Implementing hyperconnectivity characteristics in parcel last mile delivery services

Dominant stakeholder perspectives revealed using Q-methodology

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IMPLEMENTING HYPERCONNECTIVITY CHARACTERISTICS IN PARCEL LAST MILE DELIVERY SERVICES

DOMINANT STAKEHOLDER PERSPECTIVES REVEALED USING Q-METHODOLOGY

by

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Preface

This research was carried out in partial fulfilment for the degree of Master of Science in Transport, Infrastructure & Logistics at Delft University of Technology. This report is the end result of research carried out over a nine-month period at the university. The research covers the field of hyperconnectivity and last mile delivery in the Netherlands.

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Soli Deo gloria.

Summary

This research aims to identify the dominant perspectives of stakeholder groups on the implementation of hyperconnectivity (HC) characteristics in last mile delivery (LMD) services. Finding the dominant perspectives also reveals the drivers and barriers that stakeholder groups experience to implement HC in LMD services. In addition, this research provides recommendations and action points for the involved stakeholders on which HC aspects and LMD service types to focus on.

Background

The e-commerce industry has been growing consistently and experienced an additional boost during the COVID-19 pandemic (Barthel et al. 2023). As a result, the logistics industry that facilitates this development is growing in volume of packaged goods transported to meet demand (Mohammad et al. 2023). The last mile is considered the least efficient and sustainable part of the entire supply chain (Bosona 2020). In the Netherlands, active regulatory measures have been taken to reduce greenhouse gas (GHG) emissions in select city centres starting 2025 (Rijksoverheid 2025).

The Physical Internet (PI) is a vision first described by Montreuil (2011) and is inspired by the Digital Internet. Van Duin, Van Son, et al. (2022) defines the most important PI characteristics as 1) open system (data and asset sharing) and 2) standardisation (standardised collaboration protocols and modular containers). HC is an emerging concept, enabled by and built on the possibilities of PI. It allows for large-scale collaboration through shared assets, information exchange, standardised protocols, and flow alignment. A hyperconnected LMD system could lead to more optimised routing decisions through processes such as consolidation with fewer vehicle kilometres and, as a result, to more sustainable operations. Many studies have found that stakeholder groups agree to adopt measures to improve LMD sustainability; however, there is often no consensus on the specific measures to be adopted (Gonzalez et al. 2023; Maxner et al. 2022; Tolentino-Zondervan et al. 2021).

Objective and scope

Current research on the drivers and barriers to successful implementation of HC in and between LMD services is still limited. There are studies that have explored the feasibility of novel concepts in LMD, but they do not fully capture the views between multiple services from different stakeholder perspectives. Therefore, it is of relevant interest to explore HC in more detail within the context of state-of-the-art LMD methods that are currently applied and under development, as well as the relevant stakeholder perspectives towards HC. The scope of this research is the LMD system in The Netherlands.

Research gap - Implementing HC characteristics in last mile delivery services has the potential to improve operational and economic efficiency, as well as sustainability, but how and which services are deemed promising among stakeholders is not yet known.

Methodology

A literature study was performed on the fundamental concepts of LMD, PI and HC, to establish the theoretical foundation of this research. Taking into account the nature of this research and comparing it with previous studies, the method to identify the dominant stakeholder perspectives in this study is the Q-methodology. It is a mixed qualitative-quantitative method that aims to reveal different perspectives between groups on a certain topic (Van Exel and De Graaf 2005). Participants were presented with a set of statements regarding HC characteristics in LMD called the Q-set. The respondents, called the P-set, rank-ordered the statements from disagree to agree from their point of view. The completed ranking of each participant is called the Q-sort. The Q-sorts were then subjected to a factor analysis which grouped the participant results into a number of factors, based on the similarity of their rankings. Through qualitative analysis of the factors, the dominant perspectives for each factor were extracted. By analysing the additional comments provided by the participants, the underlying drivers and barriers were identified.

Results

Through quantitative analysis and using existing guidelines to determine the number of factors, a 3-factor solution was selected for the results of this study. By performing a qualitative analysis on each factor, three corresponding perspectives were formulated.

- **Perspective 1: *White label* delivery services and *parcel lockers* are suitable solutions to be hyperconnected, however, in general, *lack of trust* and *fear of losing a competitive market position* are still barriers.**

- **Perspective 2: *Service connectivity* and *data exchange* are necessary to develop efficient and sustainable last mile delivery. However, the industry still needs further *digitalisation* and convincing of its *economic benefits*.**

- **Perspective 3: *Local authorities* must take the lead in zero-emission city logistics by *setting sustainability criteria* for purchasing and tenders. The *collaboration of services* could increase the utilisation rate of assets; however, it will be a *challenge to involve large LSPs*.**

The following similarities and differences were identified between the perspectives, visualised in Figure 1. The green squares include similarities and differences in positive opinions, whereas the orange squares map similarities and differences in negative opinions. The similarities between perspectives are extracted mainly from general statements, while the differences are more related to specific service and collaboration concepts, i.e., how to improve the LMD landscape. All perspectives see the benefits of HC to minimise vehicle movements in cities, but different ways are considered promising. Perspective 1 emphasises the importance for LSPs to look beyond fleet electrification and share assets. Perspective 2 is considerably open towards more services and collaboration methods, while perspective 3 includes more opinions related to governance.

In terms of negative opinions, most concerns about HC are shared between at least two perspectives. Fear of losing a competitive market position by sharing information is a shared concern among all perspectives. As mentioned earlier in this section, drone delivery services in cities are not considered feasible by all parties. Perspectives 1 and 3 express scepticism towards crowdshipping due to many external factors that could influence its potential benefit. Another shared area of concern is the economic benefits that hamper asset and information sharing, although the perspectives highlight different aspects. Perspective 2 is of the opinion that more economic incentive is required to get companies on board, while perspective 3 states that HC is not beneficial for large and established LSPs. Trust is a perceived issue in perspectives 1 and 3, while digital readiness is a prevalent concern in perspectives 2 and 3.

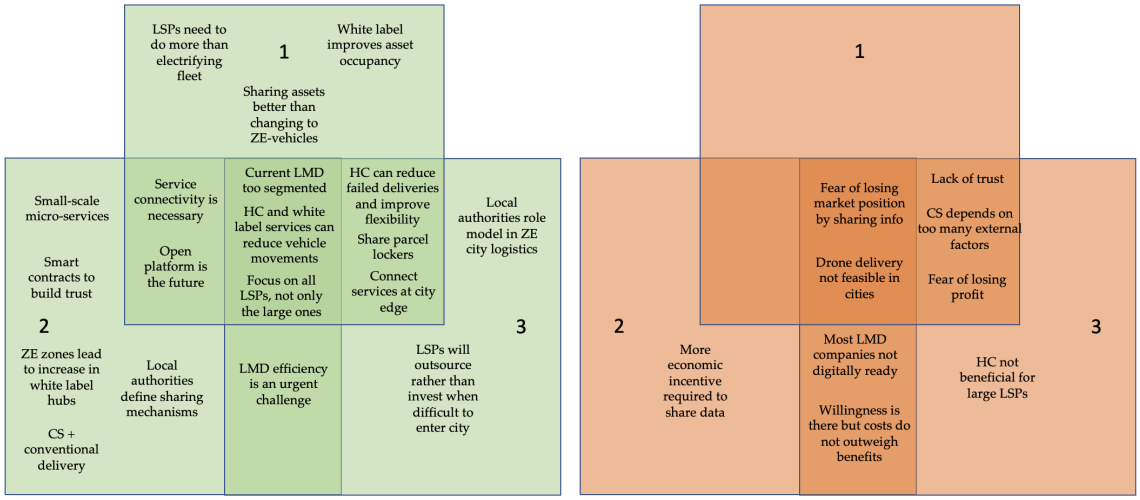

Figure 1: Similarities and differences in positive and negative opinions between all perspectives

To gain a better understanding of similarities and differences, comments on the extreme statements made by the participants can be analysed. In doing so, the implied drivers and barriers can be identified. The result of this analysis is depicted in Figure 2, where the drivers and barriers are highlighted, including the relations between them. It also indicates from which perspective these features were found. It can be observed that a barrier from one perspective can often be linked to a driver from another perspective. The following observation shows that there are still challenges and barriers to overcome when it comes to applying HC aspects to last-mile methods. However, each barrier has an identified driver that serves as a counterpart. There are also drivers that could tackle more than one barrier.

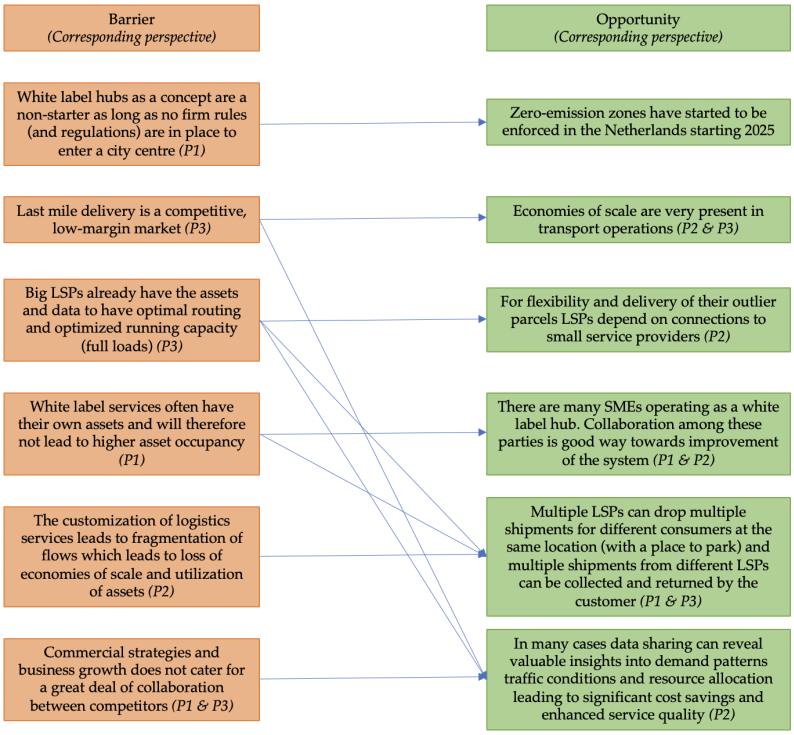

Figure 2: Named barriers and drivers to hyperconnectivity and last-mile delivery methods with their corresponding perspectives and opportunities

Conclusion

What can be noted from all perspectives, is that there is a general recognition that the current state of last mile delivery is too segmented, and that connecting services can be a solution. The most promising LMD concepts for connecting are white-label delivery services and parcel lockers. Perceived barriers to doing so include fear of losing a competitive market position by sharing information, lack of economic incentive, and concerns that the distribution of costs and benefits among parties will be uneven. These barriers are related to the IT and Collaboration characteristics of HC. (Local) authorities have the opportunity to lower these barriers by initiating collaboration with multiple stakeholder groups through public-private initiatives. With recently enforced regulations such as ZES, and emerging openness toward certain asset and information sharing concepts among LSPs, stakeholders in the LMD system can work together to achieve more sustainable last mile logistics.

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1 Introduction

1.1 Background

The e-commerce industry has been growing consistently and experienced an additional boost during the COVID-19 pandemic (Barthel et al. 2023). As a result, the logistics industry that facilitates this trend is growing in volume of packaged goods transported to meet demand (Mohammad et al. 2023). Other driving forces for this growth include globalisation, economic development, population growth, and urbanisation (Bosona 2020). As the industry expands, so does the need for efficiency and sustainability in the transportation of these goods by logistics service providers (LSPs).

The current logistics system has been considered unsustainable from an economic, environmental, and social point of view (Montreuil 2011). Packages often take up unnecessary amounts of space compared to the product itself, trucks and containers can be half empty upon departure from the depot, and some vehicles are solely used for pick-ups or deliveries. The industry is considered conservative, which means that data and assets are typically not shared among actors out of fear of competition (Mervis 2014).

Specifically, the last mile delivery (LMD) process is considered the least efficient and sustainable of the entire supply chain (Bosona 2020). As all industries are driven to reinvent themselves for the sake of sustainability, so does the call for the field of logistics. In The Netherlands, active regulatory measures have been taken to reduce greenhouse gas (GHG) emissions in select city centres starting 2025 (Rijksoverheid 2025).

The Physical Internet (PI) is a vision first described by Montreuil (2011) and is inspired by the Digital Internet. It envisions an open global logistics system built on physical, digital and operational connectivity (Montreuil et al. 2012). Through the sharing of data and assets, flow optimisation can be achieved (Van Duin, Van Son, et al. 2022). Van Duin, Van Son, et al. (2022) defines the most important PI characteristics as 1) open system (data and asset sharing) and 2) standardisation (standardised collaboration protocols and modular containers).

Hyperconnectivity (HC) is an emerging concept, enabled by and built further on the PI concept. It allows for large-scale collaboration through shared assets, information exchange, standardised protocols, and flow alignment. These characteristics lower the threshold for individual companies to collaborate in their delivery operations. However, there are many factors and several stakeholder groups that can stimulate or hamper development and implementation. These novel concepts challenge stakeholders to engage in different ways. Communities of stakeholders need to establish a foundation for trustworthy collaboration. They must have confidence that a collaborative system is secure, fair, and reliable (PILL 2024). With the growth of e-commerce and the current standard of omni-channel retailing, stakeholder decision behaviour has changed and is constantly changing with new innovations in LMD services (M. Cebeci et al. 2023). Many studies have found that stakeholder groups agree to adopt measures to improve LMD sustainability; however, there is often no consensus on the specific measures to be adopted (Gonzalez et al. 2023; Maxner et al. 2022; Tolentino-Zondervan et al. 2021).

1.2 Problem description

Current research on the drivers and barriers to successful implementation of HC in and between LMD services is still limited. Extensive research has been carried out on the general concept of PI in the context of logistics (Matusiewicz 2020; Montreuil 2011; Montreuil et al. 2012; Van Duin, Van Son, et al. 2022). Other studies have focused on one novel concept in LMD and how they are viewed and utilised (M. S. Cebeci et al. 2023; Faugere and Montreuil 2016; Van Duin, Slabbekoorn, et al. 2018). Pilot initiatives have been set up within city logistics to combine goods from different LSPs, as well as IT solutions (Frindik and Prudon 2017; Van Rooijen and Hans Quak 2010). These are important building blocks for exploring the feasibility of these methods, but do not entirely capture the views between multiple services from different stakeholder perspectives. Therefore, it is of relevant interest to explore HC in more detail within the context of state-of-the-art LMD methods that are currently applied and under development, as well as the relevant stakeholder perspectives towards HC.

Studies show that there are different methods to explore the perspectives of stakeholders, e.g., interviewing, distributing a survey that collects qualitative or quantitative data (M. S. Cebeci et al. 2023; Gonzalez et al. 2023; Van Duin, Slabbekoorn, et al. 2018. Taking into account the diverging views and many actors within the logistics industry, it is important to select a fitting methodology to extract the different perspectives.

Research gap - Implementing HC characteristics in last mile delivery services has the potential to improve operational and economic efficiency as well as sustainability, but how and which services are deemed promising among stakeholders is not yet known.

1.3 Research questions

The goal of this research is to identify the important drivers and barriers within stakeholder groups for the implementation of HC in LMD services. This results in the following main research question:

What are drivers and barriers among stakeholder groups for the implementation of hyperconnectivity aspects in parcel last mile delivery services?

The main question touches on multiple aspects that need to be addressed separately. The topic of HC is a fast-evolving concept and is expanding into new industries. Therefore, it is essential to delve into existing literature to reveal the definitions of HC. The culmination of findings will form the basis to define HC used in this research. Another aspect to explore is which stakeholder groups are part of the last mile delivery process. Furthermore, it is relevant to define emerging LMD methods. Since the exploration of these two topics requires fact finding rather than a literature review, this will not form a sub-question.

LMD is a process that involves stakeholders with diverging interests and priorities. In order to reveal the opportunities and barriers, one should aim to understand the dominant perspectives these individual actor groups have on HC as a concept. Given these observations, the main research question can be answered by looking into the following sub-questions depicted below, followed by a brief explanation how these can be answered. The detailed outline can be found in the next chapter.

1. *What are the characteristics of hyperconnectivity according to the existing literature?*

HC in logistics is a term that has been appearing in literature since the early 2010s (Faugere and Montreuil 2016). Therefore, it is important to explore how the concept has evolved over the years and the impact it has had on technological developments in logistics. The characteristics of HC found in literature contribute to the setup of the survey statements as part of the Q-methodology.

2. *What dominant perspectives can be identified among last mile delivery actors on emerging hyperconnectivity?*

To be able to draw a conclusion about what drives and hinders the application of HC in LMD services, it is necessary to explore the perspectives of the actors involved. This sub-question goes beyond theory and involves engagement with actual stakeholders. The findings on this topic form the core of the implementation of this research, in combination with the next sub-question.

3. *Is there a relationship between the perspectives and stakeholder groups?*

It is interesting to explore whether certain opinions are strongly represented in a specific stakeholder group. Whether this is the case or not, can be revealed by analysing the results.

As previously mentioned, the first sub-question can be answered through exploring literature. Along with the findings on emerging LMD methods and stakeholder groups involved, these form the basis for the statements for the survey. The second and third sub-questions can be answered by carrying out the Q-methodology. The results of the survey will reveal which views are represented the strongest, and further analysis can identify whether there is a relationship between these and specific stakeholder groups. Chapter 2 contains the literature review and Chapter 3 elaborates on the selected research method.

1.4 Research objectives and scope

The research questions can be translated into the following research objectives:

- Determine the characteristics of hyperconnectivity in relation to last mile delivery;
- Identify the dominant perspectives regarding hyperconnectivity aspects applied to last mile delivery services;
- Extract the drivers and barriers to the implementation of hyperconnectivity characteristics in last mile delivery services;
- Suggest action points for key actors to stimulate the implementation of hyperconnectivity characteristics in last mile delivery services.

1.5 Motivation, scientific and societal relevance

The study of HC in LMD services presents a timely contribution to the field of logistics, supply chain management, and information systems. With the increasing digitisation and interconnectivity of systems, understanding how HC affects last-mile logistics is critical to advance theoretical models of digital transformation in supply chains. This research identifies and analyses both the drivers and barriers to HC among key stakeholder groups (e.g., logistics providers, retailers, consumers, technology vendors, and regulators), offering nuanced insights into the sociotechnical dynamics of smart logistics ecosystems. By adopting a multi-stakeholder perspective, this study also addresses a gap in existing literature, which often focuses on single stakeholder viewpoints or isolated technological implementations without capturing the interdependencies of delivery methods.

Additionally, the findings can contribute to theoretical frameworks in innovation diffusion, stakeholder theory, and development of digital infrastructure, particularly within the context of urban logistics. As HC becomes increasingly central to enabling responsive, efficient, and sustainable delivery systems, this research lays a foundation for future empirical and conceptual work exploring how digital connectivity reshapes logistics operations and stakeholder interactions.

From a societal perspective, the relevance of this research lies in its potential to inform more efficient, sustainable, and equitable last mile delivery solutions, an area of growing importance

due to the exponential rise in e-commerce and urbanisation. Hyperconnected delivery systems promise significant societal benefits, including reduced delivery times, lower emissions through optimised routing, enhanced customer experiences, and improved labour conditions through automation and real-time coordination. However, realising these benefits requires an in-depth understanding of the barriers that prevent widespread adoption, such as privacy concerns, infrastructure limitations, lack of interoperability, and stakeholder misalignment.

By identifying these barriers and the conditions under which HC is likely to succeed, this research supports policy makers and practitioners in developing more inclusive strategies that foster innovation while mitigating negative externalities. Furthermore, the research can help guide public-private partnerships and regulatory frameworks to ensure that the technological advancements in last mile logistics align with broader societal goals, including environmental sustainability, data ethics, and urban liveability.

1.6 Thesis outline

Chapter 2 explores the existing literature related to the fundamentals of LMD, emerging city logistics services, and HC. In Chapter 3 the methodology is explained by which the research questions can be answered. In Chapter 4, the results of the factor analysis are interpreted and validated. Chapter 5 contains the discussion, recommendations, and conclusion. Figure 1.1 visualises the flow of the chapters in this thesis.

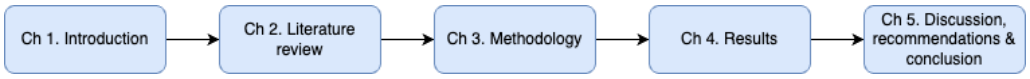

Figure 1.1: Thesis outline

2 Literature Review

The following chapter includes the literature review that provides the necessary background knowledge for this thesis. The outcome of the literature review is an identified research gap that underpins the need for this research.

Considering the previous research sub-questions, some of which require studying the existing literature, a strategy can be developed to acquire relevant articles that shed more light on these topics. Based on sub-question 1, an initial search is performed that should result in literature defining PI including its HC characteristics. In order to address fundamental concepts, terms such as *last mile delivery* and *city logistics* need to be established first. Based on the first search results, forward and backward snowballing is performed to acquire additional relevant papers. Since the review aims to highlight the recent research regarding the aforementioned technologies, only scientific papers not older than 15 years are selected for inclusion. Literature that contains fundamental theories on which recent findings are built further is exempt from the age criterion. Search engines used to find initial literature include Google, Google Scholar and Scopus.

Based on the outline above, the keywords for the literature search should include *city logistics, last mile delivery, physical internet, hyperconnectivity* and *stakeholder(s)*. An overview of keywords and search query examples are provided in Table 2.1.

Keywords	City logistics, last mile delivery, Hyperconnectivity, physical internet, Stakeholder(s)
Truncation	("city logistics" OR "last mile delivery") AND ("physical internet" OR hyperconnectivity) ("city logistics" OR "last mile delivery") AND stakeholder

Table 2.1: Methodological approach to the literature review

The following section provides an overview of the results as found in the selected literature. It is divided into four main subsections. The first defines and elaborates on the current state of LMD and city logistics. The second section highlights the relevant stakeholders in the LMD process. The third section details the background of PI and HC, while the fourth section contains emerging innovations and HC aspects in LMD.

2.1 Background: Last mile delivery and city logistics

2.1.1 Defining last mile delivery and city logistics

Since this research addresses the implementation of HC in last-LMD, it is important to clearly define the latter first. In literature there are multiple concepts and terms that touch on the final part of the logistics chain. However, these can have slight, yet important differences depending

on their use. Aside from *last mile delivery*, commonly used terms are *urban freight transport*, *city logistics*, *last mile logistics*.

Exploring existing literature, *last mile delivery* refers to the activities necessary for physical delivery to the final destination chosen by the receiver (Olsson et al. 2019). Boysen et al. (2020, September) states that the LMD process starts once a shipment has reached a starting point in an urban area, e.g., a central depot after long-haul transportation, and ends once the shipment has successfully reached the preferred destination point of the final customer. Slabinac (2015) argues that no unique definitions can be found because it depends on the objectives of the specific research. The last mile can also differ in definition, depending on the characteristics of the supply chain.

Analysing the definitions of LMD, the following common components can be identified with respect to:

1. the last mile; the leg from a transportation hub to their final destination
2. the delivery; the means of transporting goods in their last mile leg
3. the subject; freight or goods transported

The focus area of *URBANE* is the last mile of e-commerce deliveries. The project summary does not further detail what is meant by the "last mile", however, it does refer to the challenges based on an article by Banker (2020, July). In this article, the last mile represents "the final, short segment of the end-to-end origin to destination route products take to get to customers". This definition aligns with the others explored above and will be used for this research. Based on this, LMD is defined as the process of getting a good or product from the last warehouse to its final destination.

The LMD process has evolved significantly throughout time along with new technologies, the Digital Internet being the backbone of many developments. The traditional process had fewer flows compared to the current possibilities. Figure 2.1 depicts the traditional flows compared to the current state of the last mile (Mecalux 2022).

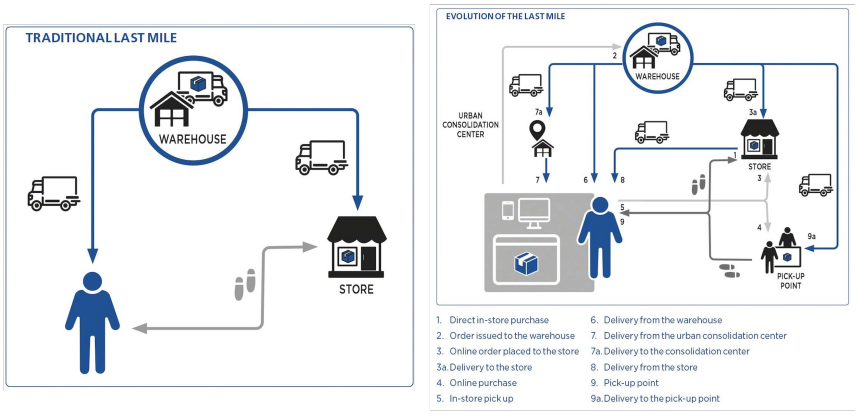

Figure 2.1: Traditional versus current last mile delivery process (Mecalux 2022)

The additional flows lead to an increased complexity of the logistic operations. On one hand, this results in a higher service quality for the customer, since there is an increased flexibility and personalisation of delivery options. However, this also puts more pressure on the operations side to deal with more personalised demands. These challenges and other externalities are detailed in further detail in Subsection 2.1.2. While LMD purely pertains to the physical movement of goods in an urban area, it undoubtedly interacts with the space, or urban environment, it moves through. City logistics combines these aspects and will be elaborated on in the next subsection.

In practice, LMD and city logistics tend to be used interchangeably.

City logistics is the means enabling freight distribution in urban areas and the strategies that can improve its efficiency while mitigating externalities such as congestion and emissions (Rodrigue and Dablanc 2024). It involves managing the movement of urban goods and providing innovative responses to customer demands. It takes place in a setting where a multitude of public actors are involved, including branches of government, advocacy groups, residents, and retail activities.

The current processes of city logistics have been the subject of extensive research and evaluation throughout the years. Many frameworks and decision models have been developed for stakeholder management in city logistics (Katsela and Pålsson 2019; Przybylska et al. 2023; Rubini and Lucia 2018). de Carvalho et al. (2019, August) performed a literature review on interactions among stakeholders in city logistics, concluding that data processing innovations are identified as a significant factor to potentially boost operational efficiencies in logistics. However, a hindering factor is often the presence of conflicts of interest among stakeholders despite the ownership of similar problems (Paddeu 2018; Paddeu et al. 2018). While local authorities are interested in reducing pollution, congestion or noise, transportation operators and retailers are mainly focused on keeping costs under control while maintaining service levels (Rześny-Cieplińska et al. 2021). A Q-analysis by Van Duin, Slabbekoorn, et al. (2018) exemplifies the divergent views among stakeholder groups towards a proposed solution of urban consolidation centres in the Netherlands. Kiba-Janiak (2016, January) identified two key success factors between stakeholders for city logistics, namely proper local regulation, and cooperation between stakeholders during planning, implementation and controlling of projects related to passenger and freight transport. However, there is still much debate how and to what extent local authorities should be involved.

A recent report by H.J. Quak et al. (2024) published by *TNO* aimed to provide an outlook on how Dutch city logistics can be developed until 2035, given the changing operating environments and regulations. Plenty of potential solutions have been identified, e.g., the aim for better vehicle consolidation, better synchronisation of delivery times, and the implementation of dynamic pick-up and drop-off locations. The majority of these solutions however, call for a higher degree of collaboration between stakeholders and an improved integration of the logistical processes. Only this would result in fewer vehicles and spatial occupancy in cities.

2.1.2 Emerging pressure on the last mile delivery process

It is a given that the portion of e-commerce purchases is increasing by the year (Sellers Commerce 2024). This also translates into an increasing demand for efficient and fast deliveries, which presents its own challenges as a result. Subsection 2.1.1 illustrated how the amount of possible transport flows has increased, leading to unwanted complexities if not handled well. The challenges are related to the following developments (Boysen et al. 2020):

- **Increasing volume**: The growth of e-commerce paired with the ongoing trend of urbanisation (Bretzke 2013) yields an increase in concentration and volume of parcels to be handled.
- **Sustainability**: National and local authorities are implementing increasingly stringent regulations to limit vehicle emissions negatively impacting public health, environment, and safety.
- **Costs**: Despite diverging estimates, the last mile delivery process is by definition the most cost-inefficient with percentages between 40-50% of the total cost of delivery (DHL 2023; Sykes 2024). This last part of the delivery chain is naturally inefficient due to the volume transported hence no economies of scale possible, traffic, mechanical failures, and only one drop-off at a time. The key components of last mile delivery costs are:
  - Delivery driver wages
  - Fuel

  - Delivery vehicle maintenance

  All of these costs increase with time and distance driven, as well as with operational inefficiencies.

- **Time pressure**: Most online retailers offer fast deliveries, with some even providing the option of same-day deliveries. As a result, last mile deliveries face time pressure as a crucial part of the logistics chain. In addition, online deliveries fluctuate due to weekly or seasonal trends. This requires last-mile concepts that are scalable on short notice.

Aside from the practical challenges, an increase in urban logistical operations also causes negative externalities, such as congestion, air and noise pollution (Hans Quak 2008, March. These negative impacts can be grouped into four overarching types as depicted below (Allen et al. 2000):

- **Negative environmental impacts**, including depletion of non-renewable energy sources, air pollution from emissions and various sorts of waste such as tyres, vehicle and other materials.
- **Negative social impacts**, including quality-of-life lowering aspects such as death, illness and injuries as a result of traffic accidents and various types of pollution, physical intimidation caused by utilised delivery vehicles, and the loss of open space in urban areas as a result of new transport infrastructure.
- **Negative economic impacts**, consisting of road congestion caused by goods vehicles and operational inefficiencies, impacting individual businesses and local economy, as well as the monetary costs of negative environmental and social impacts.
- **Negative operational impacts**, related to congestion and traffic disruption caused by goods vehicles while standing still to (un)load or while moving, causing obstructions to other modes of transport as well.

2.2 Relevant stakeholder groups

As previously mentioned, four main groups of actors can be distinguished that are involved in urban freight transport (Hans Quak and Tavasszy 2011):

- **Local authorities:** They are interested in a liveable city, which implies an emphasis on reducing truck traffic and nuisance, and on improving air quality in city centres. The means of local authorities to protect their interests include regulations, such as time windows, vehicle restrictions, and low emission zones.
- **Carriers:** They try to organise urban freight transport as efficiently as possible. Currently, their efforts are frustrated by local regulations, such as time windows that force carriers to make their deliveries during a limited time period.
- **Receivers (e.g. shop owners):** They like an attractive shopping environment, where nuisance by supplying trucks is minimised. But they also want a reliable distribution system, where goods are delivered at the times promised by the shippers.
- **Residents:** They want a pleasant environment to live in, which includes clean air (as little local pollutant emissions as possible), no noise nuisance or other inconvenience caused by supplying, loading and unloading trucks.

2.3 Background: Physical Internet and Hyperconnectivity

2.3.1 Definition, vision and concept

As briefly introduced in Chapter 1 The Physical Internet (PI) is a vision developed by Montreuil (2011) as a response to observed inefficiencies within the global logistics industry. The

assertion is that the global logistics industry is inherently not sustainable economically, environmentally, and socially (Montreuil 2011). The concept of PI aims to tackle these three unsustainable areas. The term draws its inspiration from the concept of the Digital Internet, which has enabled an open distributed network infrastructure, allowing the transmission of formatted data packets in a standardised way.

2.3.2 Characteristics of Physical Internet and Hyperconnectivity

The characteristics of PI are described in the initial paper by Montreuil (2011). Montreuil enlists these characteristics and elaborates on how they can address the non-sustainable symptoms identified in the global logistics system. The thirteen characteristics of the PI vision are as follows:

1. Encapsulate merchandises in world-standard smart green modular containers
2. Aiming toward universal interconnectivity
3. Evolve from material to p-container handling and storage systems
4. Exploit smart networked containers embedding smart objects
5. Evolve from point-to-point hub-and-spoke transport to distributed multi-segment intermodal transport
6. Embrace a unified multi-tier conceptual framework
7. Activate and exploit an Open Global Supply Web
8. Design products fitting containers with minimal space waste
9. Minimize physical moves and storages by digitally transmitting knowledge and materializing objects as locally as possible
10. Deploy open performance monitoring and capability certification
11. Prioritize webbed reliability and resilience of networks
12. Stimulate business model innovation
13. Enable open infrastructure innovation

The characteristics are formulated with the global logistics industry in mind. Montreuil (2011) acknowledges that reaching sustainability in this industry is a major challenge and that the same applies to the conceptualisation and implementation of PI in logistics. Actions required to take steps forward include further research of PI characteristics and other application areas, as well as executing pilot, prototyping, and demonstration projects among others.

In the current literature, the terms and definitions of PI, Interconnectivity and HC are not clearly distinguished from one another at times, just as last mile delivery and city logistics are not (Crainic and Montreuil 2016). Despite this entanglement at times, the concept at its core remains to enable large-scale collaboration through the sharing of assets, information procedures, standards, as well as flow alignment. In other words, a hyperconnected system means an intensified interconnectivity between actors and services. Therefore, moving forward, PI will be considered the umbrella term for the general concept, whereas HC is defined as the connection between services and actors in LMD methods, as part of PI.

Crainic and Montreuil (2016) presented an early study combining the two concepts of PI and city logistics, resulting in a framework for designing efficient and sustainable urban logistics and transportation systems. This framework provides nine core interconnection concepts that make up what the authors define as *Hyperconnected City Logistics (HCL)*, characterised as follows:

1. Interconnect Cities as nodes of the Worldwide Logistics Web

2. Interconnect Cities by Systems Standardization
3. Interconnect The Multi-Faceted Activities of City Logistics
4. Interconnect City Logistic Networks within a City Web Architecture
5. Interconnect The Multiplicity of Urban Logistics Centers
6. Interconnect City Logistics Stakeholders into an Open System
7. Interconnect Goods Through Modular Logistics Containers
8. Interconnect People Mobility and Freight Logistics in the City
9. Interconnect City Logistics with Urban Planning

Since this research is focused on the HC aspect between services and the impact on stakeholder interactions, there are a few concepts that are more relevant which are detailed further below.

Interconnect city logistics into an open system (6)

HCL acknowledges and aims to enable a system of collaboration between the various actors, envisioning engagement in three areas. In **operational** terms, the LSPs should cooperate to ensure consolidation and synchronisation. In **business** terms, hyperconnected business models can be incentivised through contractual agreements between users and providers, in terms of pricing, liability, cost, revenue and profit context, among others. In **public-service** terms, authorities should interact with stakeholders in city logistics to establish an appropriate legislative environment to incentivise interconnectivity between industry actors.

Interconnect people mobility and freight logistics in the city (8)

HCL aims at an intensification of the interconnectivity between people (mobility) and freight logistics, which currently tends to be separated by regulations. An example is to combine the use of public transport infrastructure in city cores, such as tram lines, with people and freight transport.

M. Cebeci et al. (2023) emphasise, among others, the need to study the effects of hyperconnected service networks. Within this concept, there is a distinction between horizontal and vertical connectivity. Horizontal connectivity describes the collaboration between competing actors through, for example, sharing data and assets, whereas vertical connectivity involves the creation of new service chains by connecting individual services. An example could be the combination of crowd-based delivery services with parcel lockers or micro-depots. M. Cebeci et al. (2023) encourage exploring the combined vertical and horizontal integration of partial delivery services, as it is this combined deployment that results in a hyperconnected urban freight network.

Based on relevant aspects of HC, the following characteristics can be extracted:

- Services: Specific LMD service types to be connected.
- Collaboration: LSPs cooperating on an operational level.
- IT: Information exchange between parties that enables operational synchronisation.
- Governance: Authorities have the legislative power to incentivise interconnectivity between industry actors.

2.4 Emerging innovations and hyperconnectivity aspects in last mile delivery

The following subsection details the trends and innovations that are currently developing within the LMD processes. Where relevant, there will be connections made to HC aspects that were previously explained in Subsection 2.3.2.

Crowdsourced delivery

Crowdsourced delivery, or crowdshipping, is an emerging trend in the last mile delivery process that enables citizens to become couriers. The general idea behind crowdshipping is that an item is transported by a commuter who is already making a trip for other purposes, thus, not adding extra travelled kilometers to the operation. Buldeo Rai et al. (2017, September) coins the same term as *crowd logistics* and defines it as 'an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly'. The conceptual system is centred around the existence of an app-based platform where shippers and potential couriers can communicate. A concept such as crowdshipping is a good early stage example of Physical Internet implementation in last mile delivery, where shippers, LSPs and citizens are interconnected. A conceptualisation of a crowdsourced delivery system is depicted in Figure 2.2.

Figure 2.2: An illustration of crowdsourced delivery (Le et al. 2019)

Autonomous vehicles

The use of autonomous delivery vehicles (ADVs) is another emerging concept in which its operations are embedded in the IoT and interconnectivity. Each vehicle requires the sensors to register its operating environment and control its movement while transmitting important information to the control centre. Furthermore, data needs to be fed into vehicles with respect to their route, while live parcel tracking might be a desired function for customers. ADVs are typically used to deliver goods in a short range (1 to 3 miles). The desired outcome of implementing ADVs is to decrease car trips and therefore decrease emissions, as well as operational costs. The concept is one with several classifications of autonomy level and various stages of development. However, there are a significant number of companies active in varying industries (e.g. parcel, food, maintenance service delivery) that are already active in delivering goods to consumers (Baum et al. 2019; Boysen et al. 2020). The implementation is currently tested and evaluated within the *Urbane* project as well, usually paired with exploring the micro-hub concept considering the working range of typical ADVs Urbane n.d.(a); Urbane n.d.(b)).

Urban warehousing

Urban warehouses are storage facilities typically located in or near urban areas. These facilities are placed within or in close proximity to the cities with the intent to bring fulfilment operations closer to the customer, also known as micro-fulfilment. This model has become especially relevant in the e-commerce, food and beverage and pharmaceutical sectors. The desired results are lower transportation costs, shorter delivery times, and sometimes even the ability to offer same-day delivery to the customer. By means of consolidation, there should be less trips made inside the city which in turn increases operation efficiency and lower emissions. There are varying types of facilities depending on the desired facility size and service area. An illustration of the different types is shown in Figure 2.3.

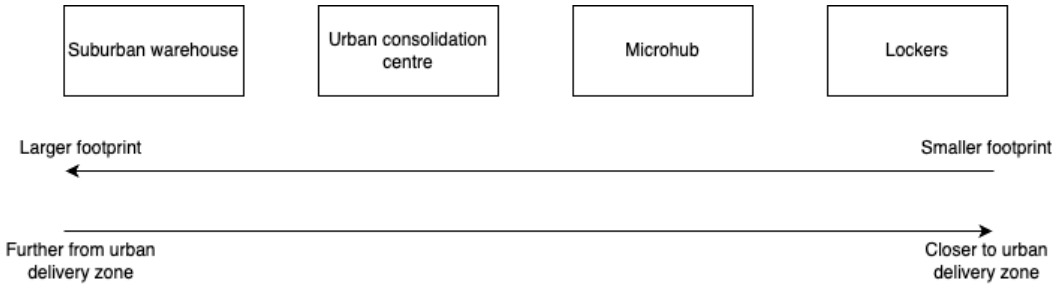

Figure 2.3: Types of logistics facilities

Microhubs are transshipment facilities in the centre of an urban area, purposed for micro-consolidation. It is a location where goods are consolidated near the final destination point (e.g. 1 to 5km from the final destination) (Lee et al. 2019). There is a clear distinction from suburban warehouses or urban consolidation centres that are typically located just outside a city border. This could potentially be an operational challenge for services such as ADVs to use as a hub, considering its limited range. Therefore, utilising micro-hubs would be more feasible. There are varying concepts of operational models for micro-hubs, whether solely used for one business or allowing use by multiple companies. Regardless of the operational details, the need for connectivity remains, namely to connect and share information and potentially assets between LSPs and citizens. In the case of a mixed multi-carrier approach, competing service providers would share infrastructure and information to a certain extent. de Bok et al. (2024) have recently conducted a simulation study on the impact of micro-hub scenarios in Rotterdam. The results revealed that the largest vehicle kilometers reduction is achieved when CEPs (courier express parcel service) fully collaborate. This means that they share in the operation of their micro-hubs.

Urban consolidation centres (UCCs) are larger consolidation facilities that are typically located in suburban and inner-city areas (Dreischerf and Buijs 2022). At this facility, freight from single or multiple suppliers can be consolidated and delivered into the city. In theory, UCCs can help decrease vehicle movements and stimulate zero-emission efforts in cities because of their consolidation ability. These potential benefits have also been shown in mathematical modeling studies (Escuín et al. 2012; Simoni et al. 2018). Despite the promising benefits, not many UCC initiatives have reached successful implementation. Hans Quak, Kin, and Meijer (2025) have categorised several types of city hubs, each with their feasibility. Hubs owned by a single LSP are deemed more feasible compared to 'neutral' hubs where multiple LSPs can consolidate their parcels. A major barrier for the latter concept is that costs and benefits are not divided equally, thus making it unappealing for certain actors, i.e., hub operators.

Parcel locker facilities

Parcel lockers serve as self-service kiosks to receive parcels, eliminating the need for delivery to one's personal address. A major advantage is that the recipient does not need to wait at home to receive their package, especially when the delivery window has a range of several hours. Reversely, they can also serve as an automated post office to send parcels. Although not necessarily a new technology, the large increase in their presence has only expressed itself in more recent years, taking Germany as an example in Figure 2.4.

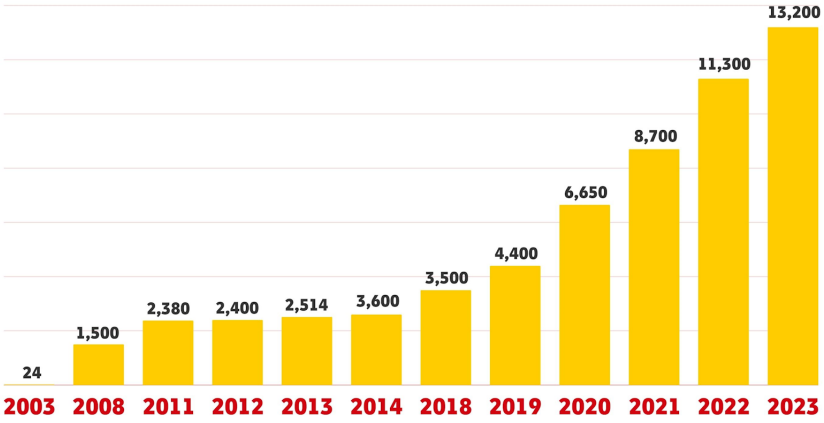

Figure 2.4: Parcel locker growth in Germany (DHL 2024)

The concept has been around since the 2000s and currently there is already a level of interconnectivity, however Faugere and Montreuil (2016) propose further intensification towards hyperconnectivity. There are two main structures, namely one where smart locker terminals are designated to one or a set of LSPs, and one where the terminals are tied to one or a set or retailers. By implementing hyperconnectivity, the terminals would instead be open to be used by any entity, whether these are retailers, LSPs or independent businesses. An illustration of such a hyperconnected supply chain is depicted in Figure 2.5 (Faugere and Montreuil 2016).

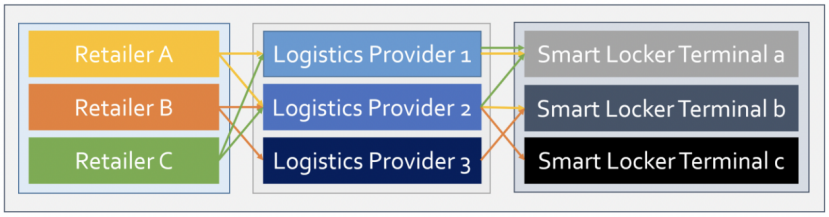

Figure 2.5: A hyperconnected e-commerce supply chain structure for smart locker terminals (Faugere and Montreuil 2016)

The desired result of such a hyperconnected system is two-fold. Firstly, it is about achieving a limited density of smart locker terminals in a specific area since no assets would be exclusive to use by a specific entity. This open system would lead to a better management of demand variability, which could potentially result in a higher utilisation rate of the assets compared to a segmented system of independent terminals.

Omni-channel delivery options

Omni-channel delivery is defined as a 'retail strategy that provides customers with a seamless and integrated shopping experience across all available channels, including online, mobile, in-store, and other channels' (Puri 2022). The goal is to create a consistent and personalised experience for customers through any channel they choose to use for shopping. Such a system enables a customer to browse, purchase, and return products through their channel of preference. All channels are connected and share real-time data, allowing customers to seamlessly move between channels and receive a consistent shopping experience. For example, a customer might browse a product online, add it to their cart, and pick it up in-store without any disruptions in the shopping experience. For a complete omni-channel experience, the same system can be applied to the process of returning ordered products. An example is signing up the product for return online and being able to choose whether to drop it off at a nearby location, or getting it picked up at their home. An important factor contributing to customer satisfaction with such a system is delivery tracking.

White label services

White label delivery is a form of on-demand delivery using a third party (e.g. Uber Direct, Doordash) while allowing the customer to shop and interact with the business's own sales channels. The latter is an important difference compared to using a third-party marketplace service like Uber Eats, where the shopping experience platform is shared with other businesses. Relevant use cases for a white label delivery service include food, local retail and grocery delivery. White label services can help smaller retailers to compete with larger companies in terms of delivery speed while maintaining control over operational costs. The white label concept is comparable to the 'neutral' hub concept as defined by Hans Quak, Kin, and Meijer (2025). Therefore, the same major barrier or cost and benefit allocation between actors are valid.

3 Methodology

The following section explains the methods how the sub-questions, and as a result the main research question as previously defined in Section 1.3, can be investigated and answered. An overview is provided in Table 3.1 and each method is further elaborated upon later in this section.

What are drivers and barriers among stakeholder groups for the implementation of hyperconnectivity aspects in parcel last mile delivery services?	
Sub-question	**Method**
RQ1. What are the characteristics of hyperconnectivity according to existing literature?	Literature research
RQ2. What dominant perspectives can be identified among last mile delivery actors on emerging hyperconnectivity?	Q-methodology
RQ3. Is there a relationship between the perspectives and stakeholder groups?	Q-methodology

Table 3.1: Main research question, sub-questions and their respective methods

Figure 3.1 illustrates the process by which the main research question can be answered. The blocks indicate the (sub) research questions. Arrows entering a research question block represent the input and the exiting arrows indicate the (desired) result of answering a research question.

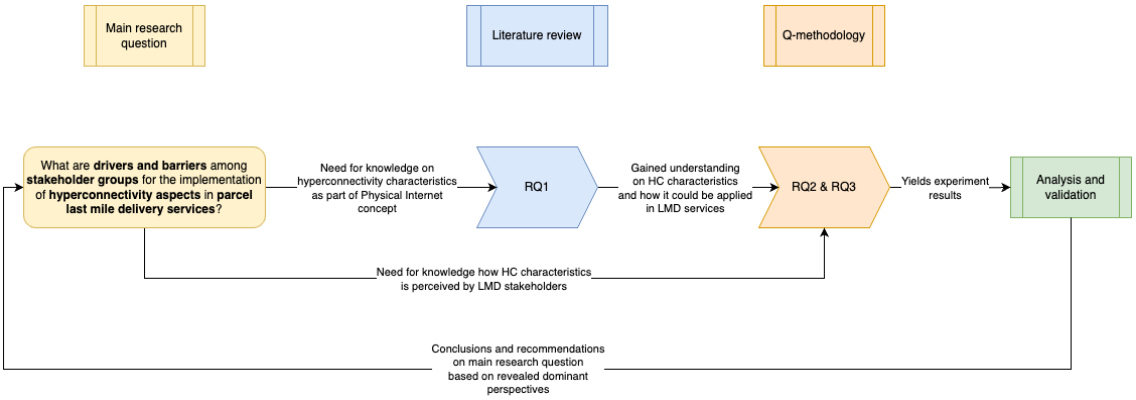

Figure 3.1: Flow chart of the research methodology

3.1 Literature research and expert consulting

The goal of conducting the literature review stems from the main research question and it is to obtain a knowledge base on the field relevant to RQ1. The acquired knowledge paves the way to make grounded and justifiable decisions pertaining to RQ2, namely how to introduce and include the HC aspect in the experiment. The method and means to find the relevant literature are further explained in Chapter 2.

Additionally, experts within the researched fields can be consulted. Institutes and companies that could be consulted include the TU Delft Transport & Planning department from the Civil En-

gineering faculty; the Technology, Policy and Management faculty; LSPs and municipalities that are within the network of the supervisors and the university.

The findings of the literature research and expert consultations will yield a firm understanding of the fundamental concepts of HC and current views on it. These findings will form the basis for the experiment as part of the Q-methodology, as explained in the following section.

3.2 Methodology choice

There is still little known about stakeholder perspectives regarding PI and hyperconnectivity. The majority of publications in PI are based on conceptual and quantitative research, whereas only a small portion is based on surveys or interviews (Treiblmaier et al. 2016; Van Duin, Van Son, et al. 2022). When it comes to HC or hyperconnected services, there have been researches conducted that identify the relevant stakeholders (Naqvi et al. 2020). M. S. Cebeci et al. (2023) performed a stated-preference survey to investigate the effect of trust on crowdshipping, which relates to a specific stakeholder group for a specific last mile delivery service. However, there is no research that explores multiple relevant stakeholder group perspectives on the idea of hyperconnecting different types of last mile delivery services. Therefore, it is important to map these opinions regarding the concept and its readiness to be implemented in practice.

3.3 Q-methodology

Considering the novel concept of HC and the many stakeholders involved in the logistics chain, it is highly likely that these actors have diverging perspectives and priorities on the topic. The Q-methodology is an exploratory technique to investigate the perspectives of participants who represent different stances on a certain issue (Better Evaluation n.d.; Brown 1993). This method has also been used in previous research on PI characteristics in the Dutch logistics industry (van Son 2020). The global application of the method will be based on this master's thesis, given the similarity of the field of research.

According to Webler et al. (2009), it is important to state the core goals of the research, as well as the context and the perspectives that need to be understood. When applying it to this research, the resulting statements are as follows:

1. In the context of *public-private participation of innovating last mile delivery services,*
2. I want to understand the different perspectives on the *implementation of hyperconnectivity between existing and new services,*
3. In order to *determine the opportunities and barriers from relevant stakeholders towards hyperconnectivity in last mile delivery.*

For the following explanation of the Q-methodology, the article by Van Exel and De Graaf (2005) will be used as a basis reference.

Typically, participants are presented with a topic-relevant set of statements called the Q-set. The respondents, called the P-set, are requested to rank-order the statements from their point of view, according to some preference as defined by the designer of the experiment. By sorting the Q-set in a quasi-normal distribution, also known as Q-sorting, the participants give their subjective interpretation to the statements, revealing their viewpoints or personal profile. Subsequently, the Q-sorts of all participants are subjected to a factor analysis the results are interpreted. Per group, the dominant perspectives are revealed, and translated into the opportunities and barriers.

Whereas conventional 'R' type analyses are based on identifying correlations between variables (e.g. age and voting preference) across individuals in a survey style, a 'Q' type analysis

is based on identifying correlations between individuals or groups across different variables. In other words, with R-methodology the variables are central while seeking a representative group of individuals, whereas with Q-methodology the participants themselves are variables. An intelligence test is an example of a R-methodology based test. Examples of the Q-method in practice include researches on identifying diverging viewpoints on PI in urban freight logistics, or on urban consolidation centres in the Netherlands (Van Duin, Slabbekoorn, et al. 2018; Van Duin, Van Son, et al. 2022).

3.3.1 Q-set

This set consists of statements about the implementation of HC characteristics in last-mile delivery methods. The statements are formulated based on findings in literature research and interviews with experts. The gathered statements are reviewed and selected for the final survey. The development of the survey is done using EQ Web Sort.

3.3.2 P-set

The P-set consists of the participants of the experiment. Given the research, the group should consist of stakeholders that are part of the last mile delivery process. Experts that have been contacted to formulate the Q-set can be included in the P-set as well. Relevant stakeholder groups can be categorised as follows (Egeli and Guttormsen 2024; Faugere and Montreuil 2016):

- Shipppers/retailers;
- Logistics service providers (LSPs);
- Citizens/consumers;
- Local authorities.

In order to anticipate their levels of participation, interest and influence in the research, a stakeholder analysis is relevant. Firstly, the stakeholder groups are evaluated how much power and interest they have in the last-mile delivery process based on their involvement. Based on the assessment, they are placed in a power-interest matrix as depicted in Figure 3.2.

- **Shippers:** Retailers sending their goods to the customer may have a moderate to high interest, since the quality and efficiency of the last mile can impact the overall customer satisfaction. Depending on the size of the business, their power might be moderate to high depending on the volume of goods shipped and their influence on the LSP choice.
- **LSPs:** These are the companies that provide logistics services such as transportation, warehousing, and distribution. They have a high interest as they are directly responsible for executing last-mile deliveries, which can be the most complex and costly part of the logistics chain. They also have high power as they control the logistics operations and have significant influence over the efficiency and effectiveness of the logistics process.
- **Citizens/customers:** These are the end recipients of the goods being shipped. Their interest is high because they rely on timely and accurate delivery of products. Their power may be low to moderate depending on their size and the extent of their buying power. Due to the increasing importance and ease to share reviews, their power may increase.
- **Local authorities:** In last mile delivery, local authorities may have a high interest due to the increased focus on urban logistics, traffic congestion, and environmental impacts. Their power is high because they can regulate delivery operations through local policies, zoning laws, and traffic management.

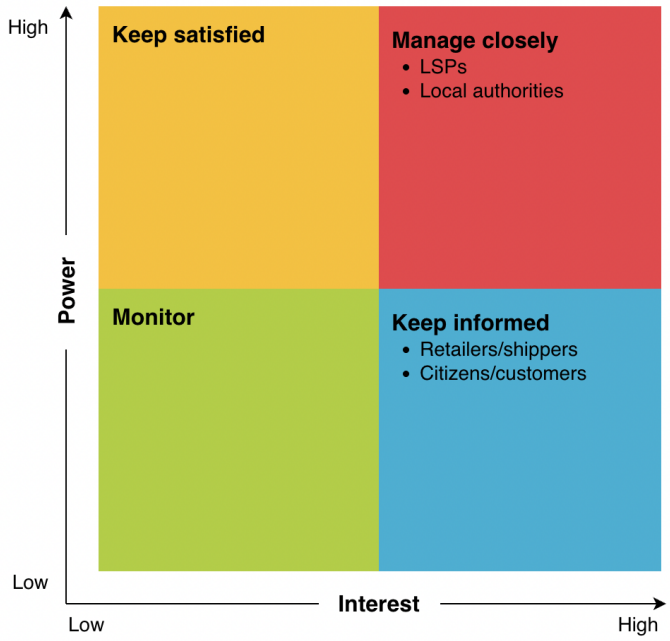

Figure 3.2: Power-Interest matrix of stakeholders in the last-mile delivery process

Based on the increased power and interest, it is particularly important to make sure to include a representative group of LSPs and local authorities. Naturally it remains relevant to reach out to shippers and customer representative groups as well, in order to gain all perspectives. Given the involvement of TU Delft as a research institute and active collaboration with industry partners, it is encouraged to make use of this network to reach out to relevant stakeholders. Examples include DHL and PostNL as established LSPs, or MyPUP. Since this research is part of the URBANE project, Lighthouse Living Lab (LL) cities can also be contacted to potentially acquire more participants.

3.3.3 Q-sort

The Q-sort is the result of participants (P-set) who rank the statements (Q-set) in a certain way, where the data represents expressions of qualitative intensity related to feeling or value. Figure 3.3 depicts an example of a Q-sort with 47 statements that has been filled in by a participant. The Q-set statements are sorted from "most unlike the participant's view" to "most like the participant's view". Through the sorting of these statements, the subjectivity of the participant is shown. The Q-grid has fewer columns the further away it is from the neutral column. This structure imitates a normal distribution and forces participants to rank the statements by making trade-offs and compare them to each other.

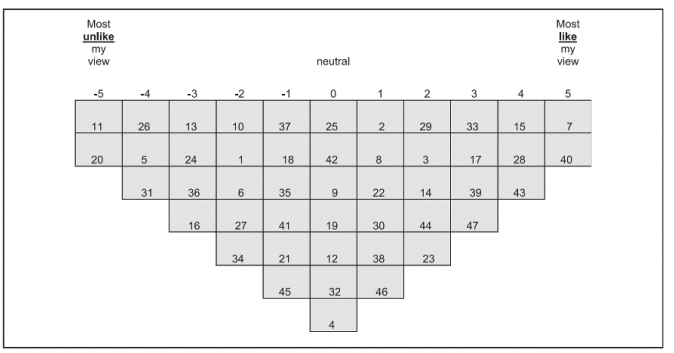

Figure 3.3: Example of a completed Q-sort with the statement numbers in the grid

3.3.4 Q-analysis

After the answers of all participants are sorted in the Q-sort phase, the results are to be analysed in the Q-analysis phase. This can be done by performing a factor analysis, revealing the participants' subjectivity and in doing so, they can be grouped. By analysing the categorised groups, their dominant perspectives can be revealed. This leads to the identification of the opportunities and barriers that they foresee towards the implementation of hyperconnectivity in last-mile delivery services. The participants can also be asked to explain why they put the statements in the most extreme columns.

3.3.5 Validation

The results before the validation phase encompass the varying groups with their respective dominant perspectives after performing the Q-analysis. Validation can be performed by feeding back these perspectives to each participant group and verify if they agree with these conclusions.

3.4 Q-set

This chapter contains the statements related to the implementation of hyperconnectivity in last mile delivery services. They are based on literature research, as well as expert interviews. Lastly, some statements have been added to cover missing areas that are relevant to answering the research question. The statements are grouped into five characteristics that encompass the various aspects of hyperconnectivity. The Q-set consists of these statements and are presented to the participants of the experiment to use for the Q-sort.

3.4.1 Statements characteristics

All statements will be connected to one of the following specific characteristics of hyperconnectivity:

- General: Statements regarding the overall concept of hyperconnectivity in last mile delivery
- Collaboration: Statements about two or more stakeholders/services working together
- Governance: Statements regarding the role of governmental authorities and regulating hyperconnectivity in urban areas
- IT: Statements regarding the sharing of digital information and infrastructure between parties
- Services: Statements regarding combining last mile delivery services to form an improved service

General

Hyperconnectivity is still considered an emerging paradigm in the field of logistics. Therefore, it is important to identify the stance on the current state of last mile delivery, as well as the expectations on the impact of hyperconnectivity on a systemic level.

The resulting statements are as follows:

1. The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips). (Gemeente Rotterdam)
2. Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.

3. It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero emission zones plan in city centres. (Gemeente Rotterdam, MyPUP)
4. Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it (Faugere and Montreuil 2016)
5. Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.
6. The idea of connecting services do not provide benefits for big/established LSPs.
7. Service connectivity is necessary to develop efficient and sustainable last mile delivery. (M. S. Cebeci et al. 2023)
8. If it becomes more problematic for carriers to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles. (Van Duin, Van Son, et al. 2022)
9. Hyperconnectivity is achievable when the mindset is to minimise the amount of vehicle movements in a city. (MyPUP)

Collaboration

A fundamental aspect of hyperconnectivity is collaboration between companies in the last mile logistics network. Traditionally, logistics companies are known to be individualistic, having their own assets and proprietary networks. Connecting services, by definition, disrupts this conventional mindset, making it of high value to gauge the attitude towards this shift.

The resulting statements are as follows:

1. Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company. (MyPUP)
2. Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero emission vehicles in last mile delivery. (Cityhub)
3. Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits. (Van Duin, Van Son, et al. 2022)
4. The best way to form a hyperconnected last mile delivery network that is more robust and impactful could be established by small-scale micro-services collaborating. (Tavasszy)
5. Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development. (H.J. Quak et al. 2024)
6. Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services. (MyPUP)

Governance

National and local authorities play and important part in allowing hyperconnectivity to be implemented, depending on their vision on logistics for the country, municipality or city.

The resulting statements are as follows:

1. Infrastructure sharing mechanisms should be defined by local authorities. (Gemeente Rotterdam)
2. Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported. (Gemeente Rotterdam)

3. Local authorities should take the lead in zero emission city logistics by setting sustainability criteria for purchasing and tenders. (Gemeente Rotterdam)

4. An efficient way to achieve hyperconnectivity is for municipalities to enforce car free zones while granting concessions to one LSP to enter specific zones. (MyPUP)

5. Municipalities need to have an enforcing role for companies to hyperconnect services. (MyPUP)

6. Enforcing zero emission zones in city centres will result in a strong increase of white label logistic hubs.

IT

The resulting statements are as follows:

1. The fear of losing a competitive market position is still a big barrier to sharing information. (Quak)

2. An open platform where logistics service demand and supply meet will be the future of last mile deliveries. (Van Duin, Van Son, et al. 2022)

3. Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible. (Frindik and Prudon 2017; Van Duin, Van Son, et al. 2022; Cityhub)

4. When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers are able to do it. (Van Duin, Van Son, et al. 2022; Cityhub)

5. Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration. (Prause 2019)

Services

The resulting statements are as follows:

1. The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport. (de Bok et al. 2024)

2. Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods. (Boysen et al. 2020)

3. White label services improve asset occupancy and is worth implementing to reduce investment and operational costs. (Cityhub)

4. White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas. (Cityhub)

5. The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs.

6. Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled. (M. S. Cebeci et al. 2023)

7. It is better to connect services on the edge of a city rather than inside the city, since the goal should be to minimise vehicle movements. (MyPUP)

8. The shortage of personnel is a driving force for white-label delivery services warehousing. (Cityhub)

3.5 Q-analysis

The Q-analysis is the step that follows after all participants have completed the Q-sort. The different perspectives on the topic can be revealed by looking at the correlations between the completed Q-sorts. Participants can 'load' on a factor based on the correlations between that factor and their respective Q-sort. The factor represents a perspective and results in a new corresponding Q-sort that belongs to the average perspective of all the participants that are coupled to that factor.

3.5.1 Factor analysis

The following subsection highlights the steps of the factor analysis. The first step is to check the Q-sorts on correlations and subsequently perform a principal component analysis. This analysis extracts 8 factors that can represent different perspectives on the topic. The solution is then mathematically rotated, so that the factors explain the most variance. These 8 factors are not retained for the final solution, but the optimal amount can be extracted by using rules, guidelines, and interpretation.

3.5.2 Determining the number of factors to extract

The first step of the factor analysis is a principal component analysis, which extracts 8 factors and calculates the corresponding eigenvalues, as well as explained variance. Literature provides a few objective rules regarding the determination of the amount of factors to retain. The main source for the rules is a paper by Webler et al. (2009), supported by other publications by Watts and Stenner (2005) and Suprapto (2016):

- The factor should minimally explain between 35% and 40% (Watts and Stenner 2005)
- Factor eigenvalues should be larger than 1 (Webler et al. 2009)
- Each factor should be represented by at least two Q-sorts (Suprapto 2016)

Although the above points are considered rules, Webler et al. (2009) argue that each situation requires a specific consideration. The amount of extra useful information gained per extracted factor should be taken into account. Furthermore, Webler et al. (2009) provide a set of qualitative guidelines to help determining the amount of extracted factors:

1. Simplicity: Fewer factors are desirable, as it makes understanding viewpoints easier. However, it should not be taken too far that important information is lost about differences in people's views.
2. Clarity: The ideal factor solution should have a participant load strongly on a single factor.
3. Distinctness: The correlation between factors should be as low as possible. However, it does not have to be problematic when there are correlations, since there could be an explanation for it when looking deeper into these shared opinions.
4. Stability: Participants with similar views should remain mostly clustered when alternating between the amount of factors.

The next step is to apply a varimax rotation, a method that produces the factor solution that maximises the amount of variance on as few factors as possible.

4 Results

The following chapter outlines the results after applying the Q-analysis to the gathered qualitative data. The goal is to determine how many factors to extract and to gain an understanding of what these factors mean on a qualitative level. The first section explains the determination of the number of factors, followed by the formulation of the perspectives. The similarities and differences between perspectives are analysed, which leads to the identified drivers and barriers. The chapter concludes with a discussion of the method and results, as well as a validation stage with participants.

4.1 Determining the number of extracted factors

Each factor solution is analysed by its eigenvalue using a scree plot, depicted in Figure 4.1. The considered range of factors varied between 1 and 8, with a stark decrease in eigenvalues up to 3 factors and the elbow point at 3 factors.

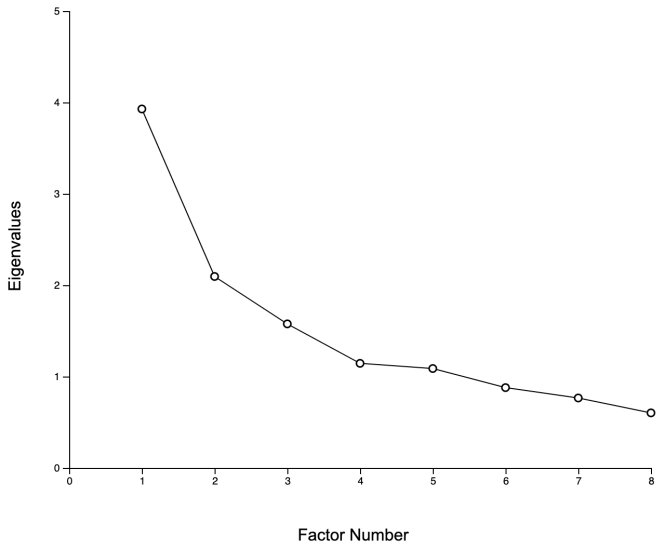

Figure 4.1: Scree plot, eigenvalues related to the corresponding number of factors (KADE v1.3.1)

Considering the recommendation to maintain simplicity, a high number of factors such as 5 to 8 would be undesirable. An 8 factor solution would also automatically violate the third rule of having at least two distinct Q-sorts per factor. The same situation occurs up to a 5 factor solution in this particular set of Q-sorts, where one factor includes only one Q-sort. Therefore, the decision is made to consider less than 5 factors.

When analysing the remaining factors, the other rules (1 and 2) can be considered—the first being a minimal explained variance between 35% and 40%, and the second a desired eigenvalue

of 1 or larger. Figure 4.2 depicts the factors with their respective eigenvalues and cumulative explained variance. With 2, 3 and 4 factors, all three fulfil the rules regarding an eigenvalue of at least 1 and an explained variance of at least 35% to 40%.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	3.9285	2.0952	1.5765	1.1446	1.088	0.8791	0.7656	0.6026
% explained variance	28	15	11	8	8	6	5	4
cumulative % explained variance	28	43	54	62	70	76	81	85

Figure 4.2: Factors with correspoding eigenvalues, explained variance and cumulative explained variance (KADE v1.3.1)

Since the quantitative set of guidelines narrows the solution space down to multiple options, the qualitative guidelines by Webler et al. (2009) can be utilised. When comparing the participant grouping between 2 and 3 factors, all participants from the third group in the 3 factor solution are transferred to the first group in the 2 factor solution. When comparing the groupings between 3 and 4 factors, participants remain less clustered than in the first scenario. This observation relates to stability, which leads to the conclusion that 2 or 3 factors are more favourable than 4 factors. When considering clarity, both 2 and 3 factors lead to similarly strong participant loadings on one specific factor. The correlations between each factor are smaller with a 2 factor solution compared to a 3 factor solution. In case of the latter, there is a relatively strong correlation between factors 1 and 3. However, this can be explained by the clustered group that was moved from factor 1 to factor 3. In this situation, the correlation is not problematic and allows for three perspectives instead of two. Based on the quantitative and qualitative guidelines, the 3 factor solution was chosen for analysis. The results of this analysis can be found in the next chapter.

4.2 Identifying meaningful factors

In order to create a relevant meaning of the factors, it is necessary to translate the quantitative information from the factor analysis to qualitative perspectives. The following identifiers can be assessed to construct the perspectives:

- Significantly distinguishing statements per factor
- Extremely ranked statements per factor
- Overall consensus-disagreement on statements and correlation between participants
- Feedback on choices made by participants

The distinguishing statements are statements that are ranked significantly differently between a given factor compared to the other factors. Extremely ranked statements are statements that are ranked the highest or lowest in a factor. Significant statements tend to be placed on one of the extremes; however, this does not necessarily have to be the case. Reversely, an extreme statement is not always a distinguishing one. Therefore, it is significant to analyse both aspects. A third starting point is to look at which statements are ranked similarly between factors and which ones are ranked the most differently, indicated by a low or high variance between scores per factor. Lastly, the extracted perspectives are fed back to the participants to evaluate how much they can relate to them.

4.3 The perspectives belonging to the factors

The following section details the three perspectives that qualitatively describe the meaning of the factors. The perspectives are supported by quotes from participants who have shared their comments during either the interview or survey phase. It is followed by an analysis of the perspective in relation to the HC characteristics as defined in Subsection 3.4.1. In addition, each perspective contains an overview of the stakeholder groups that represent this perspective, followed by a set of distinguishing and extreme statements.

4.3.1 *Perspective 1: White label delivery services and parcel lockers are suitable solutions to be hyperconnected, however, in general, lack of trust and fear of losing competitive market position are still barriers.*

This perspective shows a strongly positive attitude towards shared last-mile delivery services, specifically white-label services and parcel lockers. A quote from one stakeholder, also seen below, supports the concept of white-label services, seeing the potential for a higher drop density and utilisation rate. Multiple stakeholders also plead for sharing mechanisms of parcel lockers, since it could lead to fewer empty trips, and as a result fewer vehicle kilometers. In line with this, there is also a strong opinion that it is not sufficient for LSPs to solely electrify their fleet without additional solutions as a response to the zero-emission zones. This is supported by the agreement that sharing assets increases city liveability more than only changing to zero-emission vehicles. These observations tie well together if the end goal is to reduce congestion, delays, and increase safety in cities.

On the other hand, it has a strongly negative position on the use of drones in urban areas and crowdshipping. This is supported by multiple quotes from stakeholders in this perspective, some of them depicted below. Reasons include that drone delivery is too expensive and is only suitable in rural areas. Regarding the negative attitude towards crowdshipping, one participant argues that this concept introduces certain complexities. These include setting responsibilities and guarantees for the delivery of the parcel.

Another strong opinion is that lack of trust and fear of losing a competitive market position still form a barrier to connecting services. It should be noted that this opinion is more of a general one and not related to specific last-mile delivery services.

Quotes

BREYTNER (Industry)
"Higher drop density and utilisation rate results in best financial performance"

Significance (Research)
"Parcels assigned to different LSPs can be consolidated in one vehicle to reach the same area this can lead to fewer empty trips, hence fewer vehicle kilometers and traffic in urban areas"

PostNL (LSP)
"This will improve the use of parcel lockers greatly"

Significance (Research)
"Crowdshipping is nice as a concept of an ideal world. People need an incentive to "get out of their way" to deliver something. This starts complicating the logistics: responsibilities cannot be easily set and guarantees of the parcels delivery are not possible. So the delivery price should be reduced if a "non-professional" person is actually delivering a parcel but the complexities are increased"

Perspective 1 in relation to the HC characteristics

Table 4.1 contains the distinguishing and extreme statements. The distinguishing statements with a score of -1, 0 or 1 are excluded to improve readability. The complete table can be found in Table C.1. Table 4.1 also includes the relevant characteristic of HC that is related to the statement, indicating which aspect of HC has potential to be implemented.

This perspective has strong positive and negative attitudes towards specific services, depending on the type of delivery method. As mentioned in the perspective, there is a strong opinion about the IT or information characteristic. However, two positive distinguishing statements in this perspective are related to the collaboration characteristic, namely statements 16 and 2. In conclusion, this perspective is united on the idea of collaboration and which delivery services could work, but divided on the sharing IT and information aspects of HC.

The nature of stakeholders in this perspective

This perspective is represented by four participants. In this perspective, an industry company (BREYTNER), a research agency (Significance) and two LSPs (Cycloon and PostNL) are represented.

The presence of LSPs in this perspective could explain why concerns about trust and maintaining a strong market position are ranked highly. At the same time, it is interesting to note that the concept of sharing parcel lockers and white-label services are positively viewed. This could indicate that LSPs are open to exchange assets and information, given the right incentive and circumstances. One LSP stakeholder argued that customers do not want to go to multiple lockers, and therefore LSPs should accommodate this need. BREYTNER also observes that the parcel locker market is growing, since people increasingly do not want to miss a home delivery. This trend is confirmed by LSPs in practice, as DHL and PostNL is aiming to increase their parcel locker infrastructure due to tightening margins (nu.nl 2025). The fact that this perspective is also supported by a research agency, indicates a consensus between groups on these statements.

Table 4.1: Reduced set of distinguishing and extreme statements related to factor 1 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	2.13	4	24	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas.	Services
	1.51	4	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
	1.18	3	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Collaboration
	1.12	3	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	Collaboration
**	0.88	3	16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres.	General
**	0.86	2	2	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery.	Collaboration

Table 4.1: Reduced set of distinguishing and extreme statements related to factor 1 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
*	0.76	2	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
*	-0.81	-2	19	The idea of connecting services do not provide benefits for big/established LSPs.	General
**	-1.19	-3	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
	-1.31	-3	6	Infrastructure sharing mechanisms should be defined by local authorities	Governance
*	-1.42	-3	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General
**	-2.11	-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
	-2.45	-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services

4.3.2 *Perspective 2: Service connectivity and data exchange are necessary to develop efficient and sustainable last mile delivery. However, the industry still needs further digitalisation and convincing of its economic benefits.*

The general opinion in this perspective underpins the importance of connecting services to develop a more efficient and sustainable last mile. This is supported by a stakeholder quote, stating that both horizontal and vertical service connectivity is necessary to achieve door-to-door delivery chains and the bundling of flows. Paired with this comes a positive attitude towards the feasibility of implementing HC, relying on sufficiently established trust and willingness to collaborate between companies. One quote states that data exchange can reveal valuable information on demand patterns, traffic conditions, and resource allocation. These can lead to significant cost savings and improved service quality.

Simultaneously, this perspective highlights other barriers to overcome, such as digital readiness in smaller companies and financial hurdles. Especially smaller companies seem to struggle to upgrade their digital infrastructure, according to a stakeholder. Multiple stakeholder groups have stated in interviews and comments that the LMD market has tight profit margins, which is a big barrier for commercial actors to put their willingness into action.

An additional observation to note is the strong negative attitude towards municipalities enforcing companies to hyperconnect. An opinion frequently heard during participant interviews was that local authorities should only create a regulatory space in which companies can technically develop their solutions, and the same holds for the concept of connecting services in urban areas. One stakeholder reasoned that municipalities are not part of the primary delivery process and therefore are in no position to force companies to connect.

One distinguishing and extreme statement (22) in this perspective reveals a negative attitude towards white label delivery and warehousing services. This is in direct contrast to perspective 1. None of the participants in this perspective have provided an additional comment on the statement, so the reasoning behind the extreme ranking is unknown.

Quotes

Sapienza University of Rome (Research)
"Upgrading digital infrastructure in small companies is still underestimated in real cases, while in scientific research there are many papers going towards digitalization which is not true when you see the real world"

TU Delft (Research)
"Municipalities are not part of the primary delivery process and therefore cannot force companies to connect"

Sapienza University of Rome (Research)
"In many cases data sharing can reveal valuable insights into demand patterns traffic conditions and resource allocation leading to significant cost savings and enhanced service quality"

TU Delft (Research)
"In order to form door-to-door delivery chains services should be able to connect vertically to share client and order information. In order to bundle flows services should be able to connect horizontally to share transport and order information"

Perspective 2 in relation to the HC characteristics

Table 4.2 shows that this perspective agrees on the general notion that it is necessary for LMD services to connect. In terms of specific services, none were ranked positively. Instead, this perspective considers the IT aspect of HC a significant barrier, specifically because of two factors—

the first one being the insufficient readiness to exchange data, and the second one the lack of conviction that data exchange will yield economic benefits. When it comes to the characteristic of overall collaboration, there is an optimistic view of the willingness between commercial parties. Thus, this perspective believes in the willingness to collaborate, but acknowledges that the IT characteristic still forms a barrier to achieve this.

The nature of stakeholders in this perspective

This perspective is represented by four participants. An interesting observation is that these four all come from universities (TU Delft and Sapienza University of Rome).

Research institutes are not part of the primary delivery process, which is the role of LSPs. Instead, it generally contributes to the scientific body of knowledge and provides findings through conceptual and experimental studies. This could be an explanation on why the extreme and distinguishing statements are more general and conceptual when it comes to IT, rather than related to specific services in practice.

Table 4.2: Reduced set of distinguishing and extreme statements related to factor 2 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	2.06	4	20	Service connectivity is necessary to develop efficient and sustainable last mile delivery.	General
**	1.74	4	14	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	IT
**	1.51	3	13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.	IT
	1.44	3	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
**	1.23	3	7	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits.	Collaboration
**	-0.88	-2	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
**	-0.98	-2	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	Collaboration
**	-1.09	-3	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
	-1.33	-3	34	The shortage of personnel is a driving force for white label delivery services and warehousing.	Services
*	-1.64	-3	19	The idea of connecting services do not provide benefits for big/established LSPs.	General

Table 4.2: Reduced set of distinguishing and extreme statements related to factor 2 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	-1.93	-4	22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	Services
	-2.06	-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance

4.3.3 *Perspective 3: Local authorities must take the lead in zero-emission city logistics by setting sustainable criteria for purchasing and tenders. The current last mile delivery system is too segmented, and collaboration of services could increase the utilisation rate of assets, however it will be a challenge to involve large LSPs.*

This perspective takes a strong position in local authorities setting an example in regard to zero-emission city logistics by incorporating sustainability criteria in their tenders and purchasing policies. Furthermore, it has a strongly negative position on (local) governments enforcing companies to connect their services. One quote supporting this opinion argues that governments are in no position to force companies to work together. Collaboration also does not necessarily lead to higher efficiencies.

Additionally, this perspective acknowledges that the current last mile is too segmented and positively ranks the concept of connecting services on the edges of a cities. Possibly related to the former, the concept of microhubs inside city centres is ranked negatively. The sharing of parcel lockers is also ranked positively by a participant as quoted below. However, this is not reflected in the extreme or distinguishing statements. In contrast, drone delivery services in urban areas are ranked extremely negatively, similar to perspective 2. In addition, one quote argues that drone delivery in large cities where airports are located, due to the strong legislation regarding the use of airspace. Finally, this perspective has a negative position towards crowdshipping.

Another strong and distinguishing opinion is that connecting services will not provide sufficient benefits for large LSPs. A stakeholder quote states that large LSPs have already optimised their operations, e.g. fully loaded trucks, routing. This, paired with the possibility of losing a competitive market position, leads to a challenge to overcome to get services of different scales to collaborate. One participant argues that companies are more likely to fuse rather than collaborate because of the tight profit margins.

Quotes

DHL Express (LSP)
"The government can't force companies to work together, and doesn't necessarily say if will lead to efficiency. Most efficient is full truck loads and a very dense delivery network from which we should not take parcels out. We should focus on the white-label deliveries we don't know what's in (local winery, local butcher etc.) 80% of the movements just have 20% of the volume in. 20% of the movements is super efficient and we should not touch those as it will lead to inefficiencies"

Evofenedex (Industry association)
"Big LSP's already have the assets and data to have optimal routing and optimized running capacity (full loads). So why do they want to get involved in a more complex situation with different stakeholders on which they have to rely?"

Significance (Research)
"From what I've heard logistic operators are working in a field with tight profit margins, and any step that leads to loss of revenue or increase of costs could lead to a year with large losses. I think it's more likely that logistic operators will fuse"

Evofenedex (Industry association)
"Drone delivery is not feasible. How are you going to manage the airspace? Especially in big cities where airports are located, the legislation regarding airspace is so heavy that I believe this is never possible as a delivery solution"

DHL Express (LSP)
"Multiple LSPs can drop multiple shipments for different consumers at the same location (with a place to park) and multiple shipments from different LSPs can be collected and returned by the customer. So you

minimize the movements on both sides"

Perspective 3 in relation to the HC characteristics

Table 4.3 shows that this perspective agrees with the general notion that the current LMD system is too segmented and that collaboration between services could mitigate this. There are strong opinions on the governance aspect of HC, in particular setting an example in measures toward sustainability and the role it should tak e in connecting services. When it comes to services, there are both positive and negative attitudes depending on the specific types. It can be seen in Table 4.3 that this perspective contains more distinguishing and extreme statements on governance and services compared to the other perspectives. It should be noted that there is only one IT-related statement that is ranked highly. This could indicate that IT and information exchange is not seen as much of a barrier compared to the other perspectives.

The nature of stakeholders in this perspective

This perspective is represented by five participants. In this perspective, one LSP (DHL Express), two research agencies (TNO and Significance) and one industry association (Evofenedex) are represented.

The presence of an LSP and an industry association could explain the strong opinions regarding the role of (local) authorities. Since the LSP is part of the primary delivery process with hands-on knowledge, it could also explain the high number of strong opinions regarding specific service types. It is also interesting to note that this perspective is the only one that does not see curbside occupation as a major problem. An industry association reasons that delivery vehicles are only at at location for a short period of time. The fact that there are multiple stakeholder groups in this perspective indicates that there is a consensus on these statements.

Table 4.3: Reduced set of distinguishing and extreme statements related to factor 3 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	1.86	4	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
**	1.73	4	3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	General
*	1.43	3	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
	1.21	3	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
**	1.16	3	19	The idea of connecting services do not provide benefits for big/established LSPs.	General
**	1.05	2	26	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs.	Services

Table 4.3: Reduced set of distinguishing and extreme statements related to factor 3 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
*	0.96	2	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
*	-0.82	-2	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General
**	-1.05	-2	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
**	-1.13	-2	9	The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport.	Services
**	-1.14	-3	10	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs.	Governance
**	-1.17	-3	25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development.	Collaboration
**	-1.24	-3	28	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported.	Governance
	-1.39	-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance
	-2.09	-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services

4.4 The similarities and differences between perspectives

This section summarises the perspectives and how they relate to each other. This is done by looking at the similarities and differences between them. The goal of this analysis is to understand on which points the perspectives agree and disagree with each other. The resulting perspectives are depicted again below:

1. White label delivery services and parcel lockers are suitable solutions to be hyperconnected, however lack of trust and fear of losing competitive market position is still a barrier.
2. Service connectivity is necessary to develop efficient and sustainable last mile delivery, however the industry still needs further digitalisation and convincing of its economic benefits.
3. Local authorities need to take the lead in zero-emission city logistics by setting sustainable criteria for purchasing and tenders. The current last mile delivery system is too segmented, and collaboration of services could increase the utilisation rate of assets, however it will be a challenge to involve large LSPs.

Looking at the perspectives as they are, all have both overlapping and diverging parts between each other to a certain extent. At face value, perspective 3 seems to be the most diverging as it has a strong focus on the role of local authorities. Another method is to investigate the quantitative correlations between each factor. Three types of correlations can be distinguished:

1. A positive correlation between factors means that the statements were ranked similarly.
2. A near-zero correlation between factors means that the statements were ranked differently.
3. A negative correlation between factors means that the statements were ranked oppositely.

Figure 4.3 shows a positive correlation between factors 1 and 3, and a weaker positive correlation between factor 2 and factors 1 and 3. In other words, the statements in factor 2 were ranked more differently compared to factors 1 and 3. There is more similarity between factor 1 and 3, explained by a higher correlation.

	Factor 1	Factor 2	Factor 3
Factor 1	1	0.1499	0.4613
Factor 2	0.1499	1	0.1185
Factor 3	0.4613	0.1185	1

Figure 4.3: Correlations between the three factors (KADE v1.3.1)

To determine whether these correlations are statistically significant, Z-scores can be computed by dividing each correlation by the corresponding standard error of the difference in factor scores using the formula:

$$Z = \frac{r}{SE_{diff}}$$

The standard errors for differences between factor Z scores were 0.342 (Factor 1 vs 2), 0.297 (Factor 1 vs 3), and 0.353 (Factor 2 vs 3). The resulting Z-scores were:

- Factor 1 vs 2: $Z \approx 0.44$
- Factor 1 vs 3: $Z \approx 1.55$
- Factor 2 vs 3: $Z \approx 0.34$

None of these values exceeded the critical value of $|Z| > 1.96$ for statistical significance at the $p < 0.05$ level. Therefore, none of the inter-factor correlations were statistically significant, suggesting that the factors are not only conceptually distinct but also statistically independent. The modest correlation between Factor 1 and Factor 3 ($r = 0.4613$) indicates some degree of shared variance, but does not reach the threshold for significance. These findings support the validity of treating the factors as separate constructs.

To discover what these differences and similarities are qualitatively, the distinguishing statements from perspective 2 (Table 4.2) are analysed and compared to perspectives 1 and 3. In addition, the overall consensus-disagreement on statements is taken into account.

When analysing the extreme and distinguishing statements of perspective 2, there are a few statements that were ranked positively or negatively in all three perspectives. These statements are depicted in Table 4.4, where a statement is followed by the corresponding Q-sort value (Q-SV) in each perspective (P1, P2 and P3) and the characteristic. The distinguishing statements of perspective 2 that are excluded from this table were ranked oppositely in at least one other perspective.

Table 4.4: Set of similarly ranked distinguishing statements of perspective 2 related to perspectives 1 and 3 (p<0.05)

Statement	**P1 Q-SV**	**P2 Q-SV**	**P3 Q-SV**	**Characteristic**
Service connectivity is necessary to develop efficient and sustainable last mile delivery.	2	4	0	General
Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.	0	3	1	IT
Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	3	0	2	Collaboration
Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	-4	-1	-4	Services

The general observed similarity between the perspectives is the agreement that service connectivity and collaboration is necessary and that it could have a positive effect on the current LMD landscape. This is implicitly supported in perspective 1 by the opinion that fleet electrification alone is not sufficient in response to zero-emission zones. In terms of specific services, all perspectives consider drone delivery as infeasible in urban areas. All perspectives are positive or neutral towards the concept of shared parcel lockers. In terms of governance, there is a consensus that local authorities should not explicitly take up an enforcing role for companies to connect. However, this similarity cannot be observed from Table 4.4 because this was not a distinguishing statement from perspective 2. Lastly, all perspectives agree that most LMD companies are not digitally ready to share data, but perspective 2 has ranked this statement the highest. In conclusion, it can be seen that there are similarities in all characteristics, but none necessarily stands out from the other characteristics.

Although there are similarities, perspective 2 also has differences compared to the other perspectives. These differences in opinion, for example, are related to the reason why LSPs are not yet sharing more information and assets. Interestingly, only perspective 2 is neutral towards the statement that LMD is already sufficient and other urban challenges are more important. The other perspectives disagreed significantly with this statement. Perspective 2 is also unique with its positive attitude towards combining crowdshipping services with conventional delivery methods. The same holds for its negative stance on connecting services at the edge of the city rather

than inside the city.

As mentioned above, another way to discover similarities and differences is to analyse the overall consensus-disagreement ranking on statements. Taking into account the number of statements, the ones with the five lowest and highest ranking variances are shown in Table 4.5, whereas the complete set can be found in Figure C.4.

Table 4.5: Truncated set of statements with the five lowest and highest ranking variances between perspectives

Statement	P1	P2	P3	Var.	Char.
An open platform where logistics service demand and supply meet will be the future of last mile deliveries.	1	1	0	0.001	IT
The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	4	3	3	0.017	IT
The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city.	1	2	1	0.024	General
Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it.	1	0	1	0.032	General
An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones.	-2	-1	0	0.089	Governance
Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	-4	1	-2	0.969	Services
White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	1	-4	-1	1.121	Services
When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	-1	4	-1	1.146	IT
The idea of connecting services do not provide benefits for big/established LSPs.	-2	-3	3	1.380	General
Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	-3	0	4	1.556	Governance

These statements show that there is a neutral to positive stance on the concept of HC. The closest similarity, albeit very close to neutral, is in the idea that an open platform will be the future of last mile deliveries. All three perspectives strongly agree that fear of losing market position is still a major barrier to sharing information. Furthermore, there is a consensus that granting concessions to an LSP in car-free zones is not a desired way to achieve connectivity.

In contrast, Table 4.5 also reveals where the participant groups had the most varying opinions. The greatest disagreement is about the exemplary role that (local) authorities should embody by setting sustainability criteria for purchasing and tenders. Participants are also divided on whether connecting services would be beneficial for large and established LSPs. The motivation of LSPs to exchange data is strongly debated, whether companies are already able but not sufficiently convinced of its economic benefits yet. Lastly, pertaining to specific services, the concept of crowdshipping and white label services are topic of debate as well, whether they are worth

implementing.

Another way to approach the consensus-disagreement statements is to analyse those with at least one extreme ranking (4 or -4) and compare it with how they are ranked in the other perspectives. Table 4.6 depicts these statements with their ranking, variances and corresponding HC characteristic.

Table 4.6: Statements with at least one extreme ranking compared to the ranking in other perspectives

Statement	P1	P2	P3	Var.	Char.
The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	4	3	3	0.017	IT
The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	2	2	4	0.203	General
Municipalities need to have an enforcing role for companies to hyperconnect services.	-1	-1	-4	0.459	Governance
White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas.	4	2	1	0.089	Governance
Service connectivity is necessary to develop efficient and sustainable last mile delivery.	2	4	0	0.570	General
Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	-4	-1	-4	0.745	Services
Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	-4	1	-2	0.969	Services
White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	1	-4	-1	1.121	Services
When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	-1	4	-1	1.146	IT
Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	-3	0	4	1.556	Governance

This overview reveals some new statements that were not present in Table 4.4 and Table 4.5. There is a significant to strong agreement that the current LMD system is too segmented and that collaboration between services could be a solution. Furthermore, there is consensus that municipalities should not force companies to collaborate. One participant added that (local) governments should only establish the regulatory framework to stimulate growth in a desired market. Lastly, parcel consolidation through white label services is also ranked positively across all perspectives. The remaining statements overlap with those of the other tables.

Taking into account all the above approaches to identify similarities and differences between the perspectives, Figure 4.4 visually presents the findings. The green squares include similarities and differences in positive opinions, whereas the orange squares map similarities and differences in negative opinions. The difference of perspective 2 from the other perspectives can be seen by the number of opinions that are exclusively part of perspective 2. The similarities between perspectives are extracted mainly from general statements, while the differences are more related

to specific service and collaboration concepts, i.e., how to improve the LMD landscape. All perspectives see the benefits of HC to minimise vehicle movements in cities, but different ways are considered promising. Perspective 1 emphasises the importance for LSPs to look beyond fleet electrification and share assets. Perspective 2 is considerably open towards more services and collaboration methods, while perspective 3 includes more opinions related to governance.

In terms of negative opinions, most concerns about HC are shared between at least two perspectives. Fear of losing a competitive market position by sharing information is a shared concern among all perspectives. As mentioned earlier in this section, drone delivery services in cities are not considered feasible by all parties. Perspectives 1 and 3 express scepticism towards crowdshipping due to many external factors that could influence its potential benefit. Another shared area of concern is the economic benefits that hamper asset and information sharing, although the perspectives highlight different aspects. Perspective 2 is of the opinion that more economic incentive is required to get companies on board, while perspective 3 states that HC is not beneficial for large and established LSPs. Trust is a perceived issue in perspectives 1 and 3, while digital readiness is a prevalent concern in perspectives 2 and 3.

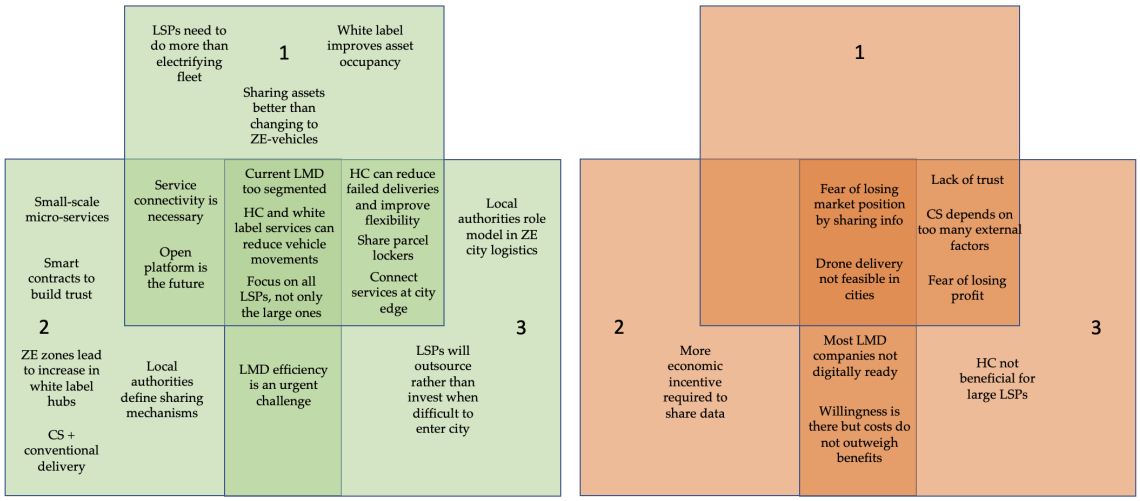

Figure 4.4: Similarities and differences in positive and negative opinions between all perspectives

4.4.1 Observed drivers and barriers from comments

To gain a better understanding of similarities and differences, comments on the extreme statements made by the participants can be analysed. In doing so, the implied drivers and barriers can be identified. The result of this analysis is depicted in Figure 4.5, where the drivers and barriers are highlighted, including the relations between them. It also indicates from which perspective these features were found. It can be observed that a barrier from one perspective can often be linked to a driver from another perspective. This is another confirmation that the extracted factors contain different viewpoints on the same matter. Features without a linked perspective are additions based on developments in practice.

The following observation shows that there are still challenges and barriers to overcome when it comes to applying HC aspects to last-mile methods. However, each barrier has an identified driver that serves as a counterpart. There are also drivers that could tackle more than one barrier.

One should also not disregard the fact that the logistics industry is constantly evolving, albeit sometimes slowly. However, there are companies that are already making collaborative efforts in their last mile. Change in mindset and business operations takes time. Regulatory actors have the power to set up the regulatory framework to stimulate positive market growth pertaining to collaboration of services.

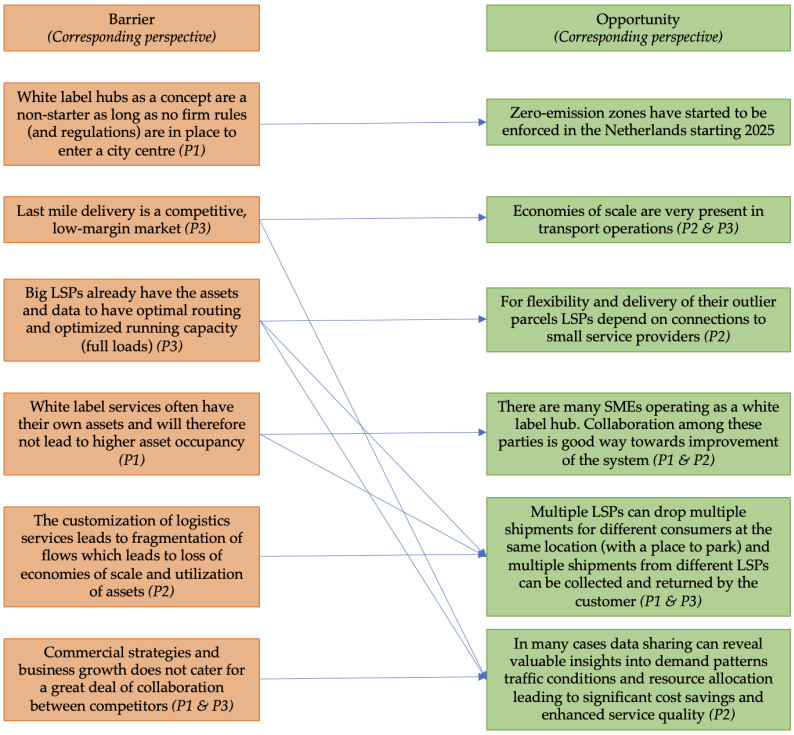

Figure 4.5: Named barriers and drivers to hyperconnectivity and last-mile delivery methods with their corresponding perspectives and opportunities

4.4.2 Comparing perspectives in relation to the HC characteristics

Several observations can be made when the HC characteristics represented in the perspectives are compared with each other. Perspective 1 has strong opinions on specific service types, as three out of four extreme statements fall into this category. What also stands out is the low number of IT-related extreme or distinguishing statements, that is, only one. In comparison, perspective 2 includes three statements related to IT. Furthermore, perspective 2 contains more distinguishing general and collaboration statements and fewer in the collaboration and governance category. Perspective 3 is more strongly opinionated on the governance aspect. Compared to the others, perspective 3 also contains the most distinguishing and extreme statements on services. To summarise, perspective 1 has the strongest opinions on services, while perspective 2 is more general with a slight focus on IT, and perspective 3 focuses on the governance and services aspect of HC.

4.4.3 Participant representation

Perspectives 1 and 3 are each represented by three different stakeholder groups (industry associations, LSPs, and research institutes), while perspective 2 is represented exclusively by universities. This distribution of stakeholder groups could explain (some of) the similarities and differences observed in Figure 4.4. Perspectives 1 and 3 are positive towards sharing parcel lockers, which could be explained by the presence of LSPs in these perspectives who already have parcel lockers in practice. Perspective 2 reveals a relatively optimistic view of emerging concepts such as crowdshipping and smart contracts, which could be the result of the innovative research nature of universities. Perspective 3 is the only one that does not see HC as beneficial for large LSPs, a perspective that includes an established LSP and an industry association.

The fact that, aside from universities, other stakeholder groups do not consolidate at one perspective makes it challenging to fully attach certain perspectives to these groups. This does not mean that the viewpoint of universities are entirely detached from other stakeholder groups because there are still overlapping opinions. Universities and research institutions tend to be more

involved in innovation research and might have more open or positive attitudes towards innovations compared to other actors. For this reason, it is important to keep exchanging findings between research and industry.

Municipalities and shippers were missing in the perspectives because there were no survey participants from these groups. One could argue that shippers' opinions are similar to LSPs because they should meet the needs of shippers in their operations.

4.5 Discussion of methodology and results

4.5.1 Methodology

This research was built on the Q-methodology, to which a few implications arise. The method has proven to be helpful in revealing different perspectives on a topic. However, scoping is a well-known challenge that is a constant trade-off. The decision has been made to include multiple emerging LMD methods with the potential to increase connectivity between services. This led to the scope and subject of the research being quite comprehensive. An implication of this was the need to provide more information and explanation to the participants to prepare them for the statements. The survey included a list of definitions and explanations of concepts to mitigate this. However, it is still possible that the statements were ranked differently because of other assumed definitions or different interpretations of the statements, which would lead to other rankings.

Another consequence of a broader scope is the difficulty in formulating the statements in such a way that it captures every view. To maintain a survey that would not take an excessive amount of time to complete, it was important to establish a limit to the number of statements. This made it very challenging to make a set of statements that fully covers a comprehensive subject such as HC and LMD services. Some statements consisted of multiple aspects in order to cover more of the subject while limiting the total number of statements. An example of such a statement is: *The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips)*. In the case that a participant agrees with this statement, interpretation is easy since they agree with the complete notion. However, a problem arises when a participant disagrees because it could mean two things. Either they disagree with a part of the statement or they disagree with the whole statement. Without additional information or explanation provided by the participant, it cannot be revealed which part they disagree with. In designing a Q-set, a trade-off must be made whether to capture views on a broader topic or to focus on a specific (sub)topic.

The survey was shared with approximately 50 actors deemed active in the logistics industry. However, not all people contacted responded. This could have led to the case that those who did participate were already more concerned about the topic.

In addition, the actual group of survey participants lacked regulatory actors as well as shippers. When it comes to shippers, it could be assumed that their opinions are generally reflected by the LSPs since these are their customers. However, the regulatory actors are to be seen as a separate stakeholder group whose opinions could diverge and would be valuable to the research.

There were cases where a participant, representing an industry association, questioned the objectivity of the statements. They were of the opinion that the set of statements was formulated in such a way that it steered towards a certain outcome. A meeting was held to explain the nature of the research and survey, as well as the possibility to validate the results at a later stage. However, they were still reluctant to contribute since they represent both their organisation and their affiliated companies in the industry. This raises an important point to keep in mind for future Q-surveys, namely whether the extremity of some statements could hinder participants or actor groups from contributing.

Finally, the survey was also shared with the Dutch Ministry of Infrastructure and Water Management. However, participants received a security warning when they opened the survey website. All other participants did not encounter this issue. There were attempts to solve this, but unfortunately to no avail. Because of this, no government views on the subject could be extracted.

4.5.2 Results

Research on hyperconnected city logistics has been increasing since the introduction of its concept by Faugere and Montreuil (2016). So far, no HC research has been found based on stake-

holder analysis. Van Duin, Van Son, et al. (2022) conducted similar research on the barriers and opportunities of PI characteristics in urban freight logistics with the same methodology. Taking into account the similarity, the results are mainly compared with their findings with additions from other literature. Gonzalez et al. (2023) performed a stakeholder analysis on how to improve the sustainability of last mile logistics in Spain.

A key development that occurred between the research by Van Duin, Van Son, et al. (2022) and this research, is the introduction and enforcement of ZE zones (Rijksoverheid 2025). This development has shifted the opinions on ZE zones from a hypothetical to an actual situation. In this research, LSPs express a slightly positive to significantly negative opinion toward doing more than electrifying their fleet in response to the ZE zones, depending on the perspective. This is in line with Van Duin, Van Son, et al. (2022), where some LSPs opt for increasing efficiency in operations rather than changing to ZE vehicles.

The observed potential of white label operations and parcel lockers in perspective 1 is supported by studies from de Bok et al. (2024), Lee et al. (2019) and Faugere and Montreuil (2016). In reality, the number of parcel lockers in the Netherlands is already increasing (nu.nl 2025). Sharing these assets could improve operational efficiency and asset occupancy due to better vehicle routing and consolidated infrastructure. However, lack of trust and fear of losing a competitive edge is a barrier to exchange information that was also found by Van Duin, Van Son, et al. (2022).

The need for service connectivity and data exchange as defined in perspective 2 is in line with the findings of Gonzalez et al. (2023). Participants in this study indicated that cooperation between distribution companies through sharing vehicles is desirable. Furthermore, the attitude in perspective 2 that the industry needs further digitalisation aligns with the barrier identified by Van Duin, Van Son, et al. (2022). There is also a similarity between perspective 2 from Van Duin, Van Son, et al. (2022) and perspective 3 from this research when it comes to government regulation. LSPs from both perspectives are relatively negative towards strong regulation to share data. Interestingly, a smaller LSP in perspective 1 of this research expressed a more positive attitude towards regulation.

Perspective 3 is partly defined by the opinion on the stronger role of local authorities, specifically by setting sustainable criteria in their purchasing and tender policy. This finding is not found in other studies, perhaps because it is quite specific. However, it might indicate something about the attitude of LSPs, namely the tendency to wait for local authorities to set an example or define clear regulatory frameworks. A possible way to tackle this attitude is to seek cooperation between city logistics stakeholders during the planning, implementation, and control of projects related to freight transport (Kiba-Janiak 2016). Local authorities could take this initiative when designing policies to stimulate sharing and collaboration mechanisms. An underlying opinion in this perspective, very similar to perspective 2, is that local authorities should not strongly regulate information sharing between companies, which is again related to the results of Van Duin, Van Son, et al. (2022). The general view that the current LMD system is too segmented is reflected in the existing literature and the proposed solutions (Matusiewicz 2020; Maxner et al. 2022; Paddeu et al. 2018; Van Duin, Slabbekoorn, et al. 2018). The last part of perspective 3 argues that it is a challenge to involve large LSPs because they have the resources to optimise their own operations. However, a Q-method study on urban consolidation centres by Van Duin, Van Son, et al. (2018) revealed that cost control is among the main focus points of cooperation. When it comes to sustainable delivery methods, a way to incentivise larger LSPs to cooperate is by proportionally allocating costs among all involved stakeholders (Van Duin, Slabbekoorn, et al. 2018). This last point is also supported by participants who have validated the perspectives in the next section.

Based on the different perspectives, the conclusion was drawn that participants had an overall positive attitude towards HC characteristics applied to LMD services. In conjunction with this, barriers were also identified that stand in the way of transition. However, a positive attitude does not always translate to actually implementing certain ideas. Participants can change their positive or negative views when a concept is implemented in practice.

There could also be situations where one perspective contains divergent views on a specific statement. For example, one perspective contained a wide range of rankings (both positive and negative) on whether to connect services on the edge or in the centres of cities. These internal differences were taken into account in the analysis as much as possible, also by feeding the perspectives back to participants as a validation step. The fact that these participants were grouped in the same perspective means there was a significant correlation in their survey result as well.

In order to identify drivers and barriers towards HC in LMD services more accurately, additional comments from participants were analysed. These comments did contribute to the observed drivers and barriers, but they were not directly linked to the correlations found in the quantitative Q-analysis part. The decision was made to include them because of their added value to the reasoning of certain rankings, but the ability to perform statistical validation was limited.

As mentioned in Subsection 4.5.1, not all stakeholder groups are included in this study. This means that the findings do not fully present an overarching view on the topic. It could be argued that the most important actor group is LSPs because they are directly involved in the logistical operations and concepts presented in this research. This also made it possible to design the statements in such a way that participating stakeholder groups could relate to it. For example, the presence of research institutes and LSPs made it easier to present more technical statements. Shippers or citizens might have had more trouble understanding the statements, despite the additional explanations provided. In the end, it is still a limitation that not all stakeholder groups are included.

The survey was completed by 14 participants with more representation from research institutes and universities compared to industry companies. According to the literature, the Q-method generally involves a sample size of between 12-40 participants (Webler et al. 2009). In theory, this study involved a sufficient number of participants, but the low number combined with an uneven representation could have skewed the results.

4.6 Validation with participants

The results from the survey were fed back to the participants as a validation step. The first method was through an online meeting with a participant where a brief overview of the research, a summary of the data collection, and the resulting perspectives were presented. If a participant was unable to attend an online meeting, validation was performed by email. Either way, the following questions were presented to the participants after a brief explanation of the specific perspective that they were assigned to:

1. *To what extent does your own perspective relate to the presented perspective and could you briefly explain why? (On a scale from 1-10)*
2. *Do you have any other comments regarding this perspective?*

The results are depicted below with shortened versions of the perspectives only for the report.

1. White label services and parcel lockers are suitable solutions, lack of trust and losing market position still a barrier
    - **BREYTNER**, 6, *"Everything is correct on paper, however it is more challenging in practice, hence the grade. We notice that the market for parcel lockers is growing. Customers do not want to miss packages again and LSPs do not want to have missed deliveries"*
2. Service connectivity necessary, industry needs further digitalisation and financial incentive
    - **TU Delft**, 8, *"The perspective reflects my view on the technological advancements, as well as the effect of this on connectivity between LSPs"*
3. Local authorities take the lead in sustainable purchasing and tenders, collaboration between services is needed but challenging to involve large LSPs
    - **Evofenedex**, 8, *"I am of the opinion that a government should set an example, however sometimes I hear that companies lose a tender despite being able to offer a more sustainable service. So the government needs to practice what they preach"*
    - **TNO***, 7, *"It is mostly a practice-what-you-preach role that pertains to a local authority's own purchasing and tender policy. It does not cover the whole process of city logistics so more is required"*
    - **TNO***, 4, *This [connecting services] could indeed lead to a better utilisation of assets, however two important side notes must be mentioned. Firstly, increased connection could increase the efficiency of vehicles in cities, but one should consider every delivery chain for larger LSPs (and the location of distribution centres) and whether it will bring advantages to every actor (for example, extra routes and, therefore, extra kilometers to exchange parcels between distribution centres). In other words: the 'efficiency gains' might not be distributed evenly and could lead to inefficiencies for individual parties. Secondly, this could be an opportunity for larger LSPs while the challenge is to involve the smaller companies (with a lower digitalisation readiness) as well.*
    - **Evofenedex**, 8, *"Indeed, I do no think you can persuade the large LSPs to collaborate more for the last mile. These companies can optimally allocate and transport their goods. For these companies, collaborating will probably lead to less efficient operations"*

In the case of TNO, the participant was under the assumption that perspective 3 had to be evaluated in two parts. The local authority part was graded 7, while the collaboration of services part was graded 4.

The number of participants who responded to the validation invitation was limited, that is, 4 participants. One participant was available for an online meeting and three participants (including from TNO) provided their feedback by email. As seen above, there was at least one participant per perspective available to provide validation.

5 Recommendations and conclusion

5.1 Recommendations

The following recommendations are based on the end result of the analysis and the topics that have been presented in the discussion section. This includes action points for stakeholder groups, recommendations on the methodology and its results, and proposed directions for future research.

5.1.1 Action points for actor groups

In order to investigate the technical feasibility of connecting services, local authorities can initiate public-private partnerships with the logistics industry, for example, in the form of pilots. The identified barriers emphasise the importance of developing a shared system that distributes costs and benefits proportionally. It is important to involve LSPs of varying sizes to evaluate whether a proposed concept leads to an even playing field for the market. This study revealed that white-label services and shared parcel lockers are considered promising concepts. Therefore, it is recommended to focus more on connecting these LMD methods. Through these public-private collaborations, the economic barrier for LSPs could be lowered because the focus is on the technical feasibility.

LSPs identify their drivers and barriers based on their direct experience of their delivery operations. In this study, this actor group recognises the potential of sharing assets and data to increase operational efficiency. However, this is not always taken into action due to barriers such as transition costs, lack of trust, or a perceived imbalance of cost and benefit distribution. LSPs can continue their efforts to increase their own operational efficiency, while also working together with (local) authorities and industry to explore the effects of service connection. Considering that this study revealed the potential of shared parcel lockers and white label services, LSPs could specifically explore these concepts. If the willingness from LSPs is there to change, they should be provided with the opportunity to obtain knowledge on how these specific barriers can be overcome.

Research institutes conduct studies that are relevant for LSPs and can incentivise LSPs to try out innovations in their delivery operations. Provided the consensus among all perspectives that the current LMD system is too segmented and that HC could potentially mitigate that, research institutes should continue to put effort in HC-focused research, e.g., *URBANE* (Urbane 2025). There is also a partly shared opinion that an open platform for LMD will be the future. This is a very broad notion that further research could help in the development of specific feasible solutions. Although some specific types of services contain neutral to negative views from other stakeholder groups, this does not mean that research on these should be stopped. In some cases, it takes time for other actors to adopt new ideas with valid concerns. This could also be the case with concepts such as crowdshipping and implementing smart contracts between parties. Therefore, it is important for universities and research institutes to remain engaged with other actors to see how opinions on these innovations form over time. To make all this possible, the government should continue to provide research possibilities for these research institutes.

The HC community should be aware of the perceived barriers in practice. In the process of gaining more knowledge, they should present their findings and proposed concepts to the logistics industry. This could be done in the form of pilots in collaboration with governments and industry.

5.1.2 Methodology and results

The use of Q-methodology for a study requires a consideration on how to scope the statements. Now that certain LMD methods are considered more promising than others, it could help narrow the scope. In doing so, a larger part of the discourse can be covered in the statements, which could reveal opinions on the topic in more detail.

Since this research reveals which HC characteristics are perceived in a positive and negative way, it could be interesting to dissect these characteristics to try revealing the underlying preferences of actor groups. The identified barriers could not be fully attributed to specific stakeholder groups. By presenting HC characteristics in more detail, perhaps combined with a certain design of a hyperconnected system, more accurate opinions could be revealed.

Some statements had two separate statements merged into one. It would be interesting to split these into separate statements, and see if the results would change. In general, the formulation of statements is very important in order to yield useful results.

Not all stakeholder groups participated in this research, so their perspectives on implementing HC characteristics in LMD services were not captured. Of the different stakeholder groups, shippers, receivers and (local) authorities were not included. This was not necessarily by choice, but none of the people contacted in these groups responded to the survey invitation. It can be argued that the participating industry association represents a part of the missing stakeholder groups, but direct participation from these groups could lead to different results. It is recommended to try to involve all stakeholder groups in future research. In doing so, the statements should be formulated in such a way that all groups can relate to them.

5.1.3 Future research directions

When it comes to services, white label services are considered promising, but there is a wide range of ways these services are characterised, in terms of connected modalities or type of goods that are handled. Therefore, it is recommended to research what type of white label service is feasible to be implemented on a larger scale, considering aspects like financial and technical feasibility. Based on the potential recognised in shared parcel lockers, it is worth researching how they can be technically implemented and, considering HC, how they can potentially be connected to other service types to provide more flexibility in parcel delivery. Combining the latter point with the collaboration aspect of HC, it is worth conducting more research on which services have the potential to be connected vertically and horizontally.

Many barriers are related to the perceived negative effects of sharing information in a connected delivery system. These perceived effects are related to losing market position, trust, digital readiness, and costs. These are each directions that future research could focus on. For example, research on designing a connected system that is transparent and fair in the distribution of costs and benefits. Another direction could be investigating how to create a platform that reduces the digital threshold to become part of an interconnected delivery system, or which innovations could enable controlled transparency and as a result build trust between parties.

5.2 Conclusion

The main goal of this research is to investigate the drivers and barriers between stakeholder groups that exist for the implementation of HC in LMD methods. This main question, along with

the sub-research questions, has been answered by investigating the varying perspectives of different stakeholder groups.

Parcel delivery companies in the Netherlands are facing long-standing challenges in a market with tight margins, combined with more recent ones like the zero-emission zones in city centres. There are certain emerging HC aspects that have the potential to mitigate these challenges. Characteristics such as IT, infrastructure, and asset exchange can improve routing decisions, resulting in fewer vehicle movements and kilometers driven.

Promising last mile methods have been researched on a conceptual and quantitative level, however, less research has been conducted when it comes to combining these service with HC aspects.

What are the characteristics of hyperconnectivity according to the existing literature?

The main characteristics of HC are defined by Crainic and Montreuil (2016) where they combine the two concepts of PI and city logistics. This research focused on the HC aspect between services and the impact on stakeholder interactions. There are a few concepts that are more relevant, considering this focus. Based on relevant aspects of HC, the following characteristics can be extracted:

- Services: Specific LMD service types to be connected.
- Collaboration: LSPs cooperating on an operational level.
- IT: Information exchange between parties that enables operational synchronisation.
- Governance: Authorities have the legislative power to incentivise interconnectivity between industry actors.

What dominant perspectives can be identified among last mile delivery actors on emerging hyperconnectivity?

Based on literature research and interviews, statements have been formulated to pose to relevant stakeholder groups, consisting of academia, LSPs and branch organisations. Participants were asked to rank the statements according to the degree of agreement or disagreement with them.

This resulted in three different perspectives, each providing a view on the topic:

1. White label delivery services and parcel lockers are suitable solutions to be hyperconnected, however lack of trust and fear of losing competitive market position is still a barrier.
2. Service connectivity and data exchange are necessary to develop efficient and sustainable last mile delivery. However, the industry still needs further digitalisation and convincing of its economic benefits.
3. Local authorities must take the lead in zero-emission city logistics by setting sustainable criteria for purchasing and tenders. The current last mile delivery system is too segmented, and collaboration of services could increase the utilisation rate of assets, however it will be a challenge to involve large LSPs.

What can be noted from all perspectives, is that there is a general recognition that the current state of last mile delivery is too segmented, and that connecting services can be a solution. The most promising LMD concepts for connecting are white-label delivery services and parcel lockers. Perceived barriers to doing so include fear of losing a competitive market position by sharing information, lack of economic incentive, and concerns that the distribution of costs and benefits among parties will be uneven. These barriers are related to the IT and Collaboration

characteristics of HC. (Local) authorities have the opportunity to lower these barriers by initiating collaboration with multiple stakeholder groups through public-private initiatives. With recently enforced regulations such as ZES, and emerging openness toward certain asset and information sharing concepts among LSPs, stakeholders in the LMD system can work together to achieve more sustainable last mile logistics.

Is there a relationship between the perspectives and stakeholder groups?

Two out of three perspectives are represented by different stakeholder groups, whereas one perspective is represented by universities, that is, perspective 2. Uniquely, this perspective is generally positive towards innovative solutions like implementing smart contracts and crowd-shipping. It also considers the IT aspect of HC a significant barrier. This does not mean that the viewpoints of universities and research institutions are detached from other stakeholder groups because it also has overlapping opinions with other perspectives. Their natural tendency to perform innovation research might result in a more open or positive attitude towards innovations compared to other actors. Therefore, it is important to continue to exchange findings between research and industry.

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A Interviews

A.1 Gemeente Rotterdam

The distinction in policy between different segments (e.g. construction, packages) is very relevant.

Larger players, especially international ones, generally have more capabilities and experience to optimise their processes.

Construction logistics, for example, has a special place because it is largely project-related. Is a housing project being realised? Such a project usually takes a year or two, perhaps even three. But then it is gone again. Think of the early construction phase when piles have to be transported. That is a process that in a sense has maximum optimisation. When you then move on to the finishing phase, you very often come across the situation with all kinds of subcontractors who do certain aspects of the finishing—plasterers, painters and plumbers. They all come to the construction site with vehicles. The assumption is that efficiency improvements are possible there, that what and who is transported can be done with fewer vehicles.

In Rotterdam, we have created a covenant for the introduction of ZES (Zero Emission City Logistics). The aim is to try to make that a reflection of the segments. This also includes the parcel delivery services, DHL, PostNL and DPD. Then you already have a very large part of the total turnover. It is true that there are many actors, but from a certain line of reasoning you can say: if you want to organise parcel delivery more efficiently in the city, then you mainly look at the largest segment.

Very often small entrepreneurs have logistic vehicles to pick up and deliver things, while transport is not their core business at all. But they are not able or willing to consider: maybe I can optimise my business operations by simply outsourcing transport to the professional, for a price of course.

We're trying to take on an example role in our purchasing process. With publishing tenders that involve the physical transport of goods or services, we consider: do we include sustainability criteria to show that the transport will be done zero emission?

In many cases you can already say: we demand you to be zero emission because the vehicles are available. But the process itself is still a challenge because it also affects the efficiency of your business operations.

Stimulating or regulating is not even that important yet, but you need to be able to express: how efficient is your logistics chain? We also try to create a digital version of the city using simulation tools. Through this way, we try to simulate and compare different systems and policty decisions.

A.2 Cityhub

All stakeholders have become more open and willing to exchange information, in order to achieve less vehicle movements.

Cities have become more crowded and dense. Along with increasing policy, these could be the factors why companies are more open.

Proof that some concepts are viable solutions (like hubs at the edge of the city) help companies consider these.

There are some parties that make use of new service types out of an intrinsic motivation to be sustainable.

Consolidation goes further than just bundling goods at the edge of the city. It's also about being able to having less drop-off points for clients, especially in the last mile. It saves time and there is no need to invest in new vehicles.

The labor shortage is also a stimulus to consolidate operations.

Local authorities should have a facilitating role with proper enforcement.

It would be interesting to explore the options of transporting goods via existing infrastructure such as tram lines.

An interesting challenge is to consolidate different data and information streams from multiple parties and plan routings in a smarter way. To have clear insights on things like CO2 reports but also on who charges who. A platform like this should be accessible to all parties involved like shippers and customers.

Parties need to be open to discuss their strengths and weaknesses, to engage in an open conversation without the fear of losing business.

The market should regulate itself.

Collaboration is born out of mutual trust and ultimately putting it down on paper.

A.3 MyPUP

What we do is a form of hyperconnectivity because different parties are able to use our infrastructure.

I believe in hyperconnectivity and an important factor is information exchange. This would be a collaboration where parties learn to say: I will let another party do my last mile and I will pay for that.

The culture of collaboration hasn't really changed in the last 10 years but the volume has increased.

Profit margins are getting slimmer and it's not feasible to keep driving the same routes with more vehicles.

Innovation power in large companies can be smaller than small companies because of the scale of investments needed.

The logistics market is one with really low profit margins.

If you really want to tackle congestion, municipalities need to enforce car-free zones. Parties have to collaborate as local authorities give concessions to party X to enter a certain zone.

The Netherlands has a culture of expecting deliveries to be made at home. Other countries are more used to going to pick-up points.

In general, customers in The Netherlands expect delivery to be free.

The vision of sustainability needs to come from the national government which in turn can trickle it down to local authorities.

In an ideal situation, you can split operational regions geographically. One party covers one city and another party covers the other. You need complete trust and proper information exchange.

I believe in chain integration, parties who collaborate more intensively and exchange information.

A.4 TNO

Enforcing zero emission zones is one opportunity to increase sustainability in city logistics.

Most of the change is triggered by smaller developments, like scarcity of public space or labor shortage.

A game changer would be to really enforce zones where vehicles are heavily limited.

Autonomous transport is a possibility but it will be challenging in an urban area.

In spatial planning and area development, the factor of logistics has not been taken into account sufficiently. But it has started to change because accessibility to logistics services has become a commodity (parcel lockers in apartment building, pick-up and drop-off locations).

Cities cannot force companies to connect. They can only change the conditions and playing field to stimulate connection.

LSPs are already outsourcing certain parts of their operations to other services.

LSPs do not want to give away a part of their core business. They would rather maintain control over their operations.

The role of an expert is to remain as objective as possible in research and consultancy. You can show what are the advantages, disadvantages and feasibilities through a proof of concept.

A singular hyperconnected system is not necessary. You could have three competing systems where the level of collaboration is already increased compared to the current situation.

B Q-set

Table B.1: Complete Q-set with statements and their corresponding HC characteristic

#	Statement	Characteristic
1	The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city.	General
2	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery.	Collaboration
3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	General
4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General
5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Collaboration
6	Infrastructure sharing mechanisms should be defined by local authorities.	Governance
7	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits.	Collaboration
8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
9	The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport.	Services
10	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs.	Governance
11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services
12	An open platform where logistics service demand and supply meet will be the future of last mile deliveries.	IT
13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.	IT
14	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	IT
15	Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration.	IT
16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres.	General
17	Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it.	General

Table B.1: Complete Q-set with statements and their corresponding HC characteristic

#	Statement	Characteristic
18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
19	The idea of connecting services do not provide benefits for big/established LSPs.	General
20	Service connectivity is necessary to develop efficient and sustainable last mile delivery.	General
21	The best way to form a hyperconnected last mile delivery network that is more robust and impactful could be established by small-scale micro-services collaborating.	Collaboration
22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	Services
23	If it becomes more problematic for LSPs to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles.	General
24	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas.	Services
25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development.	Collaboration
26	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs.	Services
27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
28	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported.	Governance
29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
31	An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones.	Governance
32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance
33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	Collaboration
34	The shortage of personnel is a driving force for white label delivery services and warehousing.	Services

C Factor analysis

C.1 Factor Q-sorts

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
** ◄ Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled	** ◄ Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders	If it becomes more problematic for LSPs to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development	** ► White label services improve asset occupancy and is worth implementing to reduce investment and operational costs	** ► Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company	** ► White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas
Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods	Infrastructure sharing mechanisms should be defined by local authorities	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits	The best way to form a hyperconnected last mile delivery network that is more robust and impactful could be established by small-scale micro-services collaborating	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible	The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips)	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services	The fear of losing a competitive market position is still a big barrier for commercial actors to share information
	* ◄ Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges	* The idea of connecting services do not provide benefits for big/established LSPs	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported	* Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit	Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration	Service connectivity is necessary to develop efficient and sustainable last mile delivery	** ► It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres	
		An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones	** ► Municipalities need to have an enforcing role for companies to hyperconnect services	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs	Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it	* It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements		
			The shortage of personnel is a driving force for white label delivery services and warehousing	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs	An open platform where logistics service demand and supply meet will be the future of last mile deliveries			
				The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport				

Legend

* Distinguishing statement at P< 0.05

** Distinguishing statement at P< 0.01

► z-Score for the statement is higher than in all other factors

◄ z-Score for the statement is lower than in all other factors

Figure C.1: Composite Q-sort of factor 1 (KADE v1.3.1)

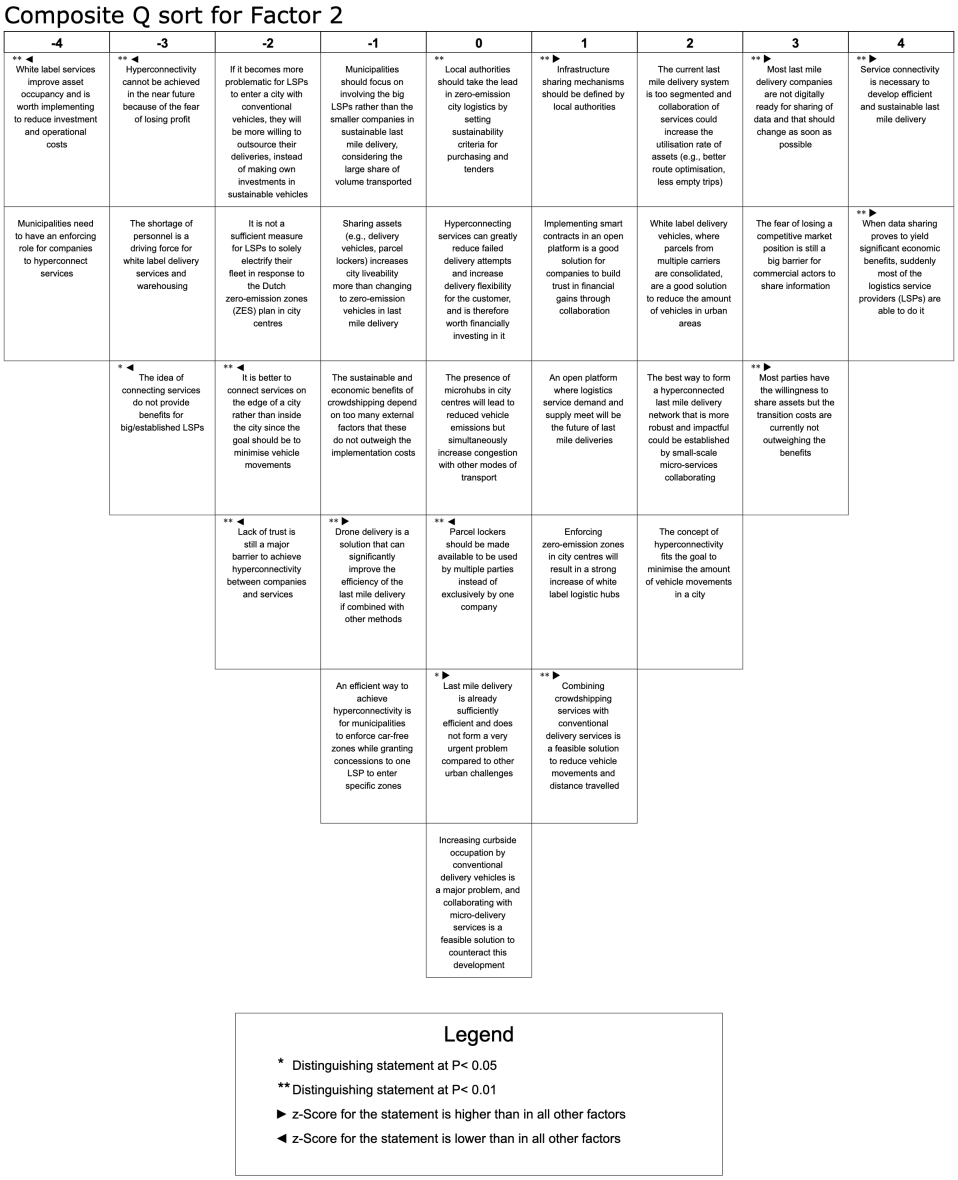

Figure C.2: Composite Q-sort of factor 2 (KADE v1.3.1)

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
Municipalities need to have an enforcing role for companies to hyperconnect services	** ◀ Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres	* ◀ Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration	An open platform where logistics service demand and supply meet will be the future of last mile deliveries	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company	* ▶ It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements	** ▶ Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders
Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods	** ◀ Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development	* Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges	The shortage of personnel is a driving force for white label delivery services and warehousing	Service connectivity is necessary to develop efficient and sustainable last mile delivery	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas	** ▶ The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs	The fear of losing a competitive market position is still a big barrier for commercial actors to share information	** ▶ The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips)
	** ◀ Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported	** Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it	The best way to form a hyperconnected last mile delivery network that is more robust and impactful could be established by small-scale micro-services collaborating	** ▶ If it becomes more problematic for LSPs to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles	* ▶ Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit	** ▶ The idea of connecting services do not provide benefits for big/established LSPs	
		** ◀ The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport	** White label services improve asset occupancy and is worth implementing to reduce investment and operational costs	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery	Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services		
			Infrastructure sharing mechanisms should be defined by local authorities	An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones	The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city			
				Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits				

Legend

* Distinguishing statement at P< 0.05

** Distinguishing statement at P< 0.01

► z-Score for the statement is higher than in all other factors

◀ z-Score for the statement is lower than in all other factors

Figure C.3: Composite Q-sort of factor 3 (KADE v1.3.1)

C.2 Distinguishing and extreme statements

Table C.1: Complete set of distinguishing and extreme statements related to factor 1 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	2.13	4	24	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas.	Services
	1.51	4	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
	1.18	3	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Collaboration
	1.12	3	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	Collaboration
**	0.88	3	16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres.	General
**	0.86	2	2	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery.	Collaboration
*	0.76	2	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
**	0.66	1	22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	Services
*	0.21	0	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
**	-0.41	-1	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance
*	-0.81	-2	19	The idea of connecting services do not provide benefits for big/established LSPs.	General
**	-1.19	-3	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
	-1.31	-3	6	Infrastructure sharing mechanisms should be defined by local authorities	Governance
*	-1.42	-3	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General

Table C.1: Complete set of distinguishing and extreme statements related to factor 1 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	-2.11	-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
	-2.45	-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services

Table C.2: Complete set of distinguishing and extreme statements related to factor 2 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	2.06	4	20	Service connectivity is necessary to develop efficient and sustainable last mile delivery.	General
**	1.74	4	14	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	IT
**	1.51	3	13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.	IT
	1.44	3	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
**	1.23	3	7	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits.	Collaboration
**	0.63	1	6	Infrastructure sharing mechanisms should be defined by local authorities.	Governance
**	0.30	1	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
**	0.13	0	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
**	0.05	0	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Collaboration
*	-0.07	0	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General
**	-0.47	-1	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services
**	-0.88	-2	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
**	-0.98	-2	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	Collaboration
**	-1.09	-3	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
	-1.33	-3	34	The shortage of personnel is a driving force for white label delivery services and warehousing.	Services

Table C.2: Complete set of distinguishing and extreme statements related to factor 2 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
*	-1.64	-3	19	The idea of connecting services do not provide benefits for big/established LSPs.	General
**	-1.93	-4	22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	Services
	-2.06	-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance

Table C.3: Complete set of distinguishing and extreme statements related to factor 3 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	1.86	4	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
**	1.73	4	3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	General
*	1.43	3	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
	1.21	3	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
**	1.16	3	19	The idea of connecting services do not provide benefits for big/established LSPs.	General
**	1.05	2	26	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs.	Services
*	0.96	2	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
**	0.47	1	23	If it becomes more problematic for LSPs to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles.	General
*	-0.36	-1	15	Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration.	IT
**	-0.72	-1	22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	Services
*	-0.82	-2	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General
**	-1.05	-2	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
**	-1.13	-2	9	The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport.	Services

Table C.3: Complete set of distinguishing and extreme statements related to factor 3 (** p<0.01, * p<0.05)

Sig.	Z-score	Q-sort	#	Statement	Characteristic
**	-1.14	-3	10	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs.	Governance
**	-1.17	-3	25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development.	Collaboration
**	-1.24	-3	28	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported.	Governance
	-1.39	-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance
	-2.09	-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services

C.3 Consensus-Disagreement between factors

Nm	Statement	1	2	3	Variance
12	An open platform where logistics service demand and supply meet will be the future of last mile deliveries	1	1	0	0.001
8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information	4	3	3	0.017
1	The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city	1	2	1	0.024
17	Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it	1	0	1	0.032
31	An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones	-2	-1	0	0.089
34	The shortage of personnel is a driving force for white label delivery services and warehousing	-1	-3	-1	0.148
21	The best way to form a hyperconnected last mile delivery network that is more robust and impactful could be established by small-scale micro-services collaborating	-1	2	0	0.171
15	Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration	1	1	-1	0.178
3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips)	2	2	4	0.203
2	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery	2	-1	0	0.212
28	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported	-1	-1	-3	0.215
23	If it becomes more problematic for LSPs to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles	-2	-2	1	0.234
9	The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport	0	0	-2	0.251
5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company	3	0	2	0.266
13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible	0	3	1	0.276
4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges	-3	0	-2	0.306
10	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs	0	1	-3	0.383
25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development	0	0	-3	0.398
26	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs	0	-1	2	0.422
32	Municipalities need to have an enforcing role for companies to hyperconnect services	-1	-4	-4	0.459
24	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas	4	2	1	0.503
20	Service connectivity is necessary to develop efficient and sustainable last mile delivery	2	4	0	0.57
16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres	3	-2	-2	0.571
7	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits	-2	3	0	0.606
6	Infrastructure sharing mechanisms should be defined by local authorities	-3	1	-1	0.664
18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit	0	-3	2	0.72
11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods	-4	-1	-4	0.745
33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services	3	-2	2	0.871
30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements	2	-2	3	0.944
27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled	-4	1	-2	0.969
22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs	1	-4	-1	1.121
14	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it	-1	4	-1	1.146
19	The idea of connecting services do not provide benefits for big/established LSPs	-2	-3	3	1.38
29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders	-3	0	4	1.556

Figure C.4: Statements sorted by consensus vs. disagreement (KADE v1.3.1)

C.4 Extremely ranked statements with comments provided

Significance (1)

Table C.4: Extremely ranked statements with additional comments, Significance (1)

Rank	Nr.	Statement	Explanation
-4	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	Many people complain about delivery whether it's noise congestion air pollution or just antisocial driving/parking.
-4	10	Enforcing zero emission zones in city centres will result in a strong increase of white label logistic hubs.	I don't think this will happen automatically. Merely enforcing a zero-emission zone could also lead to large logistic operators having an extra advantage in being able to purchase clean vehicles and small operators going bankrupt or fusing with others.
4	3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	Economies of scale are very present in transport operations.
4	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	From what I've heard logistic operators are working in a field with tight profit margins and any step that leads to loss of revenue or increase of costs could lead to year with large losses. I think it's more likely that logistic operators will fuse.

Signficance (2)

Table C.5: Extremely ranked statements with additional comments, Significance (2)

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	To be able to achieve drone delivery drastic measures will need to be taken into consideration for the urban grid. Even if efficiency is increased issues of privacy and safety will be very prominent and highly prioritized. Besides the sky will also become heavily occupied with machines which does not add to the liveability of urban areas.
-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Crowdshipping is nice as a concept of an ideal world. People need an incentive to "get out of their way" to deliver something. This starts complicating the logistics responsibilities cannot be easily set and guarantees of the parcels delivery are not possible. So the delivery price should be reduced if a "non-professional" person is actually delivering a parcel but the complexities are increased.
4	16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero emission zones plan in city centres.	Usually such a plan comes with a reinforcement of type of vehicle as well preference given on smaller vehicles to achieve livability goals. So electrification is not the only solution. Even if the vehicle size does not change the logistic model of the LSP will have to change to take charging into account.
4	24	White-label delivery vehicles, where parcels from multiple carriers are consolidated, are a good alternative to reduce the amount of vehicles in urban areas.	Parcels assigned to different LSPs can be consolidated in one vehicle to reach the same area this can lead to fewer empty trips hence fewer vehicle kilometers and traffic in urban areas.

TU Delft (1)

Table C.6: Extremely ranked statements with additional comments, TU Delft (1)

Rank	Nr.	Statement	Explanation
-4	19	The idea of connecting services do not provide benefits for big/established LSPs.	For flexibility and delivery of their outlier parcels LSPs depend on connections to small service providers.
-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Municipalities are not part of the primary delivery process and therefore cannot force companies to connect.
4	3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	The customization of logistics services leads to fragmentation of flows which leads to loss of economies of scale and utilization of assets.
4	20	Service connectivity is necessary to develop efficient and sustainable last mile delivery.	In order to form door-to-door delivery chains services should be able to connect vertically to share client and order information. In order to bundle flows services should be able to connect horizontally to share transport and order information.

TU Delft (2)

Table C.7: Extremely ranked statements with additional comments, TU Delft (2)

Rank	Nr.	Statement	Explanation
-4	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	Maybe efficient from a cost perspective of an individual LMD but definitely not from a social and sustainability perspective.
-4	19	The idea of connecting services do not provide benefits for big/established LSPs.	I strongly believe large companies will also benefit not just the smaller ones.
4	14	When data sharing proves to yield significant economic benefits suddenly most of the logistics service providers are able to do it.	Companies are driven by profits more than by sustainability.
4	24	White-label delivery vehicles, where parcels from multiple carriers are consolidated, are a good alternative to reduce the amount of vehicles in urban areas.	Unused capacity is a big issue that can be avoided by white label delivery vehicles.

RUAS*

Table C.8: Extremely ranked statements with additional comments, RUAS

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Drones are not allowed to fly everywhere. Also the AVG-law can be an opposing factor.
4	3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	There are many SMEs operating as a white-label hub. Collaboration among these parties is good way towards improvement of the system.

*Two out of four extremely ranked statements were provided with comments.

Cycloon

Table C.9: Extremely ranked statements with additional comments, Cycloon

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Drone delivery is too expensive and does not solve any problems of the current providers.
-4	22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	White label services often have their own assets and will therefore not lead to higher asset occupancy.
4	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Investment in parcel lockers is high and consumers do not want to go to multiple lockers. Therefore sharing makes the most sense.
4	10	Enforcing zero emission zones in city centres will result in a strong increase of white label logistic hubs.	Enforcement is key however my expectations of this being done are low.

PostNL

Table C.10: Extremely ranked statements with additional comments, PostNL

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	This will never be a good solution for last mile in urban areas. It could only be beneficial for rural areas.
-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	This will not reduce movements within city centers.
4	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	This will improve the use of parcel lockers greatly.
4	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	I've done intensive research on the topic on shared logistics and this was one of biggest issues.

DHL Express

Table C.11: Extremely ranked statements with additional comments, DHL Express

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Imagine all the drones above our heads.. the energy you need to fly out 1 parcel is massive and will go against sustainability/efficiency and liveability/wellbeing.
-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.	The government can't force companies to work together + doesn't necessarily say if will lead to efficiency. Most efficient is full truck loads and a very dense delivery network from which we should not take parcels out. We should focus on the white-lable deliveries we don't know what's in (local winery local butcher etc.) 80% of the movements just have 20% of the volume in. 20% of the movements is super efficient and we should not touch those as it will lead to inefficiencies.
4	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Multiple LSPs can drop multiple shipments for different consumers at the same location (with a place to park) and multiple shipments from different LSPs can be collected and returned by the customer. So you minimize the movements on both sides.
4	29	Local authorities should take the lead in zero emission city logistics by setting sustainability criteria for purchasing and tenders.	When they dont they would not be credible to implement ZE zones.

TNO

Table C.12: Extremely ranked statements with additional comments, TNO

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Drones won't work in urban areas: too expensive limited load capacity (i.e. a van carries 100-150 parcel deliveries a drone 1 or 2) and the number of facilities in close vicinity is should be very high in order to reduce time and distance.
-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Crowdshipping is in theory a nice optimization question but in practice it requires a full transparency in all spare transportation capacity (of individuals and freight vehicles) which is nearly impossible.
4	6	Infrastructure sharing mechanisms should be defined by local authorities.	Allocating and regulating space has a bigger impact on the efficiency of city logistics than emissions requirements.
4	16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero emission zones plan in city centres.	If electric vehicles become financially feasible while cities continue to grow conventional vehicles are replaced one-to-one by electric ones which might eventually lead to even more vehicles.

Evofenedex

Table C.13: Extremely ranked statements with additional comments, Evofenedex

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Drone delivery is not feasible. How are you going to manage the airspace. Especially in big cities were airports are located the legislation regarding airspace is so heavy that I believe this is not never possible as delivery solution.
-4	25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development.	I do not see curbside occupation as a major problem. Delivery services are only at location for a short period of time.
4	19	The idea of connecting services do not provide benefits for big/established LSPs.	Big LSP's already have the assets and data to have optimal routing and optimized running capacity (full loads). So why do they want to get involved in a more complex situation with different stakeholders on which they have to rely.
4	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	How to create the trust between multiple LSP's will be difficult in my opinion.

BREYTNER

Table C.14: Extremely ranked statements with additional comments, BREYTNER

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	It's a daydream.
-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Crowdshipping lacks scale to counterweigh big LSPs.
4	24	White-label delivery vehicles, where parcels from multiple carriers are consolidated, are a good alternative to reduce the amount of vehicles in urban areas.	Higher drop density and utilisation rate results in best financial performance.
4	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	This is number 1 reason for not sharing.

Sapienza Universita de Roma*

Table C.15: Extremely ranked statements with additional comments, Sapienza Universita de Roma

Rank	Nr.	Statement	Explanation
-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	It's a daydream.
-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Crowdshipping lacks scale to counterweigh big LSPs.
4	13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.	Upgrade Digital Infrastructure in small companies are still underestimated in real cases while in scientific research there are many papers going toward digitalization which is not true when you see the real world.
4	14	When data sharing proves to yield significant economic benefits suddenly most of the logistics service providers are able to do it.	In many cases data sharing can reveal valuable insights into demand patterns traffic conditions and resource allocation leading to significant cost savings and enhanced service quality.

*Two out of four extremely ranked statements were provided with comments.

D Scientific paper

Implementation of hyperconnectivity characteristics in parcel last mile delivery services: Dominant stakeholder perspectives revealed using Q-methodology

By Abia Tanusubroto

***Abstract*— Hyperconnectivity (HC) is an emerging concept in logistics that allows for large-scale collaboration of logistics services through shared assets, information exchange, standardised protocols, and flow alignment. A hyperconnected last mile delivery (LMD) system could lead to more optimised routing decisions through processes such as consolidation with fewer vehicle kilometres and more sustainable operations as a result. However, little is known about the combination of connected services that are deemed promising among stakeholders. The Q-methodology was applied to reveal the dominant perspectives among stakeholders on the implementation of HC characteristics in LMD services. Subsequently, the results were fed back to participants to validate whether the analysis was performed accurately. This paper concludes that there is a consensus among stakeholders that the current LMD system is too segmented and that services such as shared parcel lockers and white label concepts could help consolidate delivery operations. Important barriers identified were the fear of losing a competitive market position by sharing information, as well as economic concerns.**

I. INTRODUCTION

The e-commerce industry has been growing consistently and experienced an additional boost during the COVID-19 pandemic (Barthel et al. 2023). As a result, the logistics industry that facilitates this development is growing in volume of packaged goods transported to meet demand (Mohammad et al. 2023). The current logistics system has been considered unsustainable from an economic, environmental, and social point of view (Montreuil 2011). Packages often take up unnecessary amounts of space compared to the product itself, trucks and containers can be half empty upon departure from the depot, and some vehicles are solely used for pick-ups or deliveries.

Specifically, the last mile delivery (LMD) process is considered the least efficient and sustainable of the entire supply chain (Bosona 2020). As all industries are driven to reinvent themselves for the sake of sustainability, so does the call for the field of logistics. In The Netherlands, active regulatory measures have been taken to reduce greenhouse gas (GHG) emissions in select city centres starting 2025 (Rijksoverheid 2025).

The Physical Internet (PI) is a vision first described by Montreuil (2011) and is inspired by the Digital Internet. It envisions an open global logistics system built on physical, digital and operational connectivity (Montreuil et al. 2012). Through the sharing of data and assets, flow optimisation can be achieved (Van Duin, Van Son, et al. 2022). Van Duin, Van Son, et al. (2022) define the most important PI characteristics as 1) open system (data and asset sharing) and 2) standardisation (standardised collaboration protocols and modular containers).

Hyperconnectivity (HC) is an emerging concept, enabled by and built further on the PI concept. It allows for large-scale collaboration through shared assets, information exchange, standardised protocols, and flow alignment. These characteristics lower the threshold for individual companies to collaborate in their delivery operations. However, there are many factors and several stakeholder groups that can stimulate or hamper development and implementation. Many studies have found that stakeholder groups agree to adopt measures to improve LMD sustainability; however, there is often no consensus on the specific measures to be adopted (Gonzalez et al. 2023; Maxner et al. 2022; Tolentino-Zondervan et al. 2021).

Current research on the drivers and barriers to the successful implementation of HC in and between LMD services is still limited. Extensive research has been carried out on the general concept of PI in the context of logistics (Matusiewicz 2020; Montreuil 2011; Montreuil et al. 2012; Van Duin, Van Son, et al. 2022). Other studies have focused on one novel concept in LMD and how they are viewed and utilised (M. S. Cebeci et al. 2023; Faugere and Montreuil 2016; Van Duin, Slabbekoorn, et al. 2018). Pilot initiatives have been set up within city logistics to combine goods from different LSPs, as well as IT solutions (Frindik and Prudon 2017; Van Rooijen and Quak 2010). These are important building blocks for exploring the feasibility of these methods, but do not entirely capture the views between multiple services from different stakeholder perspectives. Therefore, it is of relevant interest to explore HC in more detail within the context of state-of-the-art LMD methods that are currently applied and under development, as well as the dominant stakeholder perspectives towards HC implementation in LMD services. An initial literature study is carried out on the concept of HC and LMD services that are currently used. The dominant stakeholder perspectives are identified using the Q-methodology.

II. LITERATURE STUDY

This literature study focuses on the fundamental concepts of the LMD system and the concept of PI, including its HC characteristics.

A. *Defining last mile delivery and city logistics*

Exploring existing literature, *last mile delivery* refers to the activities necessary for physical delivery to the final destination chosen by the receiver (Olsson et al. 2019). Boysen et al. (2020, September) states that the LMD process starts once a shipment has reached a starting point in an urban area, e.g., a central depot after long-haul transportation, and ends once the shipment has successfully reached the preferred destination point of the final customer. Slabinac (2015) argues that no unique definitions can be found because it depends on the objectives of the specific research. The last mile can also differ in definition, depending on the characteristics of the supply chain.

Analysing the definitions of LMD, the following common components can be identified with respect to:

1) the last mile; the leg from a transportation hub to their final destination.
2) the delivery; the means of transporting goods in their last mile leg.
3) the subject; freight or goods transported.

For this study, LMD is defined as the process of transporting a good or product from the last warehouse to its final destination. City logistics is the means enabling freight distribution in urban areas and the strategies that can improve its efficiency while mitigating externalities such as congestion and emissions (Rodrigue and Dablanc 2024). It involves managing the movement of urban goods and providing innovative responses to customer demands. It takes place in a setting where a multitude of public actors are involved, including branches of government, advocacy groups, residents, and retail activities. In practice, LMD and city logistics tend to be used interchangeably.

The LMD process has evolved significantly throughout time along with new technologies, the Digital Internet being the backbone of many developments. The traditional process had fewer flows compared to the current possibilities. Figure 1 depicts the traditional flows compared to the current state of the last mile (Mecalux 2022).

The additional flows lead to an increased complexity of the logistic operations. On the one hand, this results in a higher service quality for the customer, since there is an increased flexibility and personalisation of delivery options. However, this also puts more pressure on the operations side to deal with more personalised demands.

B. *Characteristics of Hyperconnectivity*

Crainic and Montreuil (2016) presented a study combining the two concepts of PI and city logistics, resulting in a framework for designing efficient and sustainable urban logistics and transportation systems. This framework provides nine core interconnection concepts that make up what the authors define as *Hyperconnected City Logistics (HCL)*, characterised as follows:

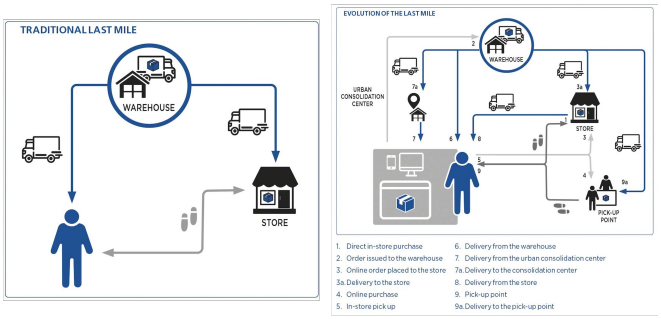

Fig. 1. Traditional versus current last mile delivery process (Mecalux 2022)

1) Interconnect Cities as nodes of the Worldwide Logistics Web
2) Interconnect Cities by Systems Standardization
3) Interconnect The Multi-Faceted Activities of City Logistics
4) Interconnect City Logistic Networks within a City Web Architecture
5) Interconnect The Multiplicity of Urban Logistics Centers
6) Interconnect City Logistics Stakeholders into an Open System
7) Interconnect Goods Through Modular Logistics Containers
8) Interconnect People Mobility and Freight Logistics in the City
9) Interconnect City Logistics with Urban Planning

Since this research is focused on the HC aspect between services and the impact on stakeholder interactions, there are a few concepts that are more relevant which are detailed further below.

1) Interconnect city logistics into an open system (6): HCL acknowledges and aims to enable a system of collaboration between the various actors, envisioning engagement in three areas. In **operational** terms, the LSPs should cooperate to ensure consolidation and synchronisation. In **business** terms, hyperconnected business models can be incentivised through contractual agreements between users and providers, in terms of pricing, liability, cost, revenue and profit context, among others. In **public-service** terms, authorities should interact with stakeholders in city logistics to establish an appropriate legislative environment to incentivise interconnectivity between industry actors.

2) Interconnect people mobility and freight logistics in the city (8): HCL aims at an intensification of the interconnectivity between people (mobility) and freight logistics, which currently tends to be separated by regulations. An example is to combine the use of public transport infrastructure in city cores, such as tram lines,

with people and freight transport.

M. Cebeci et al. (2023) emphasise, among others, the need to study the effects of hyperconnected service networks. Within this concept, there is a distinction between horizontal and vertical connectivity. Horizontal connectivity describes the collaboration between competing actors through, for example, sharing data and assets, whereas vertical connectivity involves the creation of new service chains by connecting individual services. An example could be the combination of crowd-based delivery services with parcel lockers or micro-depots. M. Cebeci et al. (2023) encourage exploring the combined vertical and horizontal integration of partial delivery services, as it is this combined deployment that results in a hyperconnected urban freight network.

Based on relevant aspects of HC found in literature, the following characteristics can be extracted:

- Services: Specific LMD service types to be connected.
- Collaboration: LSPs cooperating on an operational level.
- IT: Information exchange between parties that enables operational synchronisation.
- Governance: Authorities have the legislative power to incentivise interconnectivity between industry actors.

III. METHODOLOGY

The Q-methodology is an exploratory technique to investigate the perspectives of participants who represent different stances on a certain issue (Better Evaluation n.d.; Brown 1993). Considering the novel concept of HC and the many stakeholders involved in the logistics chain, it is highly likely that these actors have diverging perspectives and priorities on the topic. This method has also been used in previous research on PI characteristics in the Dutch logistics industry (van Son 2020). The following stages are part of the Q-methodology.

A. Q-set

This set consists of statements about the implementation of HC characteristics in last-mile delivery methods. The statements are formulated based on findings in literature research and interviews with experts. The gathered statements are reviewed and selected for the final survey. Statements are categorised based on the characteristics of HC: services, collaboration, IT, and governance. A general category is added for general statements on the LMD system. The Q-set for this study is found in Table I.

B. P-set

The P-set consists of the participants in the experiment. In this set, multiple stakeholder groups are represented that are related to LMD. The P-set contains logistics service providers (3), a branch organisation (1), and research institutes and universities (9), and a zero emission transport provider (1). In total, 14 participants participated in this research, which proved to be sufficient to extract significant perspectives. According to the literature, the Q-method generally involves a sample size of between 12-40 participants (Webler et al. 2009).

-4	-3	-2	-1	0	1	2	3	4
27	29	23	14	25	22	2	5	24
11	6	7	21	13	1	3	33	8
	4	19	28	18	15	20	16	
		31	32	10	17	30		
			34	26	12			
				9				

Fig. 2. An example of a completed grid for the survey, the numbers represent statements (KADE v1.3.1)

C. Q-sort

The statements (Q-set) were presented to the participants (P-set) in the form of a survey. An example of a completed Q-sort is found in Figure 2. The more extreme degrees of agree or disagree (4, -4) have the least space for placing the statements, while the neutral option (0) has the most. This structure imitates a normal distribution and forces participants to rank the statements by making trade-offs and compare them to each other.

The survey consists of the following steps:

1) Introduction video providing instructions on how to complete the survey;
2) Rank the statements: agree, neutral, or disagree;
3) Rank the statements in the Q-grid;
4) Optionally comment on the most extremely ranked statements.

D. Q-analysis

After the answers of all participants are sorted in the Q-sort phase, the results are to be analysed in the Q-analysis phase. This can be done by performing a factor analysis, revealing the subjectivity of the participants and in doing so, they can be grouped. The number of factors to extract is determined by multiple aspects. The main source for the rules is a paper by Webler et al. (2009), supported by other publications by Watts and Stenner (2005) and Suprapto (2016). When all results are grouped into a factor, the dominant perspectives can be extracted from the Q-sorts. As explained previously, participants are also asked to provide additional comments on their most extremely ranked statements. This contributes to understanding the underlying drivers and barriers of their points of view.

IV. RESULTS

The Q-analysis reveals that three different perspectives can be identified. Eight different factor solutions were considered as shown in Figure 3. Considering the recommendation to maintain simplicity, a high number of factors such as 5 to 8 would be undesirable. An 8 factor solution would also

TABLE I

Q-SET ON HYPERCONNECTIVITY CHARACTERISTICS IN LAST MILE DELIVERY SERVICES

#	Q-statement	Characteristic
1	The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city.	General
2	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery.	Collaboration
3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).	General
4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.	General
5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.	Collaboration
6	Infrastructure sharing mechanisms should be defined by local authorities.	Governance
7	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits.	Collaboration
8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	IT
9	The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport.	Services
10	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs.	Governance
11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.	Services
12	An open platform where logistics service demand and supply meet will be the future of last mile deliveries.	IT
13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.	IT
14	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	IT
15	Implementing smart contracts in an open platform is a good solution for companies to build trust in financial gains through collaboration.	IT
16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres.	General
17	Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it.	General
18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.	General
19	The idea of connecting services do not provide benefits for big/established LSPs.	General
20	Service connectivity is necessary to develop efficient and sustainable last mile delivery.	General
21	The best way to form a hyperconnected last mile delivery network that is more robust and impactful could be established by small-scale micro-services collaborating.	Collaboration
22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	Services
23	If it becomes more problematic for LSPs to enter a city with conventional vehicles, they will be more willing to outsource their deliveries, instead of making own investments in sustainable vehicles.	General
24	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas.	Services
25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development.	Collaboration
26	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs.	Services
27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	Services
28	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported.	Governance
29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	Governance
30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.	Services
31	An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones.	Governance
32	Municipalities need to have an enforcing role for companies to hyperconnect services.	Governance
33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.	Collaboration
34	The shortage of personnel is a driving force for white label delivery services and warehousing.	Services

automatically violate the third rule of having at least two distinct Q-sorts per factor. The same situation occurs up to a 5 factor solution in this particular set of Q-sorts, where one factor includes only one Q-sort. Therefore, the decision is made to consider less than 5 factors.

When analysing the remaining factors, the other rules (1 and 2) can be considered—the first being a minimal explained variance between 35% and 40%, and the second a desired eigenvalue of 1 or larger. With 2, 3 and 4 factors, all three fulfil the rules regarding an eigenvalue of at least 1 and an explained variance of at least 35% to 40%.

Since the quantitative set of guidelines narrows the solution space down to multiple options, the qualitative guidelines by Webler et al. (2009) can be utilised. When comparing the participant grouping between 2 and 3 factors, all participants from the third group in the 3 factor solution are transferred to the first group in the 2 factor solution. When comparing the groupings between 3 and 4 factors, participants remain less clustered than in the first scenario. This observation relates to stability, which leads to the

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	3.9285	2.0952	1.5765	1.1446	1.088	0.8791	0.7656	0.6026
% explained variance	28	15	11	8	8	6	5	4
cumulative % explained variance	28	43	54	62	70	76	81	85

Fig. 3. Factors with corresponding eigenvalues and explained variance (KADE v1.3.1)

conclusion that 2 or 3 factors are more favourable than 4 factors. When considering clarity, both 2 and 3 factors lead to similarly strong participant loadings on one specific factor. The correlations between each factor are smaller with a 2 factor solution compared to a 3 factor solution. In case of the latter, there is a relatively strong correlation between factors 1 and 3. However, this can be explained by the clustered group that was moved from factor 1 to factor 3. In this situation, the correlation is not problematic and allows for three perspectives instead of two. Based on the quantitative and qualitative guidelines, the 3 factor solution was chosen for analysis.

In order to create a relevant meaning of the factors, it is necessary to translate the quantitative information from the factor analysis to qualitative perspectives. The following identifiers can be assessed to construct the perspectives:

- Significantly distinguishing statements per factor
- Extremely ranked statements per factor
- Overall consensus-disagreement on statements and correlation between participants
- Feedback on choices made by participants

Perspective 1

White label delivery services and parcel lockers are suitable solutions to be hyperconnected, however, in general, lack of trust and fear of losing competitive market position are still barriers.

This perspective shows a strongly positive attitude towards shared last-mile delivery services, specifically white-label services and parcel lockers. In line with this, there is also a strong opinion that it is not sufficient for LSPs to solely electrify their fleet without additional solutions as a response to the zero-emission zones. This is supported by the agreement that sharing assets increases city liveability more than only changing to zero-emission vehicles. These observations tie well together if the end goal is to reduce congestion, delays, and increase safety in cities. On the other hand, it has a strongly negative position on the use of drones in urban areas and crowdshipping. Another strong opinion is that lack of trust and fear of losing a competitive market position still form a barrier to connecting services. It should be noted that this opinion is more general and is not related to specific LMD services (Table II).

Perspective 2

Service connectivity and data exchange are necessary to develop efficient and sustainable last mile delivery. However, the industry still needs further digitalisation and convincing of its economic benefits.

The general opinion in this perspective underpins the importance of connecting services to develop a more efficient and sustainable last mile. Simultaneously, this perspective highlights other barriers to overcome, such as digital readiness in smaller companies and financial hurdles. Especially smaller companies seem to struggle to upgrade their digital infrastructure, according to a stakeholder. Multiple stakeholder groups have stated in interviews and comments that the LMD market has tight profit margins, which is a big barrier for commercial actors to put their willingness into action (Table III).

Perspective 3

Local authorities must take the lead in zero-emission city logistics by setting sustainable criteria for purchasing and tenders. The current last mile delivery system is too segmented, and collaboration of services could increase the utilisation rate of assets, however it will be a challenge to involve large LSPs.

This perspective takes a strong position in local authorities setting an example in regard to zero-emission city logistics by incorporating sustainability criteria in their tenders and purchasing policies. Additionally, this perspective acknowledges that the current last mile is too segmented and positively ranks the concept of connecting services on the edges of a cities. Another strong and distinguishing opinion is that connecting services will not provide sufficient benefits for large LSPs. A stakeholder states that large LSPs have already optimised their operations, e.g. fully loaded trucks, routing. This, paired with the possibility of losing a competitive market position, leads to a challenge to overcome to get services of different scales to collaborate (Table IV).

A. The similarities and differences between perspectives

Looking at the perspectives as they are, all have both overlapping and diverging parts between each other to a certain extent. At face value, perspective 3 seems to be the most diverging as it has a strong focus on the role of local authorities. Another method is to investigate the quantitative correlations between each factor. Figure 4 shows a positive correlation between factors 1 and 3, and a weaker positive correlation between factor 2 and factors 1 and 3. In other words, the statements in factor 2 were ranked more differently compared to factors 1 and 3. There is more similarity between factor 1 and 3, explained by a higher correlation.

TABLE II

REDUCED SET OF DISTINGUISHING AND EXTREME STATEMENTS RELATED TO FACTOR 1 (** P<0.01, * P<0.05)

Sig.	Z-score	Q-sort	#	Statement
**	2.13	4	24	White label delivery vehicles, where parcels from multiple carriers are consolidated, are a good solution to reduce the amount of vehicles in urban areas.
	1.51	4	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.
	1.18	3	5	Parcel lockers should be made available to be used by multiple parties instead of exclusively by one company.
	1.12	3	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.
**	0.88	3	16	It is not a sufficient measure for LSPs to solely electrify their fleet in response to the Dutch zero-emission zones (ZES) plan in city centres.
**	0.86	2	2	Sharing assets (e.g., delivery vehicles, parcel lockers) increases city liveability more than changing to zero-emission vehicles in last mile delivery.
*	0.76	2	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.
*	-0.81	-2	19	The idea of connecting services do not provide benefits for big/established LSPs.
**	-1.19	-3	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.
	-1.31	-3	6	Infrastructure sharing mechanisms should be defined by local authorities
*	-1.42	-3	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.
**	-2.11	-4	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.
	-2.45	-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.

TABLE III

REDUCED SET OF DISTINGUISHING AND EXTREME STATEMENTS RELATED TO FACTOR 2 (** P<0.01, * P<0.05)

Sig.	Z-score	Q-sort	#	Statement
**	2.06	4	20	Service connectivity is necessary to develop efficient and sustainable last mile delivery.
**	1.74	4	14	When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.
**	1.51	3	13	Most last mile delivery companies are not digitally ready for sharing of data and that should change as soon as possible.
	1.44	3	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.
**	1.23	3	7	Most parties have the willingness to share assets but the transition costs are currently not outweighing the benefits.
**	-0.88	-2	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.
**	-0.98	-2	33	Lack of trust is still a major barrier to achieve hyperconnectivity between companies and services.
**	-1.09	-3	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.
	-1.33	-3	34	The shortage of personnel is a driving force for white label delivery services and warehousing.
*	-1.64	-3	19	The idea of connecting services do not provide benefits for big/established LSPs.
**	-1.93	-4	22	White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.
	-2.06	-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.

	Factor 1	Factor 2	Factor 3
Factor 1	1	0.1499	0.4613
Factor 2	0.1499	1	0.1185
Factor 3	0.4613	0.1185	1

Fig. 4. Correlations between the three factors (KADE v1.3.1)

To discover what these differences and similarities are qualitatively, the distinguishing statements from perspective 2 are analysed and compared to perspectives 1 and 3. In addition, the overall consensus-disagreement on statements is taken into account.

TABLE IV

REDUCED SET OF DISTINGUISHING AND EXTREME STATEMENTS RELATED TO FACTOR 3 (** P<0.01, * P<0.05)

Sig.	Z-score	Q-sort	#	Statement
**	1.86	4	29	Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.
**	1.73	4	3	The current last mile delivery system is too segmented and collaboration of services could increase the utilisation rate of assets (e.g., better route optimisation, less empty trips).
*	1.43	3	30	It is better to connect services on the edge of a city rather than inside the city since the goal should be to minimise vehicle movements.
	1.21	3	8	The fear of losing a competitive market position is still a big barrier for commercial actors to share information.
**	1.16	3	19	The idea of connecting services do not provide benefits for big/established LSPs.
**	1.05	2	26	The sustainable and economic benefits of crowdshipping depend on too many external factors that these do not outweigh the implementation costs.
*	0.96	2	18	Hyperconnectivity cannot be achieved in the near future because of the fear of losing profit.
*	-0.82	-2	4	Last mile delivery is already sufficiently efficient and does not form a very urgent problem compared to other urban challenges.
**	-1.05	-2	27	Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.
**	-1.13	-2	9	The presence of microhubs in city centres will lead to reduced vehicle emissions but simultaneously increase congestion with other modes of transport.
**	-1.14	-3	10	Enforcing zero-emission zones in city centres will result in a strong increase of white label logistic hubs.
**	-1.17	-3	25	Increasing curbside occupation by conventional delivery vehicles is a major problem, and collaborating with micro-delivery services is a feasible solution to counteract this development.
**	-1.24	-3	28	Municipalities should focus on involving the big LSPs rather than the smaller companies in sustainable last mile delivery, considering the large share of volume transported.
	-1.39	-4	32	Municipalities need to have an enforcing role for companies to hyperconnect services.
	-2.09	-4	11	Drone delivery is a solution that can significantly improve the efficiency of the last mile delivery if combined with other methods.

When analysing the extreme and distinguishing statements of perspective 2, there are a few statements that were ranked positively or negatively in all three perspectives. The general observed similarity between the perspectives is the agreement that service connectivity and collaboration is necessary and that it could have a positive effect on the current LMD landscape. In terms of specific services, all perspectives consider drone delivery as infeasible in urban areas. All perspectives are positive or neutral towards the concept of shared parcel lockers. In terms of governance, there is a consensus that local authorities should not explicitly take up an enforcing role for companies to connect. Lastly, all perspectives agree that most LMD companies are not digitally ready to share data, but perspective 2 has ranked this statement the highest.

Although there are similarities, perspective 2 also has differences compared to the other perspectives. These differences in opinion, for example, are related to the reason why LSPs are not yet sharing more information and assets. Interestingly, only perspective 2 is neutral towards the statement that LMD is already sufficient and other urban challenges are more important. The other perspectives disagreed significantly with this statement. Perspective 2 is also unique with its positive attitude towards combining crowdshipping services with conventional delivery methods. The same holds for its negative stance on connecting services at the edge of the city rather than inside the city.

As mentioned above, another way to discover similarities and differences is to analyse the overall consensus-disagreement ranking on statements. Taking into account the number of statements, the ones with the five lowest and highest ranking variances are shown in Table V.

These statements show that there is a neutral to positive stance on the concept of HC. The closest similarity, albeit very close to neutral, is in the idea that an open platform will be the future of last mile deliveries. All three perspectives strongly agree that fear of losing market position is still a major barrier to sharing information. Furthermore, there is a consensus that granting concessions to an LSP in car-free zones is not a desired way to achieve connectivity.

In contrast, Table V also reveals where the participant groups had the most varying opinions. The greatest disagreement is about the exemplary role that (local) authorities should embody by setting sustainability criteria for purchasing and tenders. Participants are also divided on whether connecting services would be beneficial for large and established LSPs. The motivation of LSPs to exchange data is strongly debated, whether companies are already able but not sufficiently convinced of its economic benefits yet. Lastly, pertaining to specific services, the concept of crowdshipping and white label services are topic of debate as well, whether they are worth implementing.

TABLE V

TRUNCATED SET OF STATEMENTS WITH THE FIVE LOWEST AND HIGHEST RANKING VARIANCES BETWEEN PERSPECTIVES

Statement	P1	P2	P3	Var.	Char.
An open platform where logistics service demand and supply meet will be the future of last mile deliveries.	1	1	0	0.001	IT
The fear of losing a competitive market position is still a big barrier for commercial actors to share information.	4	3	3	0.017	IT
The concept of hyperconnectivity fits the goal to minimise the amount of vehicle movements in a city.	1	2	1	0.024	General
Hyperconnecting services can greatly reduce failed delivery attempts and increase delivery flexibility for the customer, and is therefore worth financially investing in it.	1	0	1	0.032	General
An efficient way to achieve hyperconnectivity is for municipalities to enforce car-free zones while granting concessions to one LSP to enter specific zones.	-2	-1	0	0.089	Governance
Combining crowdshipping services with conventional delivery services is a feasible solution to reduce vehicle movements and distance travelled.	-4	1	-2	0.969	Services
White label services improve asset occupancy and is worth implementing to reduce investment and operational costs.	1	-4	-1	1.121	Services
When data sharing proves to yield significant economic benefits, suddenly most of the logistics service providers (LSPs) are able to do it.	-1	4	-1	1.146	IT
The idea of connecting services do not provide benefits for big/established LSPs.	-2	-3	3	1.380	General
Local authorities should take the lead in zero-emission city logistics by setting sustainability criteria for purchasing and tenders.	-3	0	4	1.556	Governance

Taking into account all the above approaches to identify similarities and differences between the perspectives, Figure 5 visually presents the findings. The green squares include similarities and differences in positive opinions, whereas the orange squares map similarities and differences in negative opinions. The difference of perspective 2 from the other perspectives can be seen by the number of opinions that are exclusively part of perspective 2. The similarities between perspectives are extracted mainly from general statements, while the differences are more related to specific service and collaboration concepts, i.e., how to improve the LMD landscape. All perspectives see the benefits of HC to minimise vehicle movements in cities, but different ways are considered promising. Perspective 1 emphasises the importance for LSPs to look beyond fleet electrification and share assets. Perspective 2 is considerably open towards more services and collaboration methods, while perspective 3 includes more opinions related to governance.

In terms of negative opinions, most concerns about HC are shared between at least two perspectives. Fear of losing a competitive market position by sharing information is a shared concern among all perspectives. As mentioned earlier in this section, drone delivery services in cities are not considered feasible by all parties. Perspectives 1 and 3 express scepticism towards crowdshipping due to many external factors that could influence its potential benefit. Another shared area of concern is the economic benefits that hamper asset and information sharing, although the perspectives highlight different aspects. Perspective 2 is of the opinion that more economic incentive is required to get companies on board, while perspective 3 states that HC is not beneficial for large and established LSPs. Trust is a perceived issue in perspectives 1 and 3, while digital readiness is a prevalent concern in perspectives 2 and 3.

B. Comparing perspectives in relation to the HC characteristics

Several observations can be made when the HC characteristics represented in the perspectives are compared with each other. Perspective 1 has strong opinions on specific service types, as three out of four extreme statements fall into this category. What also stands out is the low number of IT-related extreme or distinguishing statements, that is, only one. In comparison, perspective 2 includes three statements related to IT. Furthermore, perspective 2 contains more distinguishing general and collaboration statements and fewer in the collaboration and governance category. Perspective 3 is more strongly opinionated on the governance aspect. Compared to the others, perspective 3 also contains the most distinguishing and extreme statements on services. To summarise, perspective 1 has the strongest opinions on services, while perspective 2 is more general with a slight focus on IT, and perspective 3 focuses on the governance and services aspect of HC.

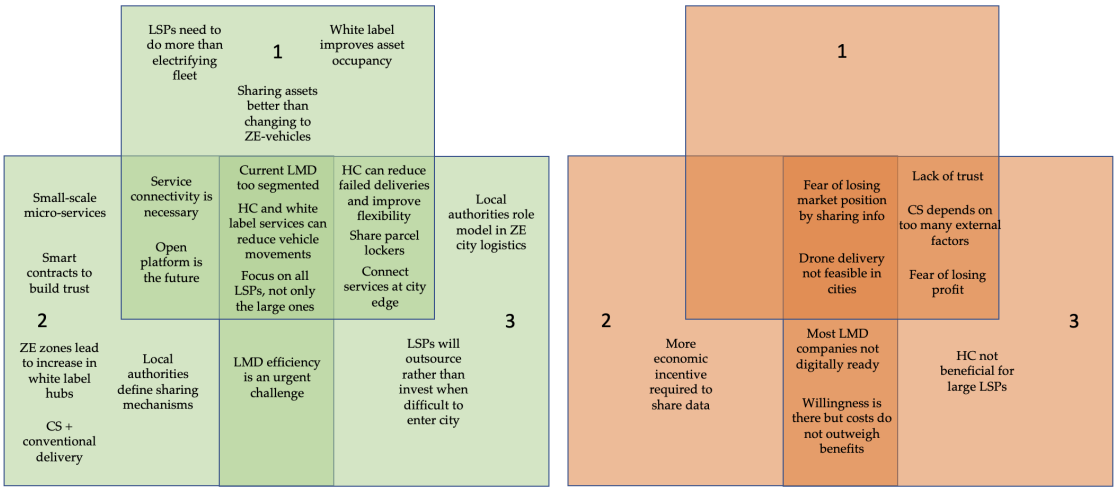

Fig. 5. Similarities and differences in positive and negative opinions between all perspectives

V. DISCUSSION

This section reflects on the results and discusses the limitations of the study.

A. *Reflection on results*

The observed potential of white label operations and parcel lockers in perspective 1 is supported by studies from de Bok et al. (2024), Lee et al. (2019) and Faugere and Montreuil (2016). In reality, the number of parcel lockers in the Netherlands is already increasing (nu.nl 2025). Sharing these assets could improve operational efficiency and asset occupancy due to better vehicle routing and consolidated infrastructure. However, lack of trust and fear of losing a competitive edge is a barrier to exchange information that was also found by Van Duin, Van Son, et al. (2022).

The need for service connectivity and data exchange as defined in perspective 2 is in line with the findings of Gonzalez et al. (2023). Participants in this study indicated that cooperation between distribution companies through sharing vehicles is desirable. Furthermore, the attitude in perspective 2 that the industry needs further digitalisation aligns with the barrier identified by Van Duin, Van Son, et al. (2022). There is also a similarity between perspective 2 from Van Duin, Van Son, et al. (2022) and perspective 3 from this research when it comes to government regulation. LSPs from both perspectives are relatively negative towards strong regulation to share data. Interestingly, a smaller LSP in perspective 1 of this research expressed a more positive attitude towards regulation.

Perspective 3 is partly defined by the opinion on the stronger role of local authorities, specifically by setting sustainable criteria in their purchasing and tender policy. This finding is not found in other studies, perhaps because it is quite specific. However, it might indicate something about the attitude of LSPs, namely the tendency to wait for local authorities to set an example or define clear regulatory frameworks. A possible way to tackle this attitude is to seek cooperation between city logistics stakeholders during the planning, implementation, and control of projects related to freight transport (Kiba-Janiak 2016). Local authorities could take this initiative when designing policies to stimulate sharing and collaboration mechanisms. An underlying opinion in this perspective, very similar to perspective 2, is that local authorities should not strongly regulate information sharing between companies, which is again related to the results of Van Duin, Van Son, et al. (2022). The general view that the current LMD system is too segmented is reflected in the existing literature and the proposed solutions (Matusiewicz 2020; Maxner et al. 2022; Paddeu et al. 2018; Van Duin, Slabbekoorn, et al. 2018). The last part of perspective 3 argues that it is a challenge to involve large LSPs because they have the resources to optimise their own operations. However, a Q-method study on urban consolidation centres by Van Duin, Van Son, et al. (2018) revealed that cost control is among the main focus points of cooperation. When it comes to sustainable delivery methods, a way to incentivise larger LSPs to cooperate is by proportionally allocating costs among all involved stakeholders (Van Duin, Slabbekoorn, et al. 2018). This last point is also supported by participants who have validated the perspectives in the next section.

B. *Research limitations*

This research was built on the Q-methodology, to which a few implications arise. The method has proven to be helpful in revealing different perspectives on a topic. However, scoping is a well-known challenge that is a constant trade-off. The decision has been made to include multiple emerging LMD methods with the potential to increase connectivity between services. This led to the scope and subject of the research being quite comprehensive. An implication of this was the need to provide more information and explanation to the participants to prepare them for the statements. The survey included a list of definitions and

explanations of concepts to mitigate this. However, it is still possible that the statements were ranked differently because of other assumed definitions or different interpretations of the statements, which would lead to other rankings. Another consequence of a broader scope is the difficulty in formulating the statements in such a way that it captures every view. To maintain a survey that would not take an excessive amount of time to complete, it was important to establish a limit to the number of statements. This made it challenging to make a set of statements that fully covers a comprehensive subject such as HC and LMD services. In designing a Q-set, a trade-off must be made whether to capture views on a broader topic or to focus on a specific (sub)topic.

In addition, the actual group of survey participants lacked regulatory actors as well as shippers. When it comes to shippers, it could be assumed that their opinions are generally reflected by the LSPs since these are their customers. However, the regulatory actors are to be seen as a separate stakeholder group whose opinions could diverge and would be valuable to the research.

VI. CONCLUSION

The main goal of this research is to identify the dominant stakeholder perspectives on HC characteristics in LMD services. Based on literature research and interviews, statements have been formulated to pose to relevant stakeholder groups, consisting of academia, LSPs and branch organisations. Participants were asked to rank the statements according to the degree of agreement or disagreement with them.

This resulted in three different perspectives, each providing a view on the topic:

1) White label delivery services and parcel lockers are suitable solutions to be hyperconnected, however lack of trust and fear of losing competitive market position is still a barrier.
2) Service connectivity and data exchange are necessary to develop efficient and sustainable last mile delivery. However, the industry still needs further digitalisation and convincing of its economic benefits.
3) Local authorities must take the lead in zero-emission city logistics by setting sustainable criteria for purchasing and tenders. The current last mile delivery system is too segmented, and collaboration of services could increase the utilisation rate of assets, however it will be a challenge to involve large LSPs.

What can be noted from all perspectives is that there is a general recognition that the current state of last mile delivery is too segmented, and that connecting services can be a solution. The most promising LMD concepts for connecting are white-label delivery services and parcel lockers. Perceived barriers to doing so include fear of losing a competitive market position by sharing information, lack of economic incentive, and concerns that the distribution of costs and benefits among parties will be uneven. These barriers are related to the IT and Collaboration characteristics of HC. (Local) authorities have the opportunity to lower these barriers by initiating collaboration with multiple stakeholder groups through public-private initiatives. With recently enforced regulations such as ZES, and emerging openness toward certain asset and information sharing concepts among LSPs, stakeholders in the LMD system can work together to achieve more sustainable last mile logistics.

Two out of three perspectives are represented by different stakeholder groups, whereas one perspective is represented by universities, that is, perspective 2. Uniquely, this perspective is generally positive towards innovative solutions like implementing smart contracts and crowdshipping. It also considers the IT aspect of HC a significant barrier. This does not mean that the viewpoints of universities and research institutions are detached from other stakeholder groups because it also has overlapping opinions with other perspectives. Their natural tendency to perform innovation research might result in a more open or positive attitude towards innovations compared to other actors. Therefore, it is important to continue to exchange findings between research and industry.

VII. RECOMMENDATIONS

This section presents recommendations for future research and practice.

A. Future research

The use of Q-methodology for a study requires a consideration on how to scope the statements. Now that certain LMD methods are considered more promising than others, it could help narrow the scope. In doing so, a larger part of the discourse can be covered in the statements, which could reveal opinions on the topic in more detail.

Since this research reveals which HC characteristics are perceived in a positive and negative way, it could be interesting to dissect these characteristics to try revealing the underlying preferences of actor groups. The identified barriers could not be fully attributed to specific stakeholder groups. By presenting HC characteristics in more detail, perhaps combined with a certain design of a hyperconnected system, more accurate opinions could be revealed.

Not all stakeholder groups participated in this research, so their perspectives on implementing HC characteristics in LMD services were not captured. Of the different stakeholder groups, shippers, receivers and (local) authorities were not included. This was not necessarily by choice, but none of the people contacted in these groups responded to the survey invitation. It can be argued that the participating industry association represents a part of the missing stakeholder groups, but direct participation from these groups could lead to different results. It is recommended to try to involve

all stakeholder groups in future research. In doing so, the statements should be formulated in such a way that all groups can relate to them.

When it comes to services, white label services are considered promising, but there is a wide range of ways these services are characterised, in terms of connected modalities or type of goods that are handled. Therefore, it is recommended to research what type of white label service is feasible to be implemented on a larger scale, considering aspects like financial and technical feasibility. Based on the potential recognised in shared parcel lockers, it is worth researching how they can be technically implemented and, considering HC, how they can potentially be connected to other service types to provide more flexibility in parcel delivery. Combining the latter point with the collaboration aspect of HC, it is worth conducting more research on which services have the potential to be connected vertically and horizontally.

Many barriers are related to the perceived negative effects of sharing information in a connected delivery system. These perceived effects are related to losing market position, trust, digital readiness, and costs. These are each directions that future research could focus on. For example, research on designing a connected system that is transparent and fair in the distribution of costs and benefits. Another direction could be investigating how to create a platform that reduces the digital threshold to become part of an interconnected delivery system, or which innovations could enable controlled transparency and as a result build trust between parties.

B. Practice

In order to investigate the technical feasibility of connecting services, local authorities can initiate public-private partnerships with the logistics industry, for example, in the form of pilots. The identified barriers emphasise the importance of developing a shared system that distributes costs and benefits proportionally. It is important to involve LSPs of varying sizes to evaluate whether a proposed concept leads to an even playing field for the market. This study revealed that white-label services and shared parcel lockers are considered promising concepts. Therefore, it is recommended to focus more on connecting these LMD methods. Through these public-private collaborations, the economic barrier for LSPs could be lowered because the focus is on the technical feasibility.

LSPs identify their drivers and barriers based on their direct experience of their delivery operations. In this study, this actor group recognises the potential of sharing assets and data to increase operational efficiency. However, this is not always taken into action due to barriers such as transition costs, lack of trust, or a perceived imbalance of cost and benefit distribution. LSPs can continue their efforts to increase their own operational efficiency, while also working together with (local) authorities and industry to explore the effects of service connection. Considering that this study revealed the potential of shared parcel lockers and white label services, LSPs could specifically explore these concepts. If the willingness from LSPs is there to change, they should be provided with the opportunity to obtain knowledge on how these specific barriers can be overcome.

Research institutes conduct studies that are relevant for LSPs and can incentivise LSPs to try out innovations in their delivery operations. Provided the consensus among all perspectives that the current LMD system is too segmented and that HC could potentially mitigate that, research institutes should continue to put effort in HC-focused research, e.g., *URBANE* (Urbane 2025). There is also a partly shared opinion that an open platform for LMD will be the future. This is a very broad notion that further research could help in the development of specific feasible solutions. Although some specific types of services contain neutral to negative views from other stakeholder groups, this does not mean that research on these should be stopped. In some cases, it takes time for other actors to adopt new ideas with valid concerns. This could also be the case with concepts such as crowdshipping and implementing smart contracts between parties. Therefore, it is important for universities and research institutes to remain engaged with other actors to see how opinions on these innovations form over time. To make all this possible, the government should continue to provide research possibilities for these research institutes.

The HC community should be aware of the perceived barriers in practice. In the process of gaining more knowledge, they should present their findings and proposed concepts to the logistics industry. This could be done in the form of pilots in collaboration with governments and industry.

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