administration and cycling knowledge institutions.

This can be in part due to the lack of data sharing as mentioned previously, but also due to the physical difficulty to collect data themselves. For administrative actors it is hard to collect data and monitor numbers and movements of cargo bikes because they have no license plates as they don't have to be registered, whilst sales figures aren't shared with administration actors and insurance isn't mandatory (Janssen, 2024). This means that unlike vans the exact numbers and movements of cargo bikes are unknown. This meant that administrators lacked an understanding regarding cargo bike users, and their behaviours and requirements meaning that it has been hard to improve network safety and facilities (Liu, Nello-Deakin, te Brömmelstroet, & Yamamoto, 2020).

Opportunity 3: Establish integrated understanding of cargo bikes within administrators

The fragmented nature of the governance presents an opportunity to better define roles and improve collaboration. This would strengthen the ability of cargo bikes to be integrated across policy and beyond ZEZ and sustainable logistics, which is often the only place where cargo bikes currently sit in municipalities (Kloostra & Godoy, 2024).

Some actors felt that there needs to be greater clarity of roles and tasks, although these may be felt more by actors with limited knowledge regarding the logistics sector, which is market led. Bridging this gap, particularly from institutions that traditionally had a focus on utility cycling may be helped by defining communication and collaboration structures. With better relationships comes clearer leadership and improved data sharing, development of knowledge and innovation between public and private actors (Morel, Balma, Berdena, & van Amstel, 2019). Events such as the International cargo bike festival (ICBF) have done well to raise the profile of cargo bikes internationally, but events such as this, as well as logistic focused ones such as Parcel+Post Expo, tend to focus on consumers, but could also offer a space for mixing administration actors with users and actors from the value chain. This approach was at the 2023 ICBF with a SUMO (simulation of urban mobility) event, which could help attract different stakeholders to learn about cargo bikes, but it is yet to be seen what the impact of this collaboration and networking will be.

The formulation of policy goals by administrators is needed. The variety or lack of specific goals beyond the ZEZ transition was noticeable, although some cities have already begun setting goals. This lack of data and understanding demonstrates the challenge that municipalities have to formulate goals and implementation programs. To do this municipalities need to better understand the logistics in their city. It has been recommended by some actors that the 'physical internet' should be leveraged by administrators, particularly municipalities. This involves the thorough investigation of all types of freight and stakeholders involved in a city in order to create an Urban freight strategy (Starr, 2020).

One such example is the Freight transport implementation program 2023-2026 from the Municipality of Utrecht, which stood apart from the freight strategies of similar sized Dutch cities. On top of targeting bundling, improving infrastructure and smart technology, this implementation program aims for a 10% modal shift away from vans. This will be achieved by using LEV's, cargo bikes and boats. In the interview with Utrecht, they stated that they have 30 million delivery movements per year, so that could be 3 to 4.5 million movements being replaced. However, the municipality is currently unsure if this 10% shift will be calculated in number of trips or weight of goods because they currently lack data, so are uncertain about what is realistic and first need to improve their understanding. One method administration could collect data could be through the granting of particular exemptions to cargo bike users in exchange for data, which is an approach that will be trialed by the Municipality of Utrecht. This demonstrates how administrators can use leverage to access data.

The successful promotion of utility cycling in the Netherlands has come from an integrated approach, in which cycling has offered a cross department solution. Similar needs to be achieved for cargo bikes, with a focus beyond urban freight distribution goals, but also city mobility plans which infrequently mention cargo bikes. Interviewees suggested that administrators are not aware of the benefits provided by cargo bikes. Beyond sustainability, there is a lack of attention regarding the role of LEV's in order to achieve the social goals (van Duin, Ploos van Amstel, & Quak, 2022). This could include benefits that cargo bikes offer for creating inclusive and liveable streets, improve public space use and increase employment (Narayanan & Antoniou, 2022). However, there is currently a lack of positive perception around cargo bikes and a lack of information of what benefits they achieve (Narayanan & Antoniou, 2022).

Greater efforts should be made to raise the benefits of cargo bikes to different departments in administrators, so that cargo bikes can be linked to a broader and more diverse range of policy goals beyond urban freight distribution and transport. One such solution to address this can come from the creation of cross departmental roles, which could exist for key areas, such as logistics and cargo bikes.

Problem 4: Inconsistent administrations has led to exemptions and confusion

The creation of goals is important, but work cannot stop there because they can only be established with a clear political agenda (Morel, Balma, Berdena, & van Amstel, 2019). This hasn't always been the case for Dutch Municipalities as the fourth problem again comes from orgware components, and highlights the importance of consistent administration to implement ZEZ's.

Differences between goals and implementation is highlighted by the fact that only 29 cities have so far announced ZEZ, despite the original climate agreement aiming for 30 cities. On top of this, just over half will commence from 2025. It was highlighted by several interviewees that cities that have recently experienced frequent changes to their government had vaguer, smaller and less impactful ZEZ compared to those Dutch cities that had stable local governments. Whilst it is important to recognize that different reasons go into the decisions regarding the size of a ZEZ, it is also important to acknowledge that different sizes will lead to different impacts in different cities across the Netherlands. This thus means that the importance of 'environment zones' as a hardware factor will vary in different geographic areas. This will cause confusion and decreases clarity for users, which some interviewees stated could explain why SME's have been slow to change, as they will wait and see what happens. Some actors predict exemptions will be needed for users of a certain composition again reducing the impact of a ZEZ.

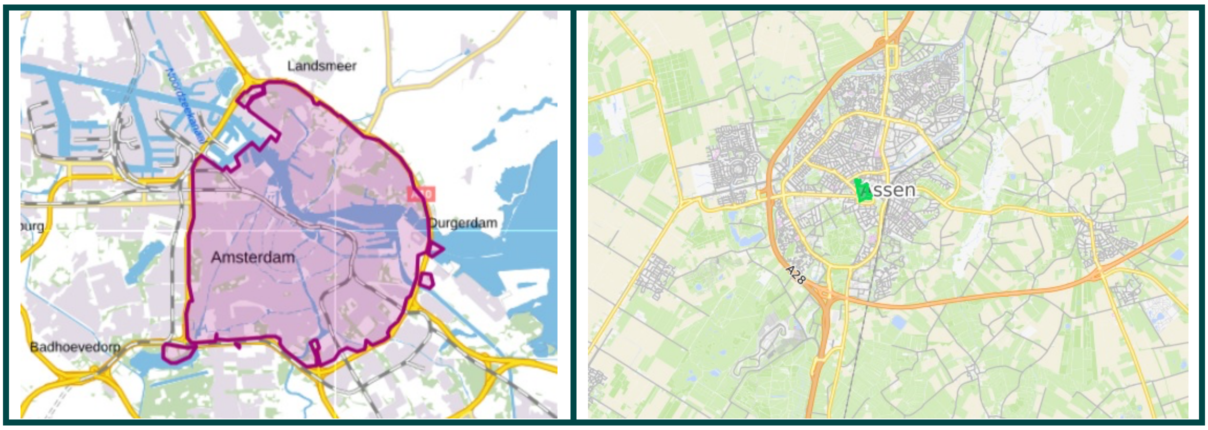

Figure 13: Example of different size zones between Amsterdam and Assen (Urban Access Regulations in Europe, n.d.)

Opportunity 4: Awareness of effective Environmental zones should be raised

Interviewees frequently mentioned the positive influence with environmental zones and indeed it was the second highest mentioned strength. However, it was highlighted that users still lack awareness of their existence, meaning opportunities exist in raising their profile.

Environmental zones clearly signal that municipalities are serious and committed to influencing the distribution of urban freight. Indeed, some interviewees highlighted that low emission zones (restrict private polluting vehicles) were more important than ZEZ's for SME's, as they were already effective in limiting their use of private vehicles to deliver in the city center. Indeed, similar effects have been seen in other countries, as more than 95% of vehicles were compliant with London ultra-low emission zones (Topham, 2023). Parking restrictions also aid users' decisions to shift to cargo bike use, as restrictions forces vans to park further away from destinations, meaning more time is spent per delivery by finding a spot and then walking to and from van to destination.

This helps build the case that ZEZ will be effective, if all users are fully aware of them and the implications. Interviewees were confident that once they are implemented, change will occur as it will force users to change behavior, and help force change of composition of users that was previously highlighted as a hindrance.

With low reference to software factors there is a need for greater marketing campaigns for users that are not aware of ZEZ's. Particular focus should be on the variations seen across cities, such as on location and size of zones, on exemptions, and on implementation dates. Hopefully in time these become more unified, which would again signal commitment to change and may persuade potential users who don't want to make an investment yet.

Problem 5: Lack of network facilities

If benefits are known, policy goals are formulated and measures implemented the urban environment needs to provide facilities to the growing demand and change in logistics behavior. However, the current lack of network facilities can hinder the satisfaction of cargo bikes as a solution and thus limit the potential being reached.

Whilst many hardware factors currently benefit users looking to utilize cargo bikes, this hasn't resulted from cargo bike specific policy but as an indirect effect of the promotion of building cycling infrastructure for citizens. No more is this highlighted by the lack of network facilities suitable for cargo bikes in urban areas. This includes a lack of suitable parking and charging for cargo bikes, as well as loading areas and sorting hubs. This can impact safety for cargo bike riders and other road users, including cyclists and pedestrians.

Due to limited public space in the Netherlands, safe parking space indoors and outdoors is hard to find for all modalities including bicycles. This is particularly relevant for cargo bike users whose bikes are more expensive compared to the average bicycle. It was noted earlier that cities lack an understanding of cargo bike users' behaviors and movements (Liu, Nello-Deakin, te Brömmelstroet, & Yamamoto, 2020). If behaviors are better understood then public space can be designed more efficiently, which should be able to relive space for other competing activities (Kloostra & Godoy, 2024). If this is not understood then users will be reluctant to switch to cargo bikes due to a lack of space to safely charge and park cargo bikes, as well as lack of facilities for cargo bike riders.

Opportunity 5: Improve cargo bike facilities and promote hubs

Hubs offer facilities to the potential cargo bike users mentioned previously; fresh produce, express deliveries & parcels, retail, facility & service and construction. These would make cargo bikes a more effective solution.

Providing space for storage and receiving shipments of goods, city hubs have traditionally allowed stores located in city centers to store the majority of their stock elsewhere. This was financially driven, as due to high prices per square meter in the city centers, shops wanted to utilize as much space as possible for sales (Ploos van Amstel W. , et al., 2018). With ZEZ coming into play, the historic use of vans and lorries to transport these goods from hubs to the city center will need to change to different vehicles. With this, more variety in hub size and locations closer to the city center and neighborhoods could be required (Figure 14) in order to make cargo bikes more cost effective (Ploos van Amstel W. , et al., 2021). However as mentioned there is a lack of these hubs due to a lack of space in city centers and expensive real estate (van Duin, Ploos van Amstel, & Quak, 2022). A temporary solution can be the use of mobile micro hubs, such as a truck or trailer that can be loaded with cargo bikes or larger mobile access hubs (Faugère & Montreuil, 2020). Beyond space concerns, neighbors of the hubs may have concerns of nuisance. This was seen with flash stores during and after the covid pandemic, which were set up in neighborhoods to delivery groceries quickly to residents, but after several complaints about noise they were restricted and shut down, with the business models of flash delivery firms also suffering in competitiveness since.

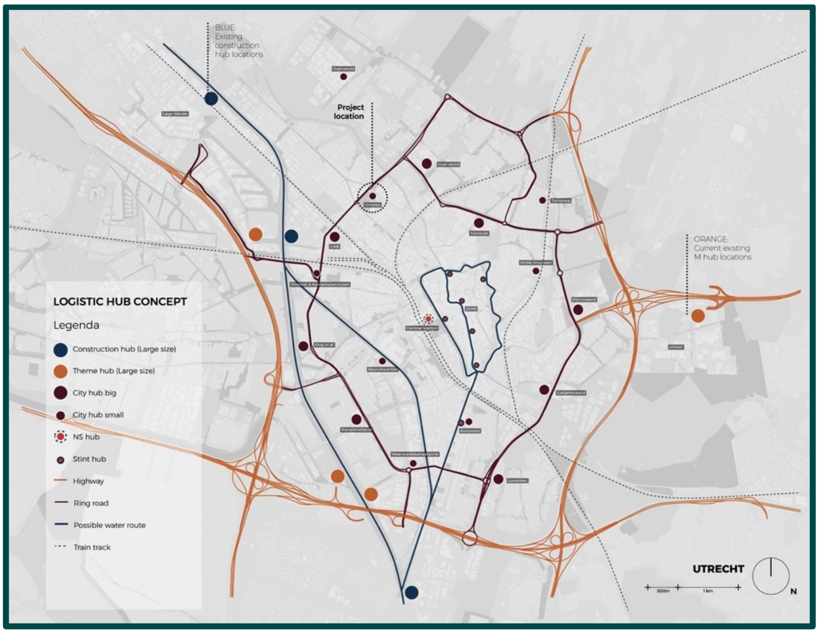

Figure 14: Example of different sized hubs in urban environment (van Bakel, 2022).

Larger users are likely to own their own hub privately, such as Cycloon but they can also be formed as part of a co-operative model with different actors involved, including some public administrative support (Starr, 2020). This integrated approach has already been seen in the Netherlands with several businesses that use the cargo bike including Fietskoeriers.nl, City Hub, Simply Mile and Binnenstadservice (Starr, 2020). This model could be promoted and supported by administrators to get over financial concerns. However, an interviewee from a city government stated that it was important for administrators not to create competition with the private sector. However, the national government has also explored options to support and develop a network of hubs (van Amstel, Het Rijk wil netwerk van landelijke logistieke hubs ontwikkelen, 2024). Governance structures are critical to the success of a hub (Starr, 2020), so with the identified fragmented governance currently in the sector, it is again an opportunity and necessary need to clearly define roles in relation to the creation and running of distribution hubs in city centres. This is because they require more complicated planning and clarity in operations in order to create efficiencies for different potential users of cargo bikes (Kaspi, Raviv, & Ulmer, 2022).

Besides sorting packages and reloading cargo bikes, these hubs can also provide additional network facilities to riders of cargo bikes. This includes as space to wash and change, have lunch and have a break with colleagues which would aid the satisfaction of a cargo bike. It also offers space to store cargo bikes and charge them. Beyond the benefits of users, other facilities can also develop from the hubs including delivery lockers, and space for local businesses by providing shop fronts.

Another opportunity provided by the hubs is the ability to combine with other transport such as EV vans and boats. Opportunities for living labs are being provided, as the city of Utrecht will look to utilize its canal system and experiment with combining cargo bikes with boats. This could see pre-loaded cargo bikes being brought into the city on the boat, or with cargo bikes remaining in the city and picking up goods that are brought in by a boat. The cargo bike can also be combined with the van, as seen by Mobian and Dockr's partnership to create space to park and ride in Amsterdam. This allows facility & service organizations to use cargo bikes, by parking their van outside the city center, loading their equipment into the cargo bike and cycling into the ZEZ. Hubs can also include bike sharing schemes, which could be attractive for SME's and reduces barriers to try out cargo bike (Kong & Pojani, 2022).

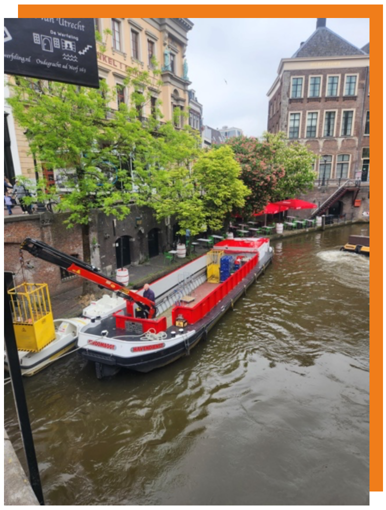

Figure 15: Boats being used in Utrecht logistics (Reddit, n.d.)

Beyond hubs, other network facilities can also be improved. This includes the need for specific cargo bike parking, that that is wide enough (225 cm) according to CROW bike parking guidelines (CROW, 2023). It also needs to be designed for different behaviors, such as short term drop off for a couple of minutes and long term secure parking for utility users. These differences in user behavior and needs were not understood by administration as mentioned above, but this problem is beginning to be addressed in research. This includes that conducted by ARUP, in collaboration with the city of Rotterdam and cargo bike specialist Jos Sluijsmans, who were tasked by Tour de Force, to create space in the street landscape for the rapidly growing fleet of cargo bikes. The results categorized different behaviors and needs of cargo bike users, which will help Dutch cities design spaces that account for different loading, parking, charging and trip behaviors (Kloostra & Godoy, 2024).

This shows that there is an opportunity for cities to better understand how to design cities for users of their public space. Creating clear spaces for cargo bike would help to reduce conflict with people and improve safety, which is the final and perhaps largest problem identified in this report.

Problem 6: Network safety and cargo bike uncertainty

Despite hardware being the most common strength of the currently policy environment, the most mentioned hindrance for hardware factors was 'Network safety'. This is important because as well as network safety being a hardware factor, problems identified in other factors are contributing to negative perceptions of the cargo bike and negative perceptions of safety. All of which can be said to cause delay in cargo bikes being fully utilized and promoted, which has created uncertainty.

Compared to a bicycle, the greater mass of a cargo bike, due to greater weight from carrying goods as well as electric assisted speeds, in combination with wider bike means that the people perceive that the level of safety will decreases with an increase in their use

(Meerstra, 2021). This comes from concerns about increased risks of a conflict, collision and injury to people. This perspective was supplemented by opinions in interviews. Whether the perceived level of safety aligns with the actual safety risk is uncertain. As with other data mentioned earlier, general cycling and cargo bike accident data is currently still hard to access in sufficient quantities. This means that comparing impact on safety of modal shift from vans to cargo bikes and impact on other road users remains inconclusive. However, the reality may be irrelevant, as literature suggests it is the perceived level of safety that is important and this is currently viewed negatively (Narayanan & Antoniou, 2022).

With the number of cargo bikes being used in urban areas expected to increase, utility cycling actors and administrators have concerns about the inadequacy of the current network quality. This results from bike paths being too narrow and congested with vehicles moving at higher speeds. In 2022 the recommended minimum width for cycle lanes in the Netherlands was increased from 200 cm to 230 cm to create safer bike lanes, due to more cycles on the lanes as well as the appearance of wider and heavier cargo bikes. This aims to reduce the likelihood of dangerous encounters. However, it was estimated in 2022 that 60% of urban cycling lanes do not comply with this standard, thus the greatest safety gains can be made on the narrowest bicycle paths (Talens, 2022; Talens, CROW Updates Bike Lane Width Recommendations, 2023). With network quality not being deemed suitable and with safety being the first priority of mobility in the Netherlands, this could help explain the lack of unified and clear leadership from cycling knowledge institutes in pushing for greater cargo bike use in logistics.

The safety concern has impacted the finalization of the LEV framework which includes cargo bikes. The delay of this framework could in part be down to debate regarding what spaces cargo bikes are allowed to use in urban areas. A discussion is occurring in the Netherlands about whether cargo bikes can use bike paths; everywhere, in certain areas or not at all. A similar discussion occurred previously with mopeds, and sees their ability to use bike infrastructure vary. A disagreement exists between actors, with certain cities wanting them to go on the roads with regular traffic, whilst rural areas would prefer them to be restricted to bike paths so not to disrupt road traffic. A decision will have impact on safety for all cyclists, whether on a cargo bike or not. If cargo bikes are pushed off the bicycle network and onto regular roads then this will change the current problems and opportunities for all actors. Delivery benefits cargo bike users gain from established cycling hardware such as network quantity and speed will disappear, but some cities argue that they have low congestion and so delays would not be expected. This decision would also see safety elements decrease for riders of cargo bikes, which could make it harder to attract riders. Safety for other cyclists may increase, but as stated previously conclusive data is still lacking. When the LEV framework is published this would clarify a lot of unknowns for potential users, such as whether they need riders to have licenses, insurance, helmets and what routes can be taken through urban areas. This would help identify clearly the positives and negatives of cargo bikes in relation to alternatives.

On top of the delay, cargo bikes being seen as one of many LEV's has also been described as a negative by interviewees as it adds to the confusion for potential users. This in combination to the delay of the LEV framework is delaying investment and decreasing the legitimacy of the cargo bike as a solution. Only once safety implications are fully understood and the framework is published, will there be more certainty regarding if and what cargo bike makes most financial and logistical sense for users. Until that point it is understandable that users delay investing.

Opportunity 6: Improve network quality and rider training

Beyond the finalization of the LEV framework which would add clarity, bringing network safety in line with the requirements of cargo bikes should be a priority.

Minimum cycling width of 230 mm for a single cycling lane should be implemented where possible in urban areas. Where space restrictions exist, then mixing vehicle and cycling traffic on a cycling street with speed limits of 20 km/h should be implemented where safety is not impacted. Opportunities to improve network quality also exist, in order to accommodate cargo bike needs and help reduce damaging heavy bikes and their goods. This could be done by maintaining the smooth surface of cycling infrastructure in places where safety doesn't demand pavers. This necessity offers plenty of research opportunity to identify different behaviors and uses of cargo bike in different cities. Inspiration could also be sought from abroad, as other countries have also seen an increase in their use. This includes Germany who have a dedicated cargo bike sign and this approach will also be introduced in Belgium (Janssen, 2024).

In addition to hardware factors, software factors can also be used to increase safety. The low reference to software factors (Figure 16) again highlights the lack of thought to education of adults and children, as well as marketing regarding cargo bikes and safety. Training for cargo bike riders is needed as the usability of cargo bike is different to a regular bike. Actors in the value chain and users already provide some training and education, such as a video to riders and users. How to use cargo bikes can aid usability and increase safety to all road users. Reference to the composition of workforce highlighted this was particularly relevant for riders who did not grow up in the Netherlands and so may not be used to riding a regular bike, let alone a cargo bike.

Actors in the value chain also highlighted in interviews that rider's behavior has direct result on the durability of cargo bike and thus impacts the total cost of ownership. Thus, training can also increase durability and decrease operational costs for users in the long term as bikes become less damaged. However not all users can afford training as its too expensive for smaller users, again which is a barrier to using cargo bikes as a solution in ZEZ's.

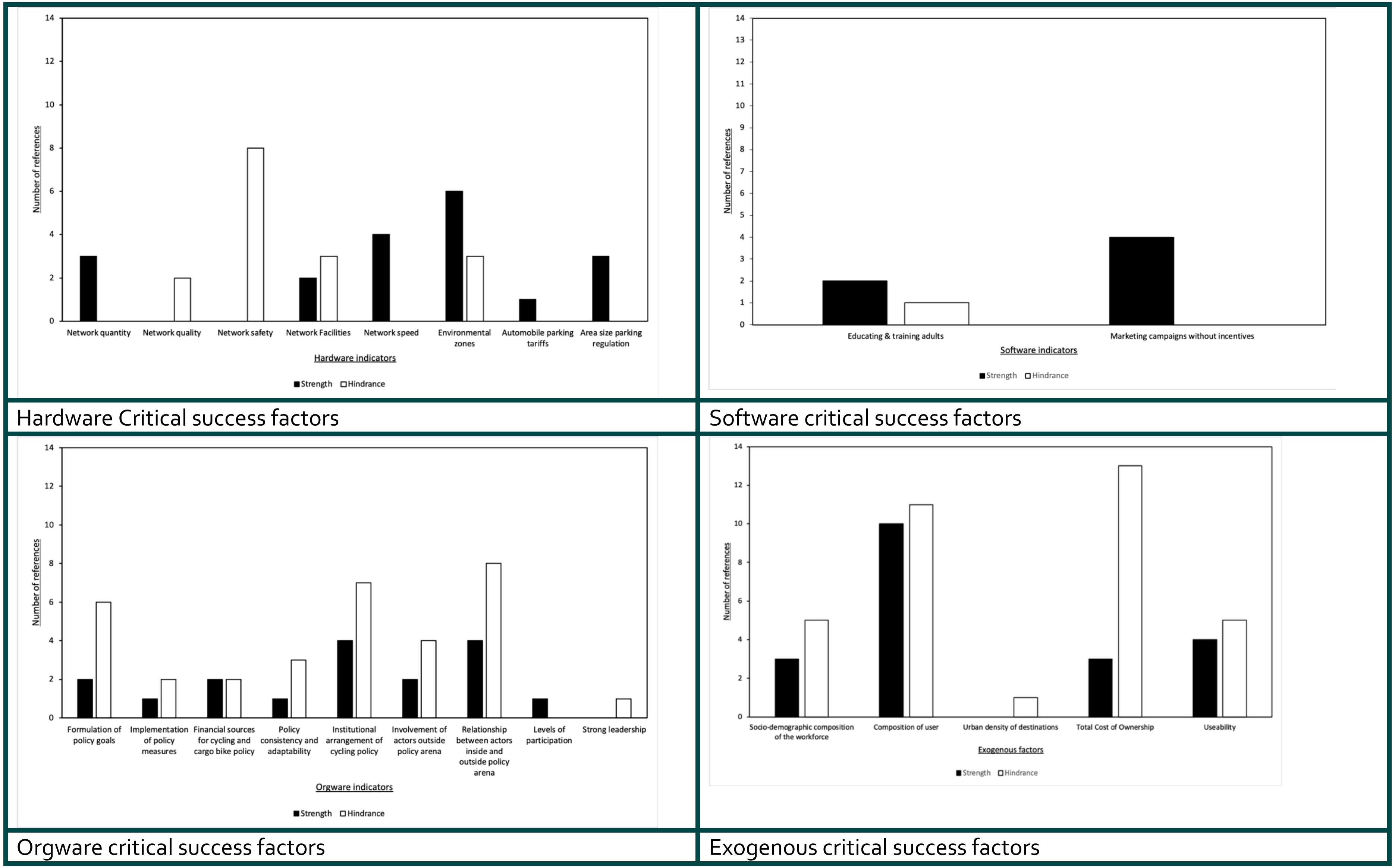

Figure 16: Reference frequency of individual critical success factors.

Conclusion

The Dutch Zero Emission Zones in logistics aim to transition towards zero emission mobility in city centers by restricting access to polluting vehicles. The possibilities for cargo bikes to play a role in this transition was not fully understood by the Dutch Cycling Embassy, and so this report looked to answer the research question *What problems and opportunities in policy and technology do actors in Dutch urban freight distribution experience when looking to utilize cargo bikes in zero emission zones?*

Table 9: Overview of identified problems and opportunities.

Problem			Opportunity
1.	Uncertain costs meant cargo bike stayed a niche technology	1.	Benefits and knowledge can be shared as market is forming
2.	Embedded logistics processes difficult to change	2.	Administrators should push for more than technological fix
3.	Fragmented governance decreased knowledge sharing and collaboration	3.	Establish integrated understanding of cargo bikes within administrators
4.	Inconsistent administration has led to exemptions and confusion	4.	Awareness of effective environmental zones should be raised
5.	Lack of network facilities	5.	Improve cargo bike facilities and promote hubs
6.	Network safety and uncertainty	6.	Improve network quality and rider training

The identification of six problems in relation to policy and technology can help explain the low modal share of cargo bikes in urban freight distribution and reveal doubts around the perceptions of safety (Table 9. However, opportunities also exist for improving the situation in the coming years due to a growing level of satisfaction for the cargo bike to provide a solution in zero emission zones. This satisfaction was seen in stakeholders that are intrinsically motivated and had the resources to trial cargo bikes. It is felt that they will be ready for zero emission zones. They benefit from hardware factors, such as the cycling network quantity and speed combining with high density destinations to offer customers fast and reliable delivery. With more and more users utilizing the cargo bike reliability problems are being found quicker, models are being improved and more success stories are being discovered and shared, to increase their use.

Problems for cargo bike stem from limitations in its usability and difficulty for users to change embedded processes. This can be overcome by using a mixed vehicle fleet including cargo bikes. With mixed fleets and a greater variety of vehicles on cycle paths to be expected in the future, the fact that only cargo bikes were the focus of the research can be considered a weakness of the research's results and may have restricted findings. With cargo bikes being combined with the as of yet unpublished LEV framework, it remains to be seen what distinctions between cargo bikes and LEV's are important for users and administration and what the future relevance of focusing only on cargo bikes as a logistic solution will be to them.

Clarity, conviction and leadership is needed from administration to show users that they are committed to the path to zero emission mobility. Problems related to orgware factors and administration indicate that this is not currently the case. Despite the Netherlands showing leadership by being one of the first countries looking to propose zero emission zones for logistics, concerns with the implementation exist due to a fragmented governance and inconsistent administration. Implementation could be further compounded by the new national government's exploration for delay. The orgware problems can be attributed to the fact that administrators deliberately left the transition to zero emissions mobility to the market because urban freight distribution is a commercial sector. However, to achieve the transition users need to change more than the vehicle they use and implementing only a ZEZ may struggle to achieve that. To achieve a transition greater institutional influence is required, along with the need for roles and relationships to be more clearly defined in order to increase knowledge sharing and collaboration. This is particularly important, as administration knowledge on urban freight distribution and about cargo bikes as a positive solution was mixed, as seen by their low understanding and presence of network facilities needed by cargo bike users.

Closer links between the knowledge institutions from the cycling sector and the urban freight distribution sector should be forged with administration actors, in order to share the benefits of cargo bikes to cities such as decreasing emissions, congestion, noise, and public space use. It was positive to see such links being created during this research and already led to a number of publications referenced in this report. Integrating the use of cargo bikes in ZEZ into broader city plans regarding mobility, the creation of livable cities and improvement of employment rights, would improve opportunities for the cargo bike. Integration is particularly important knowing that hubs are required which will add to the conflict of public space. What highlighted the difficulties in cross sector collaboration and data sharing, was the fact that this report only managed to interview one user directly, despite multiple attempts being made to different users. This is a limitation of the research, as although interviewees provided opinions that users had (which was particularly relevant to actors in the value chain who work closely with users), this would have introduced bias into the mentioned benefits and outcomes.

The perceptions of safety decreasing due to cargo bikes is a concern that needs addressing. Whilst conflicting opinions existed, trying to access clear data proved to be challenging and research on the topic is unquestionably required. It is also important that hardware factors such as network quality are raised to be in line with future use in order to maintain its benefits for all cyclists, users and people. A lack of reference to software factors matched findings in cycling literature that it is hard to identify impact of these. However, interviewed stakeholders highlighted that training for cargo bike riders can improve safety and reduce the cost of ownership. This offers tangible opportunities, such as the development of a training standard and courses which not all users may be able to afford.

Developing the opportunities to improve safety will help shift the negative perceptions regarding cargo bikes that surprising come from actors that look to promote utility cycling. You would expect to see these groups, such as local administration and knowledge institutes, to be pro cargo bike in urban freight distribution, but these actors rightly prioritize road safety of cyclists and citizens. The existence of doubt regarding cargo bikes impact on road safety in combination with the lack of awareness of cargo bikes benefits and the unfamiliarity to the commercial urban freight distribution sector, has seen many actors reluctant to fully enter the debate. Forging closer links between cycling and urban freight knowledge institutions should help to address this.

With implementation of zero emission zones for logistics and the publication of the Dutch Framework for Light Electric Vehicles both approaching, greater clarity regarding cargo bikes in urban freight distribution should be known. This should provide greater assurances to policymakers, and hopefully embolden them to create ambitions not regarding vehicles but instead ambitions that start with what cities they want to create for people. From this, decisions regarding how vehicles can help achieve this will follow, and this report has found that plenty of opportunities exist for the cargo bike to provide a positive solution to users in zero emission zones, to cities and to people.

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Appendix

Full list of Dutch cities with zero emission zones

1. Almere	1/1/2028
2. Alphen aan den Rijn	1/7/2026
3. Amersfoort	1/1/2025
4. Amsterdam	1/1/2025
5. Apeldoorn	1/1/2025
6. Arnhem	1/6/2026
7. Assen	1/1/2025
8. Delft	1/1/2025
9. Den Haag	1/1/2025
10. Deventer	1/1/2025
11. Dordrecht	1/1/2026
12. Ede	1/1/2026
13. Eindhoven	1/12025
14. Enschede	1/7/2025
15. Gouda	1/1/2025
16. Groningen	1/4/2025
17. Haarlem	1/1/2025
18. Hilversum	1/1/2027
19. 's Hertogenbosch	1/3/2025
20. Leiden	1/1/2025
21. Maastricht	1/1/2025
22. Nijmegen	1/1/2025
23. Rotterdam	1/1/2025
24. Schiphol	1/1/2026
25. Tilburg	1/1/2025
26. Utrecht	1/1/2025
27. Venlo	1/1/2027
28. Zaanstad	1/1/2026
29. Zwolle	1/1/2025