

# Urban Logistics in 2040

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M.Sc. Thesis



M.Sc. Complex Systems Engineering  
Karel T.W. Beukema



# Exploratory Scenario Analysis: The Future of Urban Logistics in 2040

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Karel T.W. Beukema

Student number: 4474236

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## **Graduation committee**

Prof. Dr. L. Tavasszy

Prof. Dr. J.A Annema

Dr. M.L.C. de Bruijne

Michael Hesp M.Sc.

Transport and Logistics, Faculty of TPM &

Faculty of Civil Engineering and Geosciences (CEG)

Transport and Logistics, Faculty of TPM

Multi-Actor Systems, Faculty of TPM

CBRE Investment Management



# Preface

After 6 years of studying at the Technology, Policy & Management faculty at Delft University of technology, this thesis is the final step to complete the M.Sc. degree in Complex Systems Engineering & Management at the Delft University of Technology. I conducted my graduation research in collaboration with CBRE Investment Management as a graduate intern in the Investments & Research team. In the last six months, I have conducted scientific research on how the urban logistics system will look like in large cities in different scenarios. I want to take the opportunity to thank some people that have played a part in this process.

First and foremost, I want to express my gratitude to my supervisor Jan Anne Annema, who has demonstrated the ability to provide extremely competent instruction in a very approachable manner. There were some small jokes, personal anecdotes, and occasionally some informal discussion of the future steps. However, there was also the chance for collected, frank, and knowledgeable feedback when it counted. Additionally, I want to thank Lori Tavasszy for his helpful feedback during our meetings. Lastly from TPM, I would like to thank Mark de Bruijne for his highly valuable comments on my thesis project.

Also, I want to thank my supervisor from CBRE Investment Management, Michael Hesp. By challenging what I did or simply offering your own thoughts, you contributed significant new knowledge to the study. But I also want to emphasize how much I appreciated our communication as a whole. It was always a pleasure to talk to you both because you were great, approachable, and enjoyable to work with. From CBRE IM, I would also like to thank Maurice Stieger, as Head of Logistics, he was able to introduce me to highly valuable logistical experts and give valuable feedback on my work.

I want to thank my parents for their support and motivation. Fortunately, I could work on this research with my parents in Nigtevecht, which is something I feel grateful for as a 'change of scenery' and often brought new ideas.

Lastly, I want to thank my friends and family for distracting me in the right and sometimes wrong moments. This made me remember the healthiness of other priorities and gave me fresh energy to finish my thesis research.

*Karel T.W. Beukema*

*Amsterdam, July 2022*

# Executive Summary

Urban logistics is characterized by a high degree of freight flow fragmentation, the employment of various delivery methods, and the use of various vehicle capacities. Urban logistics is important for inhabitants' quality of life both in a negative and positive sense and plays a large economic role with significant advantages for various stakeholders along complex, dynamic supply chains. However, there are several environmental, social, and economic difficulties with urban freight transportation. These trends influence the direction of how the city and the supply chain will develop over the coming decades. Next to economic, environmental, and social trends affecting the city and the urban logistics system, several companies have implemented new ways to improve their shipping services. As a result, the technological development of new distribution methods results in changing city supply chain organization and brings uncertainties in how the distribution of urban freight will evolve in the future.

Current research mainly focuses on the future of specific distribution innovations or specific factors influencing city logistics. There is a scarcity of scientific literature of research on the impact of multiple factors and innovative urban freight methods influencing the future of urban logistics. Policymakers, logistics businesses, and investors & developers wield the most power and (financial) resources and need to be aware of the changes in the urban logistics landscape and be prepared for the future by having resilient and robust policies and sustainable and adaptable business models in place. As a result, getting a clearer vision of city logistics by exploring (economic, societal, and environmental) trends and different new forms of transportation with exploratory scenarios benefits a wide range of stakeholders. With this vision, municipalities can adapt their urban logistics policy strategy and logistical companies & developers their investments in supply chains and infrastructure. Different scenarios provide a platform for the logistics industry and policymakers to analyze various measures and strategies to mitigate external developments and explore the future of urban logistics in the face of uncertainty. This leads to the research question:

***What could be the future of urban logistics in 2040 in large cities & what could be the implications for municipalities, logistics companies & investors in different scenarios?***

To answer this research question, a literature review and a scenario analysis were conducted. The goal of the literature review was to gain a better knowledge of the urban logistics system so that the scenario analysis could be better designed and provide information on the scenario analysis method used. Information about what stakeholders are involved and what their objectives & interdependencies are and what driving forces and innovative distribution methods affect the possible future inner city supply chain is presented for input for the scenario analysis. The scenario analysis process is followed to develop the scenarios: Preparation, an expert workshop, elaboration of the scenario plots, and validation by the participants of the workshop are the steps to develop the scenarios.

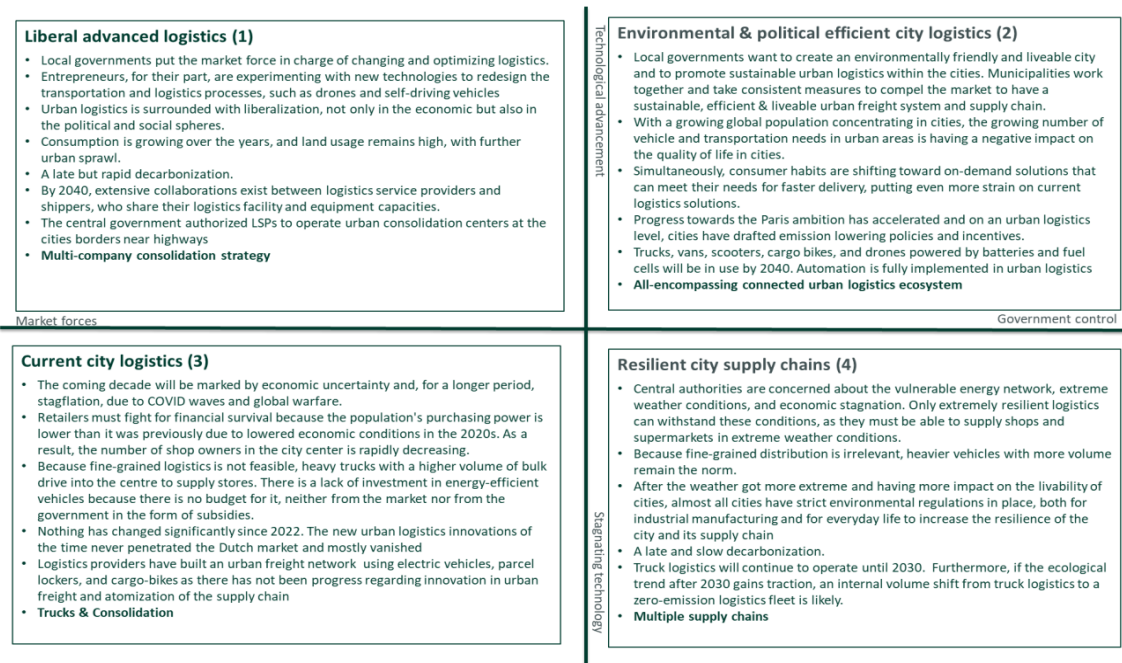
In the stakeholder analysis, it came forward that the urban logistics system comprises six actors: carriers, shippers, inhabitants, retailers, municipalities, and investors. Residents are concerned about city logistics, but they have limited options for influencing policy or the system. Municipalities indirectly represent inhabitants' interests, whereas retailers represent customers' demands. Real-estate investors are the ones with the most financial resources and municipalities with a vested interest in improving city logistics. In the urban freight industry, different public and private stakeholders have diverse interests. Rather than sharing their experiences, cities mimic each other's freight legislation. Because the stakes of the various players in the issue are not directly recognized, obligations for urban freight are passed to other stakeholders, and expectations on projects are unclear, and they do not feel responsible for the solution. Changes in logistic stakeholders' conduct are hindered by their passive and awaiting attitudes toward one another.

Several driving forces were identified, first, technological and economic developments have had an impact on urban freight leading to a growing scale of consumption and production. Several patterns have evolved, demonstrating that urban freight is constantly increasing and that the freight business as a whole creates a major revenue percentage of emissions, which is

expanding faster than personal vehicle emissions. Globalization has resulted in more products circulating the world due to fragmented spatial locations for production, distribution, and consumption which influences the city supply chain organization. At the same time, cities are becoming more crowded as a result of urbanization. More people in a limited amount of space is a result of urbanization, which puts a strain on supply and delivery.

At last, new urban distribution methods have been identified and analyzed in the different city supply chains in the scenarios. The use of autonomous vehicles in urban freight transportation is currently in the theoretical research stage. Looking back on transportation history, the last-mile delivery problem is a hard and complex issue to solve. A drone parcel delivery in the Netherlands could be essential to tackle this problem, due to its reach and flexibility. The delivery robot is a new freight technology that reduces traffic congestion and labor costs. Electric vehicles have a high potential for addressing urban environmental, social, and economic impacts. Cargo bikes are in the same stage of development as electric vehicles. Urban consolidation centers have the main objective of easing the switch from heavy trucks to zero-emission vehicles such as cargo bikes, light electric trucks, and zero-emission trucks.

With the help of an expert panel, with experience and a long-standing track record in academia & business, four distinct scenarios for exploring the future of urban logistics were developed. The four scenarios give an overview of the future of urban logistics and the organization of the inner city supply chain in 2040, based on ranked trends. According to the expert panel, the development of technological advancement and the regulatory & policy environment are critical uncertainties that drive the potential impact into four future scenarios.



The developed vision 2040 for urban logistics has shown significant changes regarding the use of technologies and infrastructure, the design of services and delivery concepts, market organization and cooperation, planning and regulation and finally to a certain extent also behavior. The technological advancement in scenarios 1 & 2 causes a wide diversity of innovative urban distribution methods to be used in a complex city supply chain. When the municipalities start to regulate and draft policies affecting the organization of city logistics (Scenario 2), an interconnected urban logistics ecosystem is created by the local government. The system is set up so that local governments can create a zone for urban logistics and offer access to logistical enterprises that meet certain criteria using a tender procedure. In scenario 1, Unmanned vehicles, robots, and UAVs could be widely used to provide urban freight services soon due to high technological advancement. The complex challenges of urban logistics cannot be solved solely through technology. Variables that influence the cost effectiveness of urban logistics processes include city characteristics and final receiver attributes and adoption of smart

technologies and more autonomous delivery may result in labor force reduction. Also, autonomous delivery and EVs may not even require human delivery personnel in the future and results in a more cost-effective supply chain, but could lead to job losses, which could be a reason for governmental intervention, due to market failure. Even in scenario 1 where autonomous delivery flourishes under technological progress with little government intervention, negative economic consequences require the government to step in.

Global warfare, pandemics and economic recessions in combination with new urban logistics innovations never penetrated the Dutch market mostly vanishing in scenario 3. The supply chains of different companies remain separate with little exchange leading to an inefficient supply chain. In this scenario, logistical businesses currently lack a comprehensive consideration of new technologies to develop a long-term urban logistics strategy. In the long run, ignoring innovation may stifle further promotion of sustainable urban logistics. Governments' top priorities are vulnerabilities in critical infrastructure and creating a resilient and robust city supply chain. Central authorities are concerned about the vulnerable energy network and extreme weather conditions in scenario 4. Multimodal and sustainable transportation systems are the foundation for resilient freight mobility. Infrastructure, logistics, and network/traffic management, in particular, play a significant role in making urban logistics climate neutral. At the same time, because these three areas are vulnerable to climate change and other disruptions, resilience will be increased by developing multiple supply chain options in the cities.

All in all, eventually in 2040, we will not be worse off in terms of CO<sub>2</sub> emissions than in the current scenario as climate change will put pressure on increasing emission reduction regulation, even in scenarios 1 & 3 where market forces dominate. Scenario 2 might be the best future outcome for increasing the city's liveability but less good for logistical businesses due to heavy regulation in the urban logistics system. A strong government is needed in combination with investments in logistics R&D to have technological progress, would this be the preferred future outcome. Scenario 4 might be the worst for businesses due to increased cost and economic headwinds and city inhabitants due to reduced living conditions caused by extreme weather. This scenario could be averted if there would be a drastic reduction in emissions to stop climate change. What also came forward, is that in all scenarios, urban consolidation centres is an important innovation in the future city supply chain: from increasing resilience due to extreme weather to lowering emissions due to freight consolidation.

The development of innovative urban distribution methods and driving forces can have a substantial impact on the future urban logistics system. Scenario 1 might provide the best environment for doing business due to high technological progress and good economic conditions, while scenario 4 may be the worst for enterprises because of increasing costs and economic headwinds. Urban consolidation plays an important role in all scenarios, from boosting resilience in the face of harsh weather to cutting emissions through freight consolidation. These scenarios, implications & recommendations should assist businesses, policymakers and investors in imagining future developments, exploring relevant uncertainties, and studying the implications for their merit.



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# 1

## Introduction to the Research

Urban Logistics Context

1.1 Problem Statement

1.2 Literature Gap

1.3 Research Objective

1.4 Research Questions & Methods

1.5 Thesis Outline

# 1. Introduction to the research: Urban logistics context

The freight supply chain is the economic link that incorporates the producer to the consumer, and it includes steps like production, transportation, distribution, and consumption (Peters, 2020). Urban freight transportation occurs at the end of the supply chain, between distribution and consumption. The commercial movement of goods and services for commercial entities between consumers and distributors with an origin or destination in urban areas is referred to as urban freight (Brown, 2012). The exchange of goods and resources among these actors is required to keep cities and people running. And a portion of transportation occurs within city limits, which is referred to as urban freight (Ambrosini, 2020).

The urban freight system is a multi-player environment with a wide range of interests. This is exemplified by the following ordering process: when a consumer or retailer orders something from a supplier, the supplier hires a logistic service provider who picks up the shipment – or uses its transport activities – and delivers it in the urban area. In addition, various goods flows can be differentiated in urban logistics: hotel and food service, building, disposal, retail non-food, retail food, parcel delivery, service and cleaning, and governmental services (Holguín-Veras, 2015). Last-mile delivery to end-users presents additional challenges in the logistic process. Last-mile transportation accounts for roughly 60% of logistics costs. Customer demands for product customization as well as the entire transportation and delivery process will change the coming years, due to new forms of commerce & transportation (Baldi 2021).

Next to that, many businesses have found new methods to improve their shipping services, such as using electric and hybrid vans and bikes. Picnic, a digital supermarket, uses light electric vehicles to deliver its products. Shipment services such as UPS and FedEx also use electric cargo bikes and vans (Dhir, 2019). Progressive developments can be seen in the meal service industry, where Deliveroo and AH Thuisbezorgd meals are all delivered by clean vehicles such as electric scooters, bicycles, and small vans. The technological development of new delivery methods within an urban context, therefore, needs to be considered by implementing measures and concepts and developing possible sketches of the future.

Innovations in the retail industry have a serious influence on city logistical operations (Dablanc, 2019). Transportation needs for alternative means of business are distinct. Municipal decision - makers encounter new issues as revenue grows, resulting in large numbers of personal deliveries. With the opportunity to acquire products from stores worldwide online and the lowering of stockholding, there is a strong market for reliable, regular, and adaptable parcel delivery, which are often small and less cost-effective and ecologically friendly (Dablanc, 2019). This could change the character of tangible business, the influence of physical establishments, and as a result, the management of urban freight in the future.

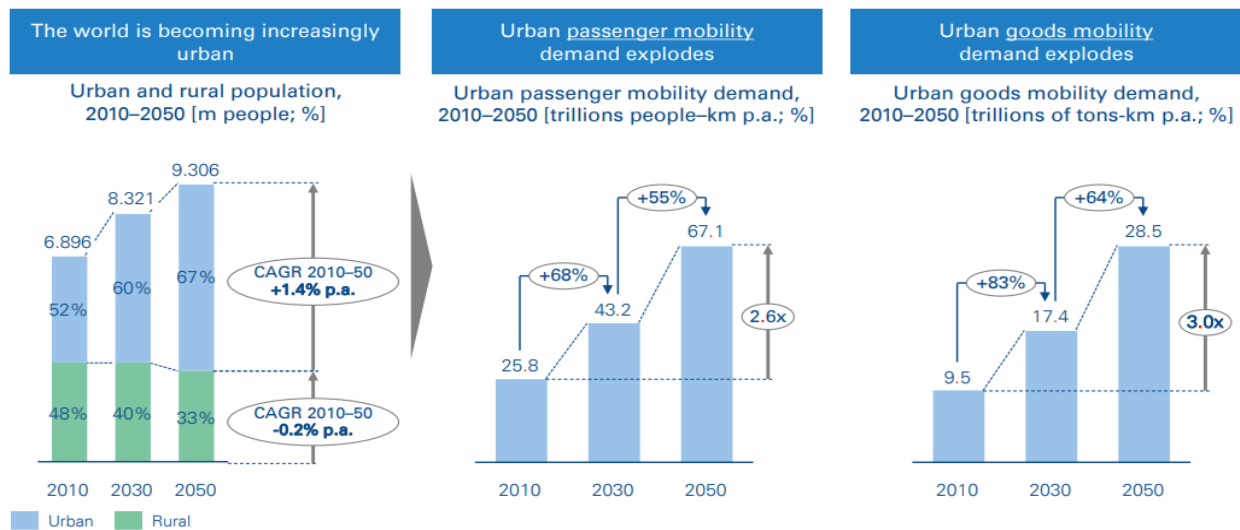


Figure 1: Increased urbanization and its impact on passenger and goods mobility demand (ADL, 2021).

## 1.1 Problem Statement

Metropolitan areas are the motors of the European economy, taking account for 85 percent of the EU's GDP (Busch, 2021). Connectivity and transportation infrastructure have erupted as key success factors for regional development. Efficient urban transportation helps transportation networks run smoothly, which is important for the economic system and citizens' needs (Harrington, 2016). However, city logistics are becoming a more inconvenient factor for residents. Policymakers have been considering alternative methods of supplying urban areas over the last decade because the current system is causing increasing problems in densely populated areas.

Residents are finding urban logistics to be increasingly inconvenient. Because the current system is producing increasing challenges in densely populated places, policymakers have been studying new methods of supplying metropolitan areas. Local governments take a variety of measures to reduce the negative externalities of urban freight. However, a part of the measures are carried out inefficiently or are inappropriate for the local context, resulting in unintended consequences, such as increasing traffic by replacing one large truck with smaller vehicles (Wang, 2010). Next to that, with new forms of commerce and new forms of delivery methods and organizing of supply chains, the future of urban freight in terms of shopping & transportation modes is uncertain. This uncertainty leads to different futures of urban logistics.

While freight transportation helps city's function, it has an environmental, economic, and social impact. Air quality (environmental); road congestion and delays in delivery (economic); and the overall built environment's safety and liveability are well-known examples (social). All these flows account for approximately 25% of street traffic in a typical city and between 16% and 50% of air pollution (Quack, 2017). Urban freight has more and more modes of transportation in use and development. All these different forms of logistics must share the same space. This could lead to negative externalities. Novel urban freight alternatives help to solve problems by making more efficient use of road & freight infrastructure (Muñuzuri, 2018).

Cities face a significant logistical challenge due to urbanization and consumption growth. People are moving away from remote regions and toward cities. Since 2008, the global urban population has surpassed the rural population (Hugo, 2013). Almost half of the world's population now lives in cities, and this figure is expected to rise to more than 60% by 2030. According to the European Commission's Environment Action Programme 2020 (Busch, 2021), urban areas will house roughly 80% of Europe's total population. If the population continues to grow while infrastructure capacity remains stagnant, there will be more traffic congestion and negative environmental consequences. Insights into different forms of city logistics can address these developments in more detail. This is done by looking into the future of different forms of urban freight transportation organizations in different scenarios for different actors.

## 1.2 Gap in literature

Given the advantages of urbanization concerning resource productivity, economic growth and connectivity, urban attractiveness and stability must still be assured and climate targets must be met: climate and environmental protection requirements are becoming more stringent (Santos, 2010). Nevertheless, as people migrate to cities, the demand for vehicles increases, and city driving is becoming more prevalent. As the urban population grows and more commercial establishments open, so does the popularity

for more services and goods for commercial and private use. Traffic jams in cities and economic harm are inevitable outcomes (Perboli, 2019). The volume of freight movements in cities has increased because of economic, operational, and social progress. The rise of consumption and the service industry has put an even greater strain on the economy. Digitization has resulted in well-informed consumers who can navigate the market effectively.

With long term trends affecting the city architecture and livability and new forms of freight delivery methods continuing to appear, the future of urban freight in terms of city supply chain organization is uncertain. In this case, several scenarios are possible (Kashef, 2016). The only certain thing is that goods will still need to be moved from the production site to the consumption site. However, the future of urban freight in terms of long-term trends & transportation modes is uncertain. These uncertainties lead to many different future possibilities for city logistics supply chains and how innovative distribution methods will have an impact on city logistics and urban consolidation. Amer (2017) identified forecasting methods for exploring the future of innovations in different sectors, e.g., scoring models, economic models and scenario analysis. These methods are designed to simulate disruptive diffusion of innovation in established markets, and constructing disruptive innovation scenarios, which will be suitable for exploring the future of different urban distribution innovations and the urban logistics system as a whole.

Initiatives are launched in numerous European cities to address these negative developments affecting the urban logistics system. Metropolitan locations like Barcelona, Paris, and London enacted legislative steps to lessen the detrimental effects of urban freight operations (Dablanc, 2011). In 2016, Madrid local government established a low-emission zone for the city center (Madrid Municipal, 2016). Hamburg introduced several policies to encourage sustainable urban freight transportation. For instance, a network of on-street loading and unloading areas. The G4 cities in the Netherlands are testing out various options and policies (Ministerie V. I&W, 2019). The Green Deal Zero Emission Stadslogistiek, is a covenant that the Dutch government, local governments, and several logistics companies signed in 2014 (Rijksoverheid, 2014). This deal is already getting outdated as different cities draft their policies and new forms of transportation & commerce are introduced since 2014, which leads to uncertainty in its effectiveness and calls for policymakers to assess regulations and policies for the future of urban logistics.

To explore the uncertainties brought by the societal, economic and environmental trends further, a scenario analysis might be useful. Many researchers agree on the fact that the future of city logistics is influenced by different factors: from new delivery methods to changing city architecture and climate change (Van Ommen, 2021, Dablanc, 2017). New studies point to the problem that urban logistics is changing fast. Looking at existing literature on the uncertainty of the future of urban logistics, Yoo (2013) and Castillo (2018) research specific urban distribution innovations to assess a market's readiness for disruption. Perego (2019) focusses on optimization of e-commerce models with new delivery methods and Kunze (2016) presents the outcomes of using ground drones in the city supply chain in 2030. Culot (2020) researches the impact of Industry 4.0 on city logistics using a scenario analysis methodology, which recommends a scenario analysis as a useful methodology to explore the future of urban logistics. Current research mainly focuses on the future of specific distribution innovations or specific factors influencing city logistics. In comparison to other research, multiple factors and innovative urban freight methods influencing the future of urban logistics will be taken into consideration in a scenario analysis in this thesis. Different scenarios provide a platform for the logistics industry and policymakers to analyze various measures and strategies based on the scenario outcomes to mitigate external developments and explore the future of urban logistics in the face of uncertainty.

To summarize, there is a sense of urgency as last-mile logistics & city architecture will change in the coming decades. As a result, getting a clearer vision of city logistics and its implications by exploring different long-term trends and new forms of transportation with exploratory scenarios benefits a wide range of stakeholders. Policymakers, logistics businesses and investors & developers wield the most power and (financial) resources, according to several sources found in the stakeholder analysis. They need to be aware of the changes in the urban logistics landscape and be prepared for the future by having resilient and robust (investment) policies and sustainable and adaptable business models in place. This research contributes to this by providing a view into the future in which long-term trends & forms of freight transportation affect the urban logistics system over time in combination with the implications for municipalities, logistics companies & investors in certain scenarios.

This offers a research gap to apply a scenario analysis method to this uncertain future of city logistics to be able to analyze the implications of societal, economic and environmental factors and disruptive freight innovations on the urban logistics system.

### 1.3 Research objective

Because the problem addressed in this research is a long-term development due to the fast change in city architecture and the introduction of new delivery methods, analyzing the impact on the current situation is insufficient. A scenario analysis method was used for this thesis because the future cannot be predicted but can be explored. The scenario analysis resulted in the identification of external influences and driving forces, each having different impacts on the urban logistics system. A clear future vision with possible scenarios can assist city logistics stakeholders in improving logistics in urban areas. With such future visions, stakeholders can receive valuable insights and implications on the future of urban logistics. The following is the research's goal:

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*“The goal of this research is to provide stakeholders outlooks in the future of city logistics in large cities using different scenarios. With these scenarios, the stakeholders can anticipate on what to do or not to do in the coming years, depending on different to be explored uncertainties.”*

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This objective is important for stakeholders because they have the ability to adapt their (investment) strategies in urban logistics based on future scenarios. Strategic planners can choose which strategic path to take by looking at the to be developed scenarios. Because the research is exploring different future possible states of urban logistics, actors can choose different paths depending on the developments over time. This study's final deliverable is a future vision of the different forms of urban logistics organizations with different delivery methods and their implications for policymakers, businesses, and investors under different scenarios. This thesis will focus on the future of urban logistics in large cities. Every city is different but it will provide a generalized vision for city policymakers and businesses on the future of urban logistics based on long term societal, economic & environmental trends and new distribution methods & supply chain organizations.

This thesis research will have a qualitative nature, with different qualitative research methods to be used. It will examine a complex socio-technical issue with a particular focus on the future development of different urban logistics options & urban consolidation centers. Urban logistics in different cities could help to consolidate freight traffic and reduce transportation movements within the socio-technical system and will be examined to determine how the future city logistics are impacted by long term trends within the social-technical system.

## 1.4 Research questions & Methods

In this chapter, the research approach will be presented. Beginning with introducing the sub-questions and ending with the steps to be taken. The scientific contribution of this thesis is to apply one of the possible scenario analysis methodologies to this uncertain future of city logistics to be able to analyze the implications of future freight delivery methods and long-term trends in the urban logistics market. The following main research question is proposed:

***What could be the future of urban logistics in 2040 in large cities & what could be the implications for municipalities, logistics companies & investors in different scenarios?***

With these future scenarios, municipalities can adapt their urban logistics policy strategy, logistical companies & developers their investments in supply chains and infrastructure. Different scenarios provide a platform for the logistics industry and policymakers to analyze various measures and strategies to mitigate external developments and explore the future of urban logistics in the face of uncertainty.

### Sub questions

To find an answer to the research question stated above, the following sub-questions must be answered next. Furthermore, these questions serve as the foundation for the research's structure.

1. **What are the stakeholders involved in the urban freight transportation system and their interdependencies?**
2. **Which of the future delivery methods & uncertainties in city logistics are relevant for the exploratory scenario analysis?**
3. **What are possible scenarios of city logistics in the Netherlands?**
4. **What are the implications of these scenarios for the urban logistics system and its stakeholders?**

#### 1. What are the stakeholders involved in the urban freight transportation system and their interdependencies?

To answer the first sub-question, information of what stakeholders are involved and what their objectives & interdependencies are will be researched and is to provide background information on city logistics and as input for the scenario analysis because the purpose of a scenario analysis is typically not for a single stakeholder. A scenario analysis should be designed in collaboration with multiple stakeholders. At the end of this chapter, stakeholders and their relations influencing the organization of urban logistics will be mentioned. The criteria of the stakeholders influencing the urban logistics system will be used to identify the driving forces used in the system analysis in sub-question 2 and will be discussed further in sub-question 3.

This information will mainly be gathered using research methods such as literature review and desk research. The data used will be the current state-of-the-art research papers but also grey literature. The sources of this data will be Scopus, Google Scholar & Web of Science.

#### 2. Which of the future delivery options & uncertainties in city logistics are relevant for the exploratory scenario analysis?

A more in-depth examination of the elements required for the scenario analysis is carried out here. This question will aid in the delineation of the problem. System analysis provides insight into the complexities of the factors influencing the development of urban logistics. It will also provide insight into the system and its components. Many studies on the relevant relationships and determinant factors in the system can be found in the literature. The factors are used to answer this sub-question and to find and elaborate on relevant factors that may explain the impact of long-term trends on urban logistics.

Next to that, this question's purpose is to provide insights into urban freight delivery methods in the future. The background information is relevant to the scope of the research and provides the necessary knowledge for understanding future developments around urban logistical methods, as they will for a large part determine the future organization of the city supply chain, which will be a part of the different scenarios. Next to that, this question's purpose is to provide input for the

scenarios by having insights into urban freight delivery methods in different stages of development & implementation now and in the future. This is done by analyzing in what phase different distribution methods are in business and research. These distribution methods will be important for giving a general vision & strategy on how the urban logistics supply chain could look as part of different scenarios. To comprehend the subject of possible delivery methods, a GE Analysis is used, which consists of a review of scientific & grey literature on city logistics.

### **3. What are possible scenarios of city logistics in the Netherlands?**

The goal of this research is to provide insight into the possible futures of urban distribution and the implication for the stakeholders involved by developing an overview with scenarios. The outcome of this sub-question is to map out the possible scenarios with each having risks and opportunities. A scenario analysis maps out the various organizations for urban logistics for the next two decades.

A workshop is part of the method used to create the possible scenarios. During the workshop, its stakeholders must discuss and interact about the possible future views around city logistics. Using pre-defined futures allows us to consider the possible implications for city logistics. An interactive environment compels stakeholders to discuss and comprehend one another's problems and solutions. This comprehension provides insight into the interdependence of actors as well as the sequence of future developments. Possible stakeholders could include experts from companies operating in dense cities, supply chain experts, professors in the field of transport & logistics and spatial placement & traffic officials from municipalities.

At first, the results of the workshops are discussed and the driving forces influencing the scenarios are ranked according to the input of the experts. With the input of the system analysis and the workshops, the scenarios are drafted by making a matrix of dividing four scenarios by the two most important driving forces from the ranking. The structure of the scenarios is that at first an overview is given of the urban environment in 2040. Next, the most important driving forces per scenario are discussed and the path from now to 2040 is presented. The scenarios end with an overview of the city supply chain organization in 2040 with different distribution innovations and nodes. The scenario plots are based on the input from the expert workshops and the stakeholder, system and GE analysis.

### **4. What are the implications of these scenarios for the urban logistics system and its stakeholders?**

The previous sub-question was answered by four scenarios giving an overview of the future of urban logistics and the organization of the inner city supply chain in 2040, based on ranked long-term trends. These scenarios should assist policymakers, logistical businesses and investors in imagining future developments, exploring relevant uncertainties, and studying the implications & recommendations for the different futures. The scenarios have numerous implications, but how the city logistics are organized with different freight distribution methods has been researched in this thesis.

This sub-question is answered by giving the main implications in different scenarios regarding environmental, societal and economic aspects. This phase is divided into developing full scenario plots and the implications & recommendations in different scenarios regarding environmental, societal and economic aspects for policymakers, logistical businesses and investors. The conclusions are drawn and the research questions are answered in the last chapter using the developed scenarios. At the end, a reflection on future research that can be conducted is presented.



## 1.5 Thesis outline



Figure 2: Research Flow Diagram

In this sub-chapter, an overview is given of the thesis project as part of the research approach.

1. In the first chapter, an introduction to the problem domain of city logistics and future delivery methods is given. This first step provides background information as well as knowledge gaps in city logistics. It defines the scope of the research and introduces the goals and methods.
2. The second chapter starts with analyzing the methodologies suitable for exploring the future of urban logistics. This chapter of the methodology phase discusses the method of developing future scenarios. This yields a scenario analysis method for creating possible future dimensions of urban logistics. A scenario study is carried out to obtain insights that account for future developments. The scenarios aid in emphasizing the plausible future and its implications for urban logistics. There are numerous approaches to developing future scenarios, and one will be discussed here. Scenarios can be created by utilizing the drivers, trends and delivery methods mentioned in the next chapters.
3. Next, in the third and fourth chapters, the underlying analyses for mapping city logistics scenarios are presented. In this stage, the stakeholders in city logistics, with their objectives and interdependencies, are presented and the system analysis generates a system diagram that defines the boundaries of the system under consideration in this study. In this phase, key factors influencing the organization of urban logistics will be mentioned. These factors will be used to identify the driving forces used in the scenario analysis. The information about the driving forces influencing the development of the urban logistics system and creating uncertainty is relevant to the scope of the research and provides the necessary knowledge for understanding future developments of the urban logistics system. The fifth chapter focuses on the urban freight distribution innovations as they will for a large part determine the future organization of the city supply chain, which will be a part of the different scenarios. Next to that, this question's purpose is to provide input for the scenarios by having insights into urban freight delivery methods in different stages of development & implementation now and in the future.
4. The final chapters 6, 7 & 8 focus on developing the scenarios and making estimations of what the implications would be for urban consolidation and society in city logistics. This phase is divided into developing full scenario plots and the implications & recommendations in different scenarios regarding environmental, societal, and economic aspects for policymakers, logistical businesses and investors. The conclusions are drawn and the research questions are answered in the last chapter using the developed scenarios. At the end of chapter 8, a reflection on future research that can be conducted is presented.

## 1.6 Societal & Scientific Relevance

While freight transportation is necessary for cities to function, it harms the environment, economy, and society. Air quality (environmental), traffic congestion and delivery delays (economic), and the overall safety and liveability of the built environment are all well-known examples (social). All these movements account for roughly 25% of street traffic in a typical metropolis, as well as between 16 and 50% of air pollution (Santos, 2010). More means of transportation are being used and developed for urban freight. All these distinct types of logistics must coexist in the same location. Negative externalities may result because of this and influence social liveability.

In city centres, the societal relevance is on increasing social, economic & environmental liveability. The goal of improving city distribution is to minimize pollution and boost safety; these elements have a direct impact on the retail environment, safety, and noise level, as well as an indirect impact on economic development (Srivastava, 2007). In addition, the results represent a significant step toward the EU's emission reduction targets (Busch, 2021).

Therefore, the goal is crucial for stakeholders because it allows them to change their urban logistics (investment) strategies based on future scenarios impacting society. By examining the yet-to-be-developed situations, strategic planners can determine which strategic direction to adopt. Because the research is looking into several future possible states of urban logistics, actors can take various paths based on how things develop over time. The product of this study is a future vision of various forms of urban logistics organizations with various new delivery techniques and their impact on society under various scenarios. At the same time, the thesis responds to several global, national, regional, and city-level climate targets such as the Paris Climate Agreement and the EU Green Deal (Hainsch, 2022).

A lack of awareness and knowledge amongst municipal councils makes building a comprehensive urban freight strategy hard. This results in drafting policies ad-hoc after changes in the urban logistics landscape to lead to negative externalities, instead of anticipating and developing long-term freight strategies. With new issues in the realm of urban freight arising, searching for a deeper knowledge of urban logistics, presents urban planners the uncertainties affecting the future of urban freight (Lindholm, 2013). Increased overlap between the knowledge of scenario planning and urban logistics to find alignment in the future with a plan to deal with negative externalities is needed as there is a lack of clarity and alignment in the steps taken by the government.

Governmental officials have started a new round of collaboration amongst parties to speed up the smart city logistics process. Several initiatives have been launched at the European, national, and local levels. However, these authorities do not account for the changes in city logistics throughout time (Kominos et al., 2019). Next to that, current studies appear to be mostly focused on the future of certain distribution innovations or specific issues influencing city logistics. In contrast to previous studies, this thesis will investigate a variety of issues and innovative urban freight technologies that are shaping the future of urban logistics. Different scenarios provide a forum for the logistics industry and policymakers to evaluate various actions and tactics to mitigate external trends and explore the future of urban logistics in an uncertain world.

# 2

## Methodologies

- 2.1 Literature & Desk Research
- 2.2 Scenario Analysis
- 2.3 Intuitive Logic Method

## 2. Methodologies

To answer the research question in this thesis, one main method was used: scenario analysis methodology. A literature review with a stakeholder analysis, system analysis and an innovation analysis is conducted to identify and elaborate on relevant factors & uncertainties that may explain the impact of long-term trends and future delivery methods on city logistics and are used as input for the scenario analysis. Paragraph 3.1 focuses on how potential scenarios can be constructed as this is the main methodology used in this thesis. This section goes over the methodology choices that were made in this study. Paragraph 3.2 contains more information on how the literature review was conducted and why and which submethods are used for delivering input for the scenario analysis.

Because the problem addressed in this research is a long-term problem due to the many (long-term) uncertainties regarding the evolution of the urban logistics ecosystem, analyzing the impact of the current situation is insufficient. A scenario analysis method was used for this thesis because the future cannot be predicted but can be explored. For the scenario analysis, the identification of external influences & driving factors is needed, which were used to supplement the factors discovered in the literature. These key factors will be found by using the system & stakeholder analysis approach to the urban logistics system in the next chapters and the scenario creation workshops. Scenarios can aid in understanding the implications of future events on logistics because they are primarily the same as creating a plan. Expert interviews can be used to create scenarios for the urban freight horizon.

Because the purpose of scenario analysis is typically not for a single stakeholder, a scenario analysis should be designed in collaboration with multiple stakeholders. The stakeholders will be identified in a stakeholder analysis in the next chapter. Interaction and alignment with stakeholders are critical in this case, so a workshop is planned to go over the fundamentals of the scenario analysis. Finally, this results in multiple possible future visions on city logistics involving multiple stakeholders. The researcher completes the final step, which is information conversion. Figure 3 depicts the five steps used in this study in chronological order.

The literature review of analyzing the urban logistics system has been executed in Chapters 3 t/m 5. In Chapter 3, the stakeholders with their objectives involved in the urban logistics system have been identified and analyzed. In Chapter 4, the external influences and driving forces, which have an impact on the urban logistics system, have been identified based on scientific & grey literature. In Chapter 5, future freight distribution innovations will be discussed based on a GE Analysis. These methods supplement the scenario analysis with input for developing the scenarios, such as which stakeholders are involved and what the status is of innovation in urban freight delivery and what trends influence the urban logistics landscape.

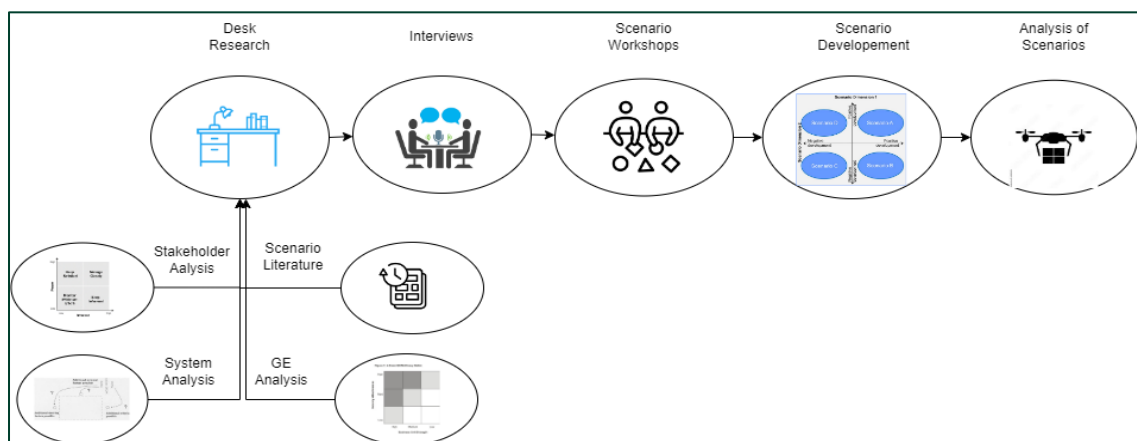


Figure 3: Methodologies used in this MSc Thesis.

## 2.1 Scenario Analysis

### Scenario Analysis Overview

Scenario planning has been around for more than 60 years and is widely used in a variety of industries (Duinker, 2007). People have been fascinated by the future since the beginning of time, and the concept of scenarios has been used as a tool to investigate this future. Following World War II, the military began to employ scenarios. It was used for the first time as a strategic planning tool (Postma, 2005). With the traumatic experience of the early 1970s oil crisis, people began to realize what the extreme consequences of unexpected changes in the business environment are (Arai, 2006).

Since then, scenarios, or future visions, have had a significant impact on human thinking and decision making. According to Arai (2012), there is a link between scenario analysis and the business environment having to deal with uncertainty, unpredictability, and instability. This relationship may explain the growing popularity and application of scenario analysis. The revival and increasing popularity of scenario analysis in various sectors has, however, the lack of a single accepted definition and a clear methodology resulted in conceptual and definitional confusion (Duinker, 2007).

Herman Kahn, regarded as one of the method's founders, defined scenario planning as "*a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points*". Scenarios are "*descriptions of possible futures that reflect different perspectives on the past, present, and future*" (Clemons, 1995). According to Bishop (2007), a scenario is a product of future studies, which focus on thinking deeply and creatively about the future so that one is not surprised or unprepared for what is to come. Simultaneously, at the same time, because of these uncertainties, we should plan for multiple futures.

The definition of Fahey (2011) is similar to that of Bishop et al. (2007), but it emphasizes what distinguishes scenario planning:

*"Rather than focusing on the accurate prediction of a single outcome, the central idea of scenario analysis is to consider a variety of possible futures that include many of the system's important uncertainties".*

A review of the literature reveals that there are numerous definitions. Because there is no agreement on a single definition for scenario planning, this study employs a self-defined definition by the researcher that encompasses the majority of the aforementioned aspects to avoid exclusion:

*Scenario analysis is an analysis technique that is used to provide insight into various possible future situations based on an analysis and understanding of what is considered the drivers of change in an uncertain system.*

The analysis and understanding of what is considered the drivers of change in a system are used to describe various possible future scenarios. Drivers, also known as change drivers, are defined as the exogenous variables for which we set values in a scenario (Busch, 2016). Choosing and incorporating the appropriate change drivers is critical for scenario analysis. The key factors & drivers determine how a system will look in the future and prepare you for it. These key factors & drivers will be presented in the next chapter.

Uncertainty is important in scenario planning because the future is unpredictable and thus characterised by uncertainty. When dealing with the future, dealing with uncontrollable and irreducible uncertainties. Scenario analysis will investigate the combined impact of uncertainties (Dahlberg, 2017).

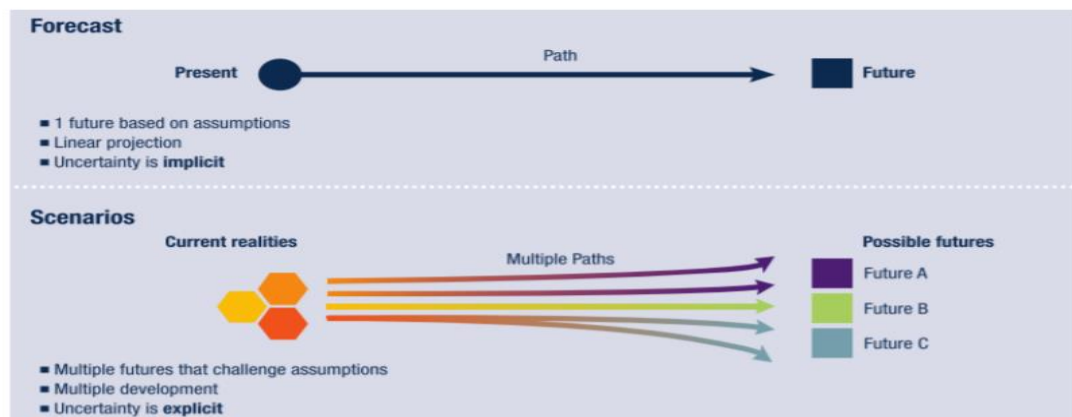


Figure 3: Scenario VS Forecast (Rehman, 2018).

The most common scenario analysis methods are **the intuitive logic school, the la prospective school, and the probabilistic modified trends school**, which are all based on scenario techniques. These three scenario methodologies are referred to as the three main schools of techniques, and each has a unique origin and development path over time (Dahlberg, 2017).

### Intuitive Logics

In literature, the intuitive logics school receives the most attention. This technique is also known as the Shell approach because it first gained attention when it was used at Royal Dutch Shell (Bryant, 2010). The intuitive logics methodology assumes that decision making is based on a complex set of relationships between an economic, political, technological, social, resource, and environmental factors.

The intuitive logics method heavily relies on the understanding and knowledge of experts and scenario participants when developing scenarios. Because the intuitive approach is based on an interactive group of people who develop stories or storylines, the intuitive approach relies heavily on qualitative data (Bradfield, 2005). There are several approaches within the intuitive logics school. The number of steps taken by the process varies, ranging from 5 to 15 or more.

### Probabilistic modified trends

The probabilistic modified trends school incorporates cross-impact and trend-impact analysis. Both analyses involve examining the impact on a key variable by examining the effect from probable future events. The intuitive logistics school relies mostly on qualitative data (Ramirez, 2014). Both are quantitative techniques which are opposite to the intuitive logistics school which relies mostly on qualitative data. The advantage of trend impact analysis is that there is a choice in the selection of factors influencing a key variable.

### La prospective

La prospective school results from the 'French Centre'. The French were in Europe the first to use scenario techniques to study the future. The method relies on four basic concepts: the base, the external context, the progression and the images. The objective of la prospective is to formulate an acceptable scenario-based methodology (Rounsevell, 2010).

## Chosen Scenario Analysis Method

The choice of predictive, explorative, or normative scenarios is determined by the scenario developer's basic question: "What will happen?" or "What can happen?" Or, "how can a specific goal be met?" Because our question is "What could happen?" question, an exploratory scenario will be set up.

The next step is to decide which scenario building method will be used to create the scenarios. Bryant (2014), examined the benefits and drawbacks of quantitative and qualitative scenario development methods. Because innovative urban logistics concepts are quite new, the statistical data required to perform quantitative scenario methods is scarce. As a result, a qualitative scenario analysis method is proposed (Cairns, 2014).

**The intuitive logics method is chosen from among these three options.** PMT necessitates reliable time series data, which is not available in our case, and La prospective is ruled out because it is a directed approach and the goal of our scenario study is not to steer in the desired direction. The intuitive logics method has several advantages, including the complete use of future information, the generation of new ideas, and the identification of underlying future drivers. One disadvantage is that the method is heavily reliant on the knowledge, commitment, and skills of the expert panel that developed it, making scientific evaluation difficult (Bryant, 2010).

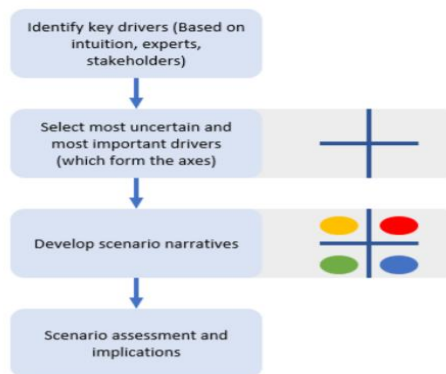


Figure 4: Scenario Development Steps (Rehman, 2018).

## Scenario Analysis: Intuitive Logic Method

It is an iterative process to create scenarios. The feedback on preliminary scenarios will aid in the validation of the scenarios. This is accomplished through the reflection of the interviews that could take place after the scenario creation workshop. The process followed to develop the scenarios in this master thesis is inspired by the work of Maack (2001) and in four steps: preparation, an expert workshop, elaboration of the scenario plots and validation by the participants of the workshop. Figure 4 depicts the progression of these activities, and the process will be further elaborated in the following indentions.

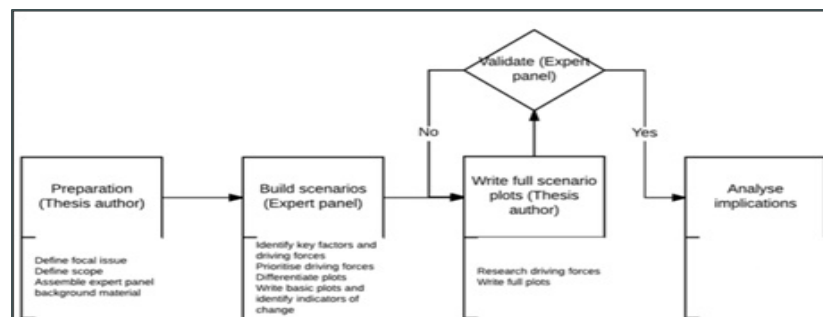


Figure 5: Scenario Analysis Method



## 1. Preparation

The preparation of a scenario workshop in the intuitive logic's method follows a few distinct steps. These are not strict, and deviations can be made freely, but following these will lead to solid preparation for the scenario workshop (Maack, 2001). According to Maack (2001), the focal issue should be defined first, followed by the scope. Following that, participants are chosen, background material is gathered, and finally the workshop's engagement rules, and process is described. The steps taken to develop and analyze the scenarios can be seen in figure 5.

## 2. Focal Issue

In scenario planning, the focal question serves as both an anchor and a boundary. It anchors the project so that everyone understands what they are trying to solve. It is important to note that the focal question must be broad, but that once developed, the scenarios themselves can easily serve as the foundation for exploring what an institution or any other concept might be in the future. However, rather than acting as an anchor and drawing the fence in, the larger context creates space for the smaller ideas to roam interestingly. The focal question, like a fence, establishes the foundation for context. The focal question keeps the discussion focused on the problem space and prevents project members from deviating into areas that are unrelated to the question at hand (Varum, 2010).

The focal question also serves as a project fence, reminding people that scenario planning is a decision-making tool designed to help organizations achieve better outcomes by more robustly exploring what could be, and the factors of influence in the future, before making long-term strategic decisions (Mietzner, 2005).

The focal issue is identified, using desk research as mentioned in chapter 3.1, as the first step in any scenario analysis study. This could be a decision or a question that is currently crucial to the organization's future. To develop a precise focal issue, one must first determine the desired outcome of both the problem for which a strategy is required and the scenario process (Mietzner, 2005). In this thesis, the problem that requires a strategy is exploring the uncertainties regarding the future urban logistics landscape and its freight transportation methods.

The desired outcome of the scenario analysis is to identify a framework of future urban logistics landscapes with impacts on society & the urban environment as well as change indicators to be monitored by governments, retailers & real estate developers. The year 2040 was chosen as the time horizon because it corresponds to the time horizon of recent government & business reports on the future of change in the urban environment and urban traffic planning in the Netherlands (Rijksoverheid, 2019).

As a result, the following focal issue was selected:

***What will the city logistics landscape look like within big urban regions and cities in 2040?***

## 3. Scope

- Big urban regions (500,000+ inhabitants) in the Netherlands.
- Urban Logistics is meant: Urban Logistics is the system and process by which goods are collected, transported, and distributed within urban environments. The urban freight system can include seaports, airports, manufacturing facilities, and warehouse/distribution centers that are connected by a network of railroads, rail yards, pipelines, highways, and roadways that enable goods to get to their destinations (Peters, 2020).
- The role of new or still in development freight transportation methods in the urban logistics system.
- The role of societal, economic and environmental trends affecting the urban logistics system.

#### 4. Participants

In the next chapter, a stakeholder analysis & system analysis of the urban logistics system will be executed. Based on the outcomes of the stakeholder analysis 5-7 stakeholders from the academic world to retailers in the city will be invited to participate in the workshops 'Urban Logistics in 2040'. According to Maack (2001) "Team members should be chosen based on their ability to represent distinct viewpoints on the issue being discussed, be it technical or political. Thus, the best scenario teams are diverse". The viewpoints were chosen to represent the triple helix collaboration of government, industry and university, commonly used for developing scenarios (Maack, 2001).

1. Owner & Director, SkyServices (25+ year's experience)
2. Head of Real Estate, CEVA Logistics (20+ year's experience)
3. COO: OZ Export B.V. (20+ year's experience)
4. Chief Executive Officer, Intospace. (20+ year's experience)
5. Supply Chain & Logistics Manager, ERIKS. (15+ year's experience)
6. Chief technology officer, HEMA. (25+ year's experience)
7. Assistant professor of Section Transport and Logistics, TU Delft. (15+ year's experience)
8. lecturer-researcher, the Logistics department of the Amsterdam University of Applied Sciences (AUAS). (15+ year's experience)
9. Projectleider City Logistiek, Themaregisseur Connectiviteit & Mobiliteit HVA (5+ year's experience)
10. Traffic and Transport Department, City of Rotterdam (15+ year's experience)
11. Supply Chain Director, Picnic supermarkets (15+ year's experience)
12. Professor Port & City Logistics, Hogeschool Rotterdam & TU Delft (15+ year's experience)
13. Director, DHL Supply Chain (15+ year's experience)
14. Real Estate Expansion Specialist, Getir (2+ year's experience)

## 5. Background Information

Background material should be presented to the scenario team in addition to the focal issue and scope. The goal is to assist the group in starting with the same basic reference points while still leaving room for creativity. Before the workshop, the thesis author had discovered relevant factors for the focal issue through his research in the next chapters. However, to avoid bias and allow for full creativity, these factors were not given to the participants. Instead, the factors discovered by the experts during the workshop will be compared to those discovered in the literature review, to extend the list of the long-term trends. During the workshop, some general information was displayed to avoid discussions about facts of urban logistics in the Netherlands.

## 6. Developing The Scenarios

Five steps were taken during the half-day expert workshop, as shown in Figure 6, leading to a few possible future views of the urban logistics landscape.

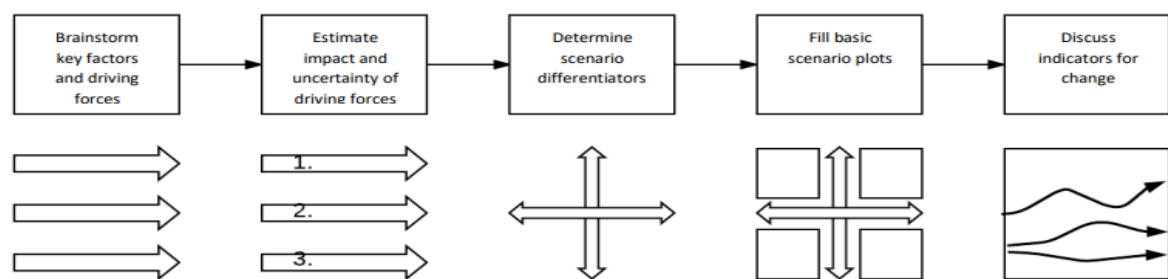


Figure 6: Scenario Analysis Workshop.

The goal of the workshop is to fully utilize the participants' diverse expertise and come up with four distinct basic scenario plots in 3.5 hours. The workshop is divided into four sections.

- **First**, the organizer will give a presentation to ensure that each participant understands the central issue.
- **Second**, in a brainstorming session, key factors and driving forces for the focal issue are identified. the key factors and driving forces were identified in a brainstorming, and the workshop participants were individually assessed on the level of impact on the focal issue and the uncertainty of their future state using the Wilsons matrix (Figure 7) on a scale from low to high by the 14 experts in total. The scale of low to high was transferred to a numerical scale of 1-3 to make the aggregated ranking of the identified driving forces by the 14 experts easier. The results can be found in chapter 6.
- **Third**, using Wilson's matrix (Figure 7), the identified forces and drivers are prioritized. Following that, the impact and uncertainty assessment was used to create a two-by-two scenario matrix, and four scenario plots were created.
- **Fourth**, the four fundamental scenario plots are constructed and written. Each step is elaborated in greater detail in the appendix, along with a time frame and, if applicable, rules of engagement for participants. Finally, key factors were discussed to aid in the development of a logical development path for each scenario and the creation of full future visions on urban logistics in large metropole areas in the Netherlands.

The first result was used to compare expert-discovered factors with those discovered by the author from the system analysis approach applied to the city logistics system to create a complemented list of impact factors. The second result was used to distinguish the scenario plots and to determine what and how the identified driving forces should be included in the scenario plots. The third result served as a foundation for the full scenario plots. The following paragraph will explain how the elaborated scenarios were created.

Degree of uncertainty			Level of impact
Low	Medium	High	
<b>Critical planning issues</b> Highly relevant and fairly predictable (can often be based on existing projections). Should be taken into account in <i>all</i> scenarios.	<b>Important scenario drivers</b> Extremely important and fairly certain. Should be used to differentiate scenarios. Should be based on projections but potential discontinuities also should be investigated.	<b>Critical scenario drivers</b> Factors and forces essential for success and highly unpredictable. Should be used to differentiate scenario plots and trigger exit strategies.	
<b>Important planning issues</b> Relevant and very predictable. Should be figured into most scenarios.	<b>Important planning issues</b> Relevant and somewhat predictable. Should be present in most scenarios.	<b>Important scenario drivers</b> Relevant issues that are highly uncertain. Plausible, significant shifts in these forces should be used to differentiate scenario plots.	
<b>Monitorable issues</b> Related to the decision focus but not critical. Should be compared to projections as scenario is implemented.	<b>Monitorable issues</b> Related but not crucial to the decision focus. Should be monitored for unexpected changes.	<b>Issues to monitor and reassess impact</b> Highly unpredictable forces that do not have an immediate impact on the decision focus. Should be closely monitored.	Low

Figure 7: Wilson's Matrix (Novick, 2000).

## 7. Analysis Of The Developed Scenarios

Based on the outcomes of the scenario workshop, the author of the thesis created full-length scenario plots. The basic scenario plots and indicators of change served as the foundation for the full plots, which were filled with research on the identified driving forces. All scenarios include a context that includes the end state of urban logistics in 2040, the path to that end state, and the implications of new freight transportation methods on the urban logistics landscape. Following completion, the plots, along with the workshop results and scientific backing, were distributed to each participant for content validation. Their feedback was used to improve the author's work and logic.

The final part of the thesis focuses on developing the scenarios and making estimations on what the implications would be for society and urban consolidation in city logistics. These scenarios should assist scientists and policymakers in imagining future developments, exploring relevant uncertainties, and studying the implications for their merit. The scenarios have numerous implications, but how the city logistics are organized with different freight distribution methods has been researched in this thesis. The main opportunities in different scenarios regarding economic, societal, and environmental aspects are elaborated first in this chapter. As a result, the leading operational indicators of change are presented based on the developed scenarios. At last, as seen in the different scenarios as an important part of the city supply chain, the operational and design aspects of urban consolidation centers are analyzed.

## 2.2 Literature Review

To answer the first and second sub-question, a literature review and interviews were conducted. The literature review focused first and foremost on how the urban logistics landscape in the Netherlands is currently organized and which factors influence this socio-technical system and which innovative distribution methods will be used in the future. This literature review is used in chapters 3,4 and 5 and forms the basis for the stakeholder & system analysis and the GE multifactorial analysis. Because our research topic involves potentially disruptive innovations in the urban logistics sector, we examined both the fields of future freight delivery methods and the urban logistics system currently in use by using peer-reviewed papers or books found via Scopus, the TU Delft Library, Science Direct. The literature review focuses on urban logistics, innovative delivery methods, and urban environment attributes.

This section begins with a discussion of the databases that are used, as well as the keywords that are used to extract the data. The discovered literature is then grouped to imply which focuses on analyzing it is used for.

Desk research's goal is to compress the published research in a profession and, as a result, define areas where improvement research would be advantageous (Dale, 2004). Understanding the topic area is required to select high-quality publications to develop new theories. The goal is to find literature on sustainable urban freight transportation and scenario analysis.

Search Engine	Search Term	Hits
Science Direct	Urban Freight Transport	3934
Science Direct	Urban Logistics	4593
Science Direct	Urban Logistics Methods	1739
Science Direct	City Logistics	12790
Science Direct	Future Delivery Methods	7803
Scopus	Urban Freight Transport	789
Scopus	Urban Logistics	1802
Scopus	Urban Logistics Methods	344
Scopus	City Logistics	8930
Scopus	Future Delivery Methods	698

Table 1 displays the number of hits for equivalent key phrases in two search engines. Although some important references from previous research were included in the review, the literature search was restricted to the last 10 years (2012-2022) to render the references more relevant. To guarantee that only a limited number of references to the specific topic area were displayed, the search queries were used in various combinations with other terms related to the subject.

Table 1: Example of number of hits in one search of urban freight transport and city logistics.

Table 1 shows two samples derived from the literature review's search for urban transportation and city logistics. Over 200 abstracts were reviewed for relevance, as well as tables and figures, to narrow down the hits. There was a need for boundaries because the field of urban freight transportation is so vast. In this regard, the following observations have been made:

1. Only articles about urban freight distribution are considered, so no literature about people and passenger transportation is considered.
2. Only references dealing with European cities or perspectives are included.
3. The majority of the literature considered is recent, i.e., from the 2010s and onward.
4. In terms of language, only references in English and Dutch were considered during the selection process.

Type of source	Number of references
Book	19
Conference proceeding	7
Journal paper	57
PhD thesis	7
Web pages	11
Governmental report	8
Project report	30

After performing this literature review with these rules, a list of 139 references is obtained. The type of sources is summarized in Table 2. The most used sources are journals, books and research reports.

Table 2: Category of references.

## Stakeholder Analysis

City logistics involve several parties. In this study, stakeholders are defined as those with a direct interest in the system's ability to impact it, either explicitly or implicitly. This chapter investigates the various players to obtain a greater understanding of the inter-dependencies and power structures in the urban logistics landscape. By mapping the options and interests of various stakeholders, a thorough stakeholder analysis contributes to policy analysis by generating ideas for which stakeholders to include in the scenario analysis and which implications and recommendations can be suitable for which stakeholders based on the different scenarios, and stakeholder objectives and interdependencies. The result of this chapter will be used as input for the system analysis described in the next chapter (Van Heeswijk, 2020). It aids in the understanding of common ground and shared fundamental values, allowing for the identification of needs and potential compensatory or mitigating measures to satisfy specific stakeholders (Bryson, 2004). A wealth of information on various stakeholders and their roles in the system can be obtained through the use of literature.

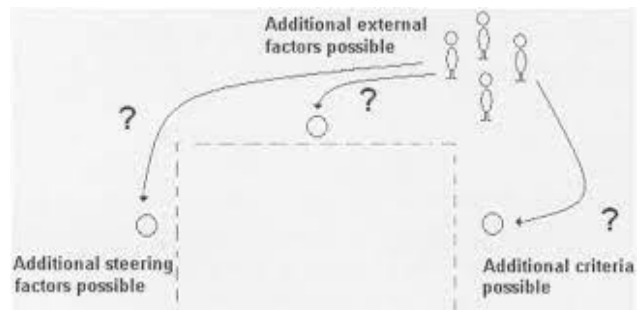
Figure 4: Category of stakeholders.



## System Analysis

Urban logistics operations are a complex process involving many actors, each with their stakes and interests; see the next chapter for more information on stakeholder analysis. The urban logistics environment is dynamic and ever-changing. By defining the system's boundaries and structure, as well as the main elements and their relationships, a system description aids in mapping and analyzing the system (Witkowski, 2014). These analyses have the advantage of helping to structure ill-defined and complex policy domains. The system diagram is a core concept that is used to represent a structured view of a problem situation (MacQueen, 2000). The system diagram is linked to all the analytical tools that will be presented as part of our approach.

Figure 5: System Analysis Diagram.



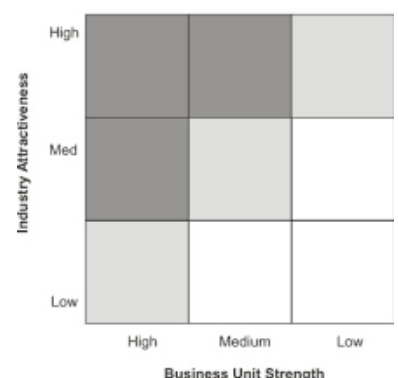
The system diagram distinguishes between the system, steering factors, external factors, and desired or criterion outcomes. As we will see in the following sections, the entire diagram is built in several steps and iterations. Although we have presented our steps in a logical order, there is no perfect order, and much iteration occurs in practice.

## GE Multifactorial Analysis

McKinsey developed GE multifactorial analysis, a business strategy method that helps a company decide which long-term strategic projects to pursue and which market opportunities to continue investing in (Bourgeois, 2010). It provides the necessary knowledge for understanding future developments around urban logistical methods, as they will for a large part determine the future organization of the city supply chain, which will be a part of the different scenarios and aid in the analysis of how certain distribution innovations develop over time. Each dimension is divided into three levels to create the two-dimensional matrix. Because each product, service, and strategy is represented in this two-dimensional matrix, the GE matrix can aid in the evaluation of a strategy's overall strength. The phases of academic distribution innovations research are as follows: (1) conceptual model phase, (2) analysis and planning phase, and (3) promotion and evaluation phase (Zhangyuan He, 2019).

Figure 6: Multifactorial Analysis

Figure 1: A Blank GE/McKinsey Matrix



The research is divided into three phases: the research introduction, the underlying analyses for finding the stakeholders, key factors, driving forces, distribution methods needed for the scenario development and the design of the scenarios. The first phase of system design is to determine the research approach. The Intuitive Logic scenario analysis method appears to fit the purpose of providing a study with possible future visions perceived by city logistics stakeholders. A stakeholder analysis & system analysis are required to provide key factors influencing possible scenarios. The innovation multifactorial method is used to analyze the future potential of different urban freight innovations. These methods supplement the scenario analysis with input for developing the scenarios, such as which stakeholders are involved and what the status is of innovation in urban freight delivery and what trends influence the urban logistics landscape. The execution of the scenario analysis of Maack (2001) after the workshop is the study's final phase. The goal of this phase is to create future visions that depict the various routes that the city logistics industry could be in 2040.



# 3

## Urban Logistics System Stakeholders & Objectives

3.1 Urban Logistics Overview

3.2 Approach of Stakeholder Analysis

3.3 Stakeholder & Objectives Identification

3.4 Stakeholder Relations

3.5 Concluding Remarks

# 3. Urban Logistics System: Stakeholder Perspectives

The parties involved in city logistics are examined in this chapter. The problems associated with urban goods transportation activities are primarily attributed to underlying characteristics such as heterogeneous stakeholders, their competing goals, and the resulting distributed decision making (Curtis, 2011). The stakeholder analysis elaborates on the stakeholders' objectives and relations. Mapping the current power position, attitude, and interests of stakeholders reveals interdependencies. The perspectives of stakeholders are central to the research and will be revisited in each chapter. Local governments, shippers, carriers, logistic hubs, retailers and investors are the six primary stakeholders in this study.

This chapter investigates the various players involved to gain a better understanding of the interdependencies and power dynamics in the urban logistics system. By mapping the options and interests of various stakeholders, a thorough stakeholder analysis contributes to policy analysis by generating ideas for which stakeholders to include in the scenario analysis and which implications and recommendations can be suitable for which stakeholders based on the different scenarios, and stakeholder objectives and interdependencies. The result of this chapter will be used as input for the system analysis described in the next chapter.

## 3.1 Urban Logistics Overview

Urban logistics encompasses a wide range of activities and relationships involving a diverse range of actors and stakeholders in the production, storage, trading, and supply of a wide range of goods and services (Peters, 2020).

Urban logistics is critical for citizens' quality of life and plays a significant economic role with significant benefits for multiple stakeholders along rather complex, dynamic supply chains (Le Pira, 2017). However, urban freight transportation has several environmental, social, and economic issues, particularly in terms of pollution and gas emissions, noise, traffic congestion, pedestrian safety, and journey unreliability and delivery delays. This is becoming more critical as load fragmentation increases and small parcels are frequently carried by nearly empty transport vehicles (Lagorio, 2016).

However, freight transportation planning is still in its infancy. In comparison, urban goods transportation is almost entirely managed by private logistics service providers and/or shippers who look at their transport requirements without any coordination, resulting in many unnecessary, from a city standpoint, movements of underutilized vehicles in congested areas (Lagorio, 2016).

Urban logistics serves as the primary point of contact between the service provider and the customer. However, there are some constraints in defining urban logistics. There should be a clear definition of urban logistics that identifies its scope throughout the goods supply chain, i.e., where city logistics begins and ends (Peters, 2020). For example, it is unclear whether the term "last stage" refers to the transport segment between the distribution center and the final destination, the transport segment between the local distribution center and the final destination, or only the transport segment between the pick-up point and the final destination. To avoid this misunderstanding, in this study, urban logistics is defined as transporting freight along the last part of the supply chain from the distribution center or retailer to the consumer's address within densely populated urban environments. Urban logistics is based on the last stage of the supply chain in the case of the goods supply chain (Schoder, 2016). The final leg of delivery from business to customers.

Based on six-year average data, road transport accounts for approximately 75% of inland freight transport in the EU, with rail accounting for the remaining 18% (Rai, 2020). This suggests that, as part of road transport, urban freight has a significant negative impact on urban development sustainability, as it is already known as the most fragmented and inefficient part of

the goods supply chain. Understanding the main characteristics of urban freight is critical for making future visions for the urban freight system for a specific urban area or city (Schoder, 2016). Freight distribution is characterized primarily by the involvement of numerous actors (e.g., carriers, suppliers, etc.), short routes, low speed driving, short time of effective driving, long vehicle downtimes, labor intensive, space restriction, and limited traffic infrastructure compared to high demand for transportation, inefficiency (low load factor, empty running), high population density, and related high environmental concern.

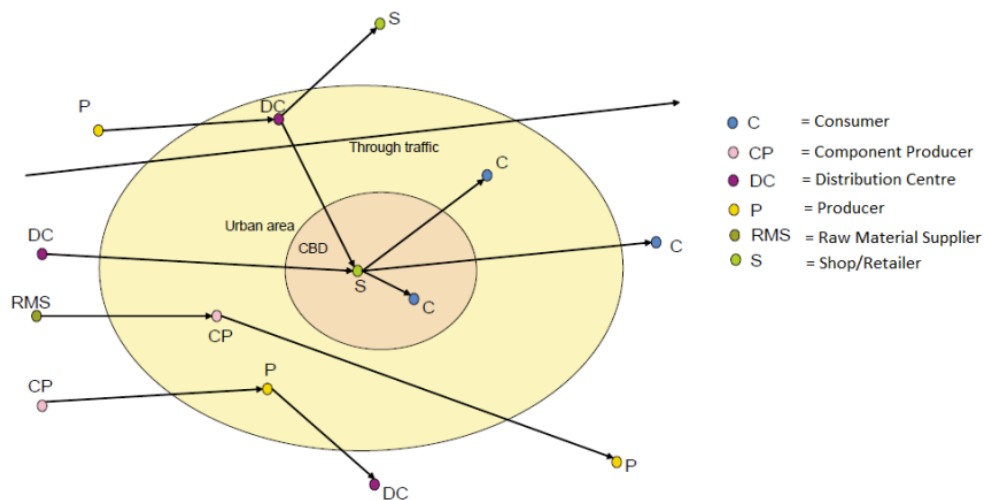


Figure 8: Urban Logistics Schematic Overview (Huang, 2020).

Urban freight is also known for its reliance on local conditions and infrastructure constraints (e.g., unloading spaces), as well as trends such as rising service demand, complexity, and inefficiency (Schroder, 2016). Urban logistics, in particular, is distinguished by a high degree of fragmentation of freight flow, the use of different delivery methods, and the use of different vehicle capacities. These characteristics result in uncertainties in how urban freight systems will evolve in the future. As a result, more research is needed to investigate the urban logistics system and provide authorities with different scenarios of the urban logistics system.

## 3.2 Approach of Stakeholder Analysis

Several parties are involved in city logistics. In this study, stakeholders are defined as those who have a vested interest in the system and can influence it, either directly or indirectly. This chapter examines the various players involved to gain insight into the interdependencies and power dynamics. A thorough stakeholder analysis contributes to policy analysis by generating ideas for alternative strategies and tactics by mapping the options and interests of various stakeholders (Van Heeswijk, 2020). It aids in the understanding of common ground and shared fundamental values, allowing needs and potential compensation or mitigating measures to be identified to satisfy specific stakeholders (Bryson, 2004). Using literature, a wealth of information on various stakeholders and their roles in the system can be gleaned.

### 3.3 Stakeholder & Objectives Identification

Stakeholders can be divided into a few groups: authorities, such as municipalities and national governments, residents, receivers, logistic companies and investors. All stakeholders in urban freight share the common goal of ensuring that goods are transported in urban areas at the right time, place, and quantity. Nonetheless, the stakeholders' interests are frequently at odds, as they all have different perspectives on urban freight transportation (Macharis, 2012).

Essentially, the stakeholders with direct influence on the city supply chain can be divided into two groups: private stakeholders and public stakeholders, both of which can incite change and possess the rationale to move toward a sustainable urban freight system. Policymakers can fund or invest in initiatives, shippers can change logistics, consumers can vote or buy, and receivers can choose their shippers (Bauwens, 2015).

Wang et al. (2016) created a stakeholder classification of the urban logistics system in China. Shippers, carriers, shop owners/retailers, municipalities, and customers were among these groups. De Oliveira et al. (2017) consider six agents in urban freight: carriers, shippers, residents, administrators, retailers and real-estate investors. Other stakeholders in urban logistics include European and national governments, research institutes, and citizens. These stakeholders are interested in city logistics, but they have few ways to influence decision-making or the system.

This section focuses on stakeholder identification & goals. The objectives of various stakeholder groups are diverse and, at times, contradictory. Stakeholders strive to optimize their activities in accordance with their own interests, regardless of the interests of their neighbors (Frederik, 2010). An overview of the various objectives provides insight into the stakeholders' attitudes.

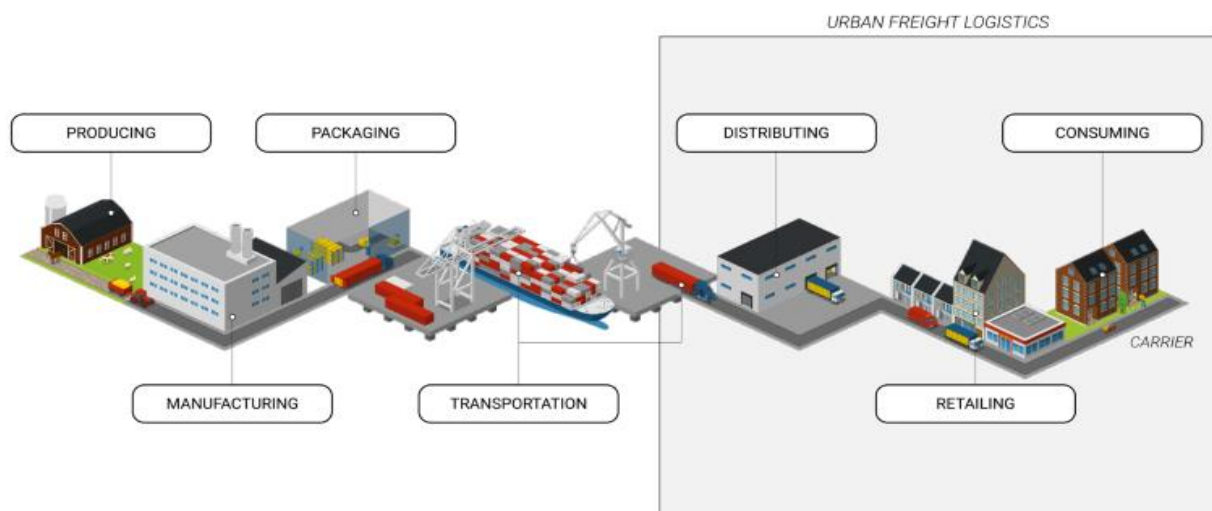


Figure 9: Urban Logistics Supply Chain.

**Shippers** are suppliers in the city logistics domain who oversee delivering goods to retailers. Shippers can be small independent businesses or part of a large retailer chain. In city centers, the shippers may be stores, retailers, restaurants, hotels, or public institutions (De Oliveira, 2017). The variation suggests that different shippers can influence and be influenced differently by urban distribution policy measures (Solomon, 2020). Shippers come from a wide range of backgrounds. Small, independent transport companies or one-man transport operators, for example, who collect and distribute goods for their organization or larger companies. Logistics service providers are a growing group of private stakeholders in addition to carriers, owing to the importance of supply chain integration and increased outsourcing of logistics to third parties.

Stakeholder	Objectives
Carrier	Positive Return on Investment Profitability Satisfying shipper and retailer Punctuality Worker's satisfaction Reduce delivery time Sustainable operations
Shipper	Satisfying the receiver High service level Accessibility Low cost of logistics Profitability Sustainable operations
Retailer	Profitability Frequently delivery Low cost of logistics High service level Customer's satisfaction Low stock Attractive shopping environment Sustainable operations
Local Authority	Optimal use of existing infrastructures Low-cost measures Sustainable urban environment Citizen's Quality of life Positive business climate Accessibility
City Hub	Positive Return on Investment Profitability High service level Sustainable operations
Real-estate investors	Investment diversification Positive Return on Investment Sustainable development Steady long-term revenues

Table 3: Summary of the objectives of the stakeholders.

**The carrier** is a 3rd logistics company that receives and delivers items from various shippers to retailers.. Carriers have traditionally been identified as private logistics stakeholders. Carriers are responsible for transport from distribution terminals and strive to collect and deliver goods as efficiently as possible by optimizing load capacity, co-loading, and delivery routes (Carvahlo, 2012).

**Retailers** can be small independent businesses or part of a large retailer chain. In city centers, the receivers may be street or shopping mall stores, retailers, restaurants, hotels, or public institutions. Retailers are the final link in the supply chain, and their primary responsibility is to commission and receive deliveries. Finally, they determine when to order, how much to order, and when they want the order delivered (Fancello, 2017). The shops want to ensure the safety of their merchandise. As a result, their goals are to deliver frequently, at a low cost, and on-demand, allowing stock to be kept to a minimum. Furthermore, they expect high service, such as real-time information and deliveries at a time when there are not as many customers as possible.

**The local government**, also known as the municipality, is the city administration that can influence urban freight activities by enacting various policies, measures, regulations, and so on and plays an important role in logistics performance and in reducing the environmental impact of freight transport. One major impediment to coordinated urban logistics planning is that different actors within local governments have varying degrees of awareness of their potential influence. This is because of their disjointed responsibilities and ambiguous roles in urban freight (Gatta, 2017). Different departments within the city government, such as planning and building agencies, police, parking agencies, labor inspection authorities, and food safety authorities, frequently represent competing goals and motivations. Local government attitudes frequently reflect the perception that optimizing urban distribution is a private concern (Gatta, 2017).

Local government interests are not always directly related to urban freight. Municipalities represent a diverse range of city users, so multiple points of view must be considered. They seek to optimize the transportation network by making the best use of existing infrastructure and implementing social & environmental solutions. The trade-off for governance is, on the one hand, making the urban environment nice and appealing to citizens while also attempting to improve the citizens' quality of life. On the other hand, the local government wants to ensure a positive business climate and an appealing environment for businesses, so accessibility is critical (Sun, 2021).

**The city logistic hubs or urban consolidation centers** are the providers of logistics within urban areas. Consolidate goods and deliver them quickly and with a high level of service in the city center. The hubs oversee the city's first and last mile logistics. Among the services provided by city hubs are bundling and storage of goods (Elbert, 2018). The main goal of the city hub, like the carriers, is to generate a positive return on investment and profit by providing logistic services. The goal is to provide excellent service by offering same-day delivery, punctuality, storage, and bundling of goods. The logistic city hub is concerned about the environment and is working to reduce emissions, noise levels, visual nuisance, and congestion.

**Real-estate investors**, which range from development companies, asset managers and banks, have a deep interest in logistical assets, such as warehouses and urban consolidation centers due to wanting to capitalize on the increase in online shopping. A wider spectrum of investors and investment platforms are drawn to industrial real estate close to cities (CBRE, 2021). According to JLL (2021), the urban logistics sector as a whole has grown quickly over the past ten years and will account for more and more of real estate investment volumes in the future. Just over a year after the epidemic began, the drive to diversify, which was already present due to debuts in some industries like last-mile deliveries, has only grown. Investment portfolios are more diverse than they were a year ago as investors seek out new assets in the urban logistics landscape (Baglio, 2019).

**Consumers** are the people in the city who want to buy goods from stores. People are the end-users of urban freight transportation systems, and they are also the ones who suffer from city transportation annoyances such as noise pollution and congestion. Furthermore, urban freight transportation has a direct impact on several actors, even though their involvement is always indirect (Lindhol, 2012). To name a few, citizens, workers, shoppers, and tourists. Historically, such stakeholders have not been involved in transportation planning, but their interests should be considered by public authorities during mobility planning processes, despite their roles and responsibilities are not well defined.

### 3.4 Stakeholder Relations

Cities all over the world are reaching the point where they can no longer accommodate the growing transportation demand by delivering urban freight. This has pushed policymakers to improve or restrict logistical performance while reducing transportation's social, economic, and environmental impacts (Allen, 2012). As a consequence, municipalities now need to set clear regulations on urban freight. A proper understanding of the interplay between commercial and governmental stakeholders is essential since the variety of stakeholders have competing interests. It is obvious from identifying players and their objectives that, government efforts and comprehension of urban freight operations are insufficient, despite the growing significance of urban freight movement in cities (Marsden, 2020).

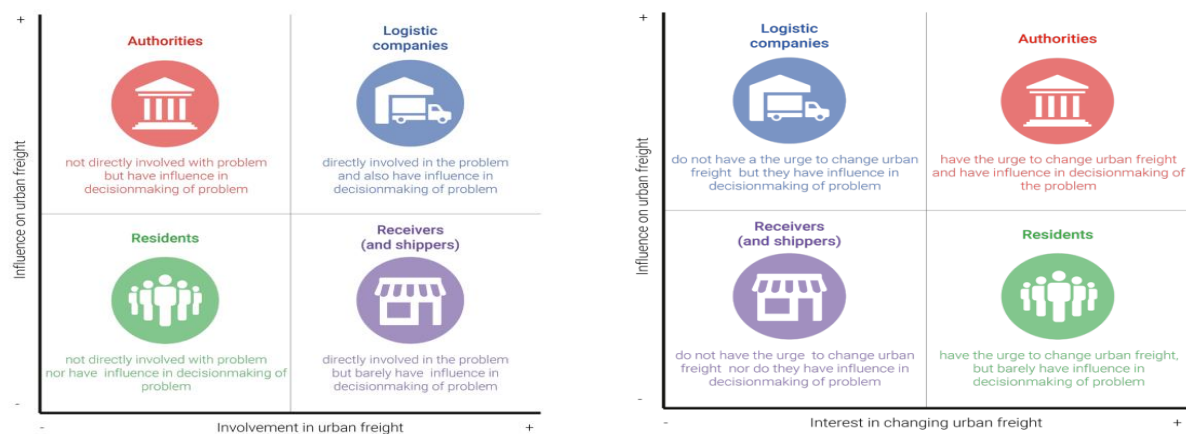


Figure 10: Urban Logistics Stakeholder Influences.

With different future visions of urban logistics in cities, authorities will be equipped to define different regulatory strategies for urban logistics. When authorities are aware of the needs of key stakeholders in urban freight, it results in better collaboration. Conflicting interests among stakeholder groups are unavoidable (Witkowski, 2020). When commercial and public actors' interests are compared, it is clear that commercial stakeholders want to benefit primarily from economic stability, in something they want to fulfill their clients with excellent and quick delivery in a competitive industry, whereas public bodies work to improve the desirability and general quality of life of their city on behest of their residents and visitors, which is primarily related to environmental and social sustainability (Clemons, 2016).

The logistical companies, municipalities and investors wield the most power as seen in figure 10. The retailer has control over how the shipper delivers the goods to him. In turn, the shipper can select the carrier and specify how the goods should be transported. In addition, the municipality can impose regulations to alter the logistics. The stakeholders' attitudes toward changing city logistics to improve the urban environment vary (Maltese, 2021). Retailers want to concentrate on what they do best: sell goods to customers. Shippers and carriers do not want limitations and measurements that limit their ability to deliver goods to stores. Additionally, freight forwarders compete with one another to win and keep clients for their freight distribution services. Within the parameters of the land use zoning framework, residential and commercial developers are also competing for real estate projects (Baglio, 2019).

The municipality, its residents, and its visitors have an interest in having a safe, attractive city center with a reliable supply chain. Along with the municipality, the local economy also gains from it, which is advantageous. One of the main responsibilities of the municipality is to support the policy that will achieve these goals (Belissent, 2010). They could use incentives to reward sustainability and sustainable logistics solutions and limits such as time access windows, road fees, and unloading and parking restrictions. In other words, the job of municipal authorities is to control, encourage, facilitate, and/or coordinate (Kaiser, 2020). Municipalities and companies could be persuaded that working together to regulate volume with different forms of distribution in the logistic chain benefits all participants. Additionally, local governments should play a motivating role in encouraging people to switch to sustainable options, particularly among sustainability pioneers. For instance, the advantages of road pricing can be utilized to fund the development of sustainable distribution methods (Schwartz, 2019).

Since municipal governments primarily focus on the role of steering the changes in the urban freight network to improve the environment for its residents and the economic operations of local businesses, there is room for financial promotion of societal beneficial objectives. Steering logistical companies toward green technology have to be encouraged because retailers, shippers, and carriers are unwilling to pay more for green logistical solutions and funding must come from different source, such as local governments and investors (Piaralal, 2015). There are various ways to go about doing this. If companies invest in green technologies, they might be allowed to enter the city with goods using sustainable distribution methods before a regular truck or delivery outside of set delivery windows. For parties with environmentally friendly vehicles, this might open up completely new market opportunities and help achieve future zero-emission goals. The same goes for developers of logistical real estate, as the new market opportunity of developing logistic city hubs will consolidate freight and lead to fewer emissions (Elbert, 2018). Incentivizing logistical businesses with subsidies and other forms of financial stimulation for contributing to greener supply chains could result in public private partnerships and a changing urban logistics system. Investors could also provide financing for these green city hubs or sustainable delivery methods but to get them on board, city councils need to take a leading role because investors are risk-averse and want to minimize default risks (Baglio, 2019).

Furthermore, It is crucial from the perspective of transporters to have a strong enough interaction with the municipalities and between different city municipalities in terms of city-to-city coordination, to assure national coverage of policies affecting the future of urban logistics (Haupt, 2020). It would be extremely difficult to organize cooperation among the stakeholders who are required for adequate volume to guarantee success if every city had distinct regulations and constraints. Shippers must understand that all goods are handled consistently and under the same circumstances.

As seen above, different stakeholders have different interdependencies and objectives and conflicts between stakeholders are unavoidable as a result of the urban logistics landscape's density, complexity, and lack of available space for example. Conflicts appear when people, planners, and regulators decide that the externalities caused by urban freight distribution on local communities for ongoing or proposed projects are no longer acceptable. Sometimes disagreements over particular concerns occur between locals and planners, evoking traditional NIMBY reactions (Sanofi, 2018). A development project, such as a new distribution center, may be stopped or more closely regulated by using legal means or located in less preferred areas by the city governments.

Officials predict that private stakeholders would create long-term operations to suit customers' and merchants' rising needs. At the same time, these corporations anticipate government-led and subsidized controls on long-term operations because they don't want to take on significant risks or invest a lot of money in them until they know if they will pay off. (Haddadi, 2016). Changes in the behavior of logistic stakeholders are slow as a result of their awaiting and passive attitudes toward one another as seen in figure 11. Local governments view this as a private affair since difficulties are brought about by private commercial operations, whereas national governments abdicate responsibility to them because they see it as a local issue. Nevertheless, the private sector considers urban freight to be an infrastructure and regulatory issue that requires government attention.

Also, authorities in cities are aware that freight transportation is vital for economic reasons, yet the majority of cities believe that truck traffic should be outlawed or closely controlled, while just a small number believe that freight activities should



be supported in their objectives (Russo, 2010). At the same time, there is a lack of continuity and uniformity in city freight development because the freight strategy is often not a long term strategy, making it more difficult to come up with robust and adaptive policies. In addition, guidance on the future development of urban freight in practice is lacking from the national governing body (Russo, 2010).

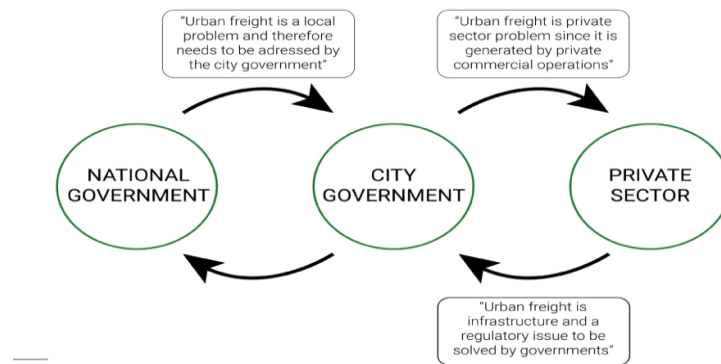


Figure 11: Stakeholder Vision of Urban Logistics.

The idea of city logistics allows for the implementation of several plans while also taking into account the fact that each stakeholder has unique goals and viewpoints, and that it is crucial to take these distinctions into account while coming up with solutions. Stakeholders do not need to oppose each other's objectives, but rather attempt to collaborate and trust one another to develop a sustainable and reliable urban freight system. Because policies from different actors are often pitted against one another, uncertainty increases in the direction of how the urban logistics system develops. It is challenging to develop collaboration among various efforts due to passive behavior between actors as seen in figure 11. The complexity of the goals of politics as well as the loose and diffuse links between the objectives and interdependencies of different stakeholders involved make developing a city logistics system inherently ambiguous and wrong policies difficult to rectify (Van Dijck, 2018). Asymmetries of power and unclarity of who is responsible for drafting urban freight strategies and developing urban logistics infrastructure could create path dependency and lock-ins in which it is unclear which stakeholder is responsible for what part of the future development of the urban freight system and development will stall (Giordano, 2012). The above mentioned problems can be solved by the involved stakeholders defining their well-considered urban logistics strategy aided by creating insights and future visions of the city logistics landscape and including the identified stakeholders with their objectives and interdependencies in the scenarios.

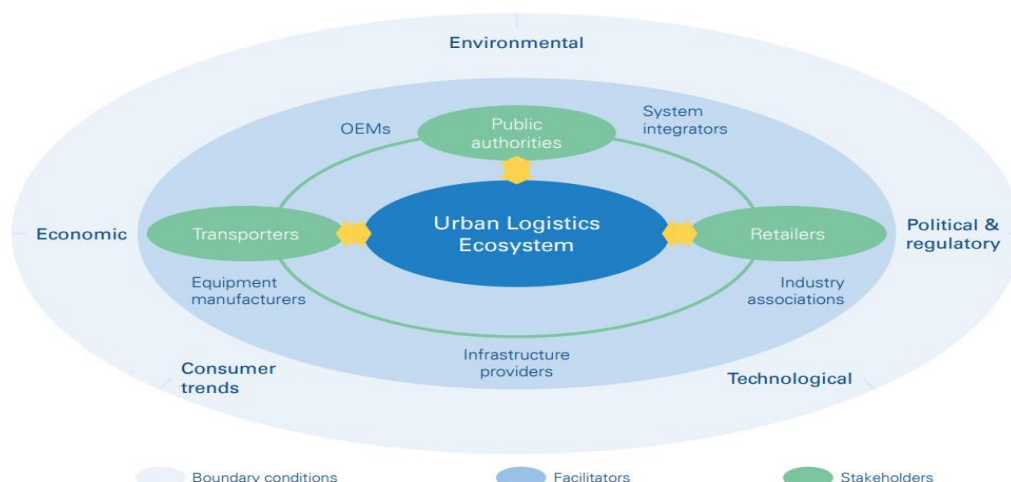


Figure 12: Overview of stakeholders involved in the urban logistics landscape (ADL, 2019).

### 3.5 Concluding Remarks: Stakeholders

This section summarizes the findings of the stakeholder analysis. It explains how the stakeholder analysis contributed to which elements of city logistics are relevant to developing future visions for city logistics. Shippers, carriers, retailers, city hubs, municipalities and investors are among the stakeholders involved in this study. However, municipalities indirectly represent the interests of residents, while retailers represent the needs of customers. Municipalities have the most influence and vested interest in changing city logistics based on the analysis of stakeholder relations. Logistics businesses and investors & developers wield a lot of influence and have significant (financial) resources and need to be aware of the changes in the urban logistics landscape.

Different public and private stakeholders have different interests in the urban freight sector. Cities copy each other's freight regulations rather than sharing their experiences. All stakeholders involved are open to change, but expectations for initiatives are unclear because no one is holding the other stakeholders expressly responsible for the issue's resolution or acknowledging their stakes in it. As a result, responsibilities for urban freight are transferred to other stakeholders. Changes in the behavior of logistic stakeholders are slowed by their awaiting and passive attitudes toward one another.

The identified stakeholders with their objectives and interdependencies provide boundaries for the urban logistics system and provide input for the scenario analysis in which certain long-term trends influence certain stakeholders on decision making, objectives and goals affecting the organization of the city supply chain. Next to that, the different futures for urban logistics, developed using scenario analysis, will help induce collaboration and counter passive behavior between the public and private sectors, by alignment of the stakeholder interdependencies and objectives. Insights into the future development path of city logistics can aid the stakeholders in collaboration & cooperation for countering uncertainties by drafting robust policies and developing adaptable business models regarding the future of urban logistics. The identified stakeholders with their objectives and relations will aid in forming recommendations for the municipalities, logistical companies and investors, which have the most influence on the future of the urban logistics system based on the different scenario outcomes.

# 4

## Urban Logistics System Analysis

- 4.1 System Analysis Method
- 4.2 Influencing Factors on Urban Logistics
- 4.3 Urban Logistics System Diagram
- 4.4 Concluding Remarks

# 4. Urban Logistics System: System Analysis

This chapter discusses the conceptualization of urban logistics. The conceptualization simplifies the urban logistics sector. It follows on from the stakeholder analysis in the previous chapter which described the various perspectives and goals for different stakeholders in city logistics. A system described as a starting point for developing multiple future scenarios of the urban logistics system is a good point to start. It will aid in understanding the relationships and effects of urban logistics elements. Because external factors & driving forces are used to design scenarios, this chapter comes before the scenario analysis. In this chapter, different driving forces & external factors influencing the urban logistics system will be presented. These factors will be compared later to the ones found in the scenario analysis workshops. The chapter is organized as follows: First, a brief overview of the system analysis method and its functions is provided. The theory is applied to the urban logistic system in the second part. Finally, several driving forces & external factors will be identified & discussed.

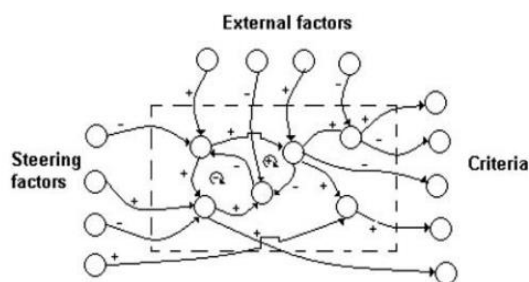
The system analysis aids in comprehending the scope of the research as well as the current situation. The system serves as a foundation for creating context scenarios in the next chapters. The system analysis is inextricably linked to the stakeholder analysis.

## 4.1 System Analysis Method

This section goes over the theoretical approach of system analysis in greater detail. This theory is used to simplify the city logistics system. An objective tree and a simplified map of the system are used to analyze the system.

Urban logistics operations are a complex process in which many actors are involved, each with their stakes and interests; for more information on stakeholder analysis, see the previous chapter. The urban logistics environment is a dynamic one that changes over time. A system description aids in mapping and analyzing the system by defining its boundaries and structure, as well as the main elements and their relationships (Gioia, 1996). The benefit of these analyses is that they help to structure ill-defined and complex policy domains. As a core concept, the system diagram is used to represent a structured view of a problem situation (Yu, 2018). All the analytical tools that will be presented as part of our approach are linked to the system diagram.

The system diagram differentiates between the system, the steering factors, the external factors, and the desired or criterion outcomes. The entire diagram is built in several steps and iterations, as we will see in the following sections. Although our steps are presented in a logical order, there is no perfect order, and much iteration occurs in practice.



Analysis Theory (Van der Lei, 2017).

This system diagram depicts the relationships between the system's various elements. The stakeholders in the system can influence the relationships between the elements in the system by acting differently or taking measures (Kumar, 2016). These elements are referred to as 'means' or 'steering factors'. It is possible to demonstrate the effects of system changes by defining objectives, which are represented by 'criteria.' Changes can be influenced by elements over which actors have no control, which is referred to as 'external factors.' External factors do impose significant limitations or constraints on the system's behavior and outcome

These elements serve as the foundation for the system diagram.

Figure 13: System

A general system diagram is depicted in Figure 13. On its borders, the system is comprised of three groups of factors: the means, the external factors, and the criteria. The arrows in the figure indicate that the means and external factors ultimately influence the criteria. Criteria are placed on the right side, or output side, of the system diagram.

## 4.2 Influencing Factors on Urban Logistics

Other variables in the system influence the criteria mentioned in the previous section. This section addresses variables such as means and external factors. The goal of this section is to identify appropriate system boundaries and main factors, as well as the important relationships between them. The method described by Van der Lei et al. (2017) is used in this analysis. The potential means of the stakeholders must be identified so that a map with the main causal relations and their influence on the outcome of interest can be created. These steps, when taken together, form a solid system description of city logistics. This system analysis is used to support the scenario analysis.

This system analysis is used to support the scenario analysis, which is used to establish the key factors and driving forces for the scenario analysis. The following section expands on the system diagram of the city logistic system used in this research. It combines the objectives and means of the stakeholder analysis criteria defined in the previous chapter.

### Means for influencing city logistics

The research perspective determines the goals and objectives. The research's perspective is clear because urban logistics involves a wide range of stakeholders with varying interests. It is also important to see what problems different stakeholders have with city logistics as seen in the previous chapter.

The authorities operate in different areas and cities, and as a result, they have different goals. However, distinctions can be made between municipalities. Municipalities' primary goal is to increase the city's attractiveness to its inhabitants. An appealing city has the following characteristics: a low environmental impact, less congestion, safety, and so on. Local governments perceive a hindrance in their centers caused in part by the logistics sector, which contributes to congestion and emits greenhouse gases and particulates (Haddadi, 2016). The Dutch municipalities of the G4 cities are aiming for more sustainable logistics in their cities to improve the city's attractiveness. The local governments possess the means to realize this by using different means, such as regulation, urban planning & subsidizing sustainable distribution modes. Russo et al. (2010) elaborate on government measures and proposed the following measures: enforcement, harmonization, information provision, permission, pricing, restriction, and subsidization.

Investors possess the means to influence the city logistics landscape by for example developing logistics hubs, which have long been used as a real estate option for urban logistics (Nisar, 2017). These are unique urban locations where logistics-related businesses coexist. Logistical businesses have measures to pool transportation and storage resources to reduce costs and gain access to stronger infrastructures when developing and operating distribution centers in urban areas (Gros, 2013). Even while the significance of last-mile delivery and customers' demands for access to their purchases at any time and any place are not new, they are having an increasing impact on urban logistics. Although there is still a need for traditional logistics measures, urban fulfillment is an increasingly popular means (Elbert, 2018). In contrast to centralized distribution approaches, the emergence of regional distribution centers enables online retailers to store goods much closer to end users and match the fast delivery expectations of users. The importance of naming these actions is irrelevant because the essential actions were identified during the workshop 'Urban Logistics in 2040'.

## External Influences

**The uncertainty of external influences and driving forces distinguish them. The driving forces are predictable trends, but the impact of external factors on city logistics is not** (Wollenberg, 2000). The following external influences on urban logistics are identified in the literature and briefly explained:

- |                                       |
|---------------------------------------|
| • <b>Economic development</b>         |
| • <b>Active or passive government</b> |
| • <b>Development of e-commerce</b>    |
| • <b>Central vs. local services</b>   |
| • <b>Level of urbanization</b>        |
| • <b>Priority of urban livability</b> |

**Economic development** has a direct impact on urban logistics development in which it plays a significant integrating role in the modern economy: expanding regional transport capabilities, reducing costs, increasing the speed, safety, quality, and efficiency of transport and logistics services, and creating conditions for increasing the added value of produced and transported goods and services, all of which contribute to the growth of global economic efficiency (Loudon, 2013). Numerous studies covering various regions of the world have revealed the significant influence of urban logistics on regional development: OECD countries and the United States (Islam, 2013). The system diagram in Chapter 4 refers to economic development in a roundabout way: It is known as the demand of goods.

On an economic cost basis, the rising popularity of online and online grocery retailing is associated with high costs and complicated fulfillment for items purchased online (Boysen, 2021). Delivery processes, in particular, are associated with high costs and complexity. Although home delivery has a lower initial investment cost, it has a higher delivery cost due to the high number of failed deliveries and the customer's forced presence at home during delivery activity (Siegfried, 2020). Economic costs are affected by variables such as service time, service area (distance from DC), driver cost, and investment cost. Driver costs may have an impact on the cost of delivery with electric cargo bikes because this option requires more driving time.

**The second factor is the local government's attitude toward urban logistics policy.** Several policies and initiatives are already in place or are about to be launched in a variety of cities around the world affecting urban logistics (Haan, 2021). In Amsterdam, for example, an action plan called Actie plan Schone Lucht was established this year to shift the conversation "from the inside to the outside" and "from business to private." As a result, the goal is to provide emission-free traffic in the entire city center by 2030, with diesel and other combustion engines banned for commercial use 2025 (Haan, 2021).

Many different initiatives can be identified when looking across most global capitals and major cities. However, we contend that systemic change requires a systematic shift in which the entire last-mile ecosystem transitions from the most effective individual examples to systemic change. Because policymakers seek low-cost solutions, a government may choose to be passive. The philosophy is to let market forces determine how logistics functions (Garces, 2021). On the other hand, when the government interferes, a variety of measures can be implemented as can be seen in chapter 4. Subsidies, restrictions, and permissions become relevant at this point. The system diagram incorporates this external factor.

**E-commerce is the third external factor.** A new era of online presence has begun, and consumers are enthusiastic about online purchases. People are increasingly shopping online. In each of the last three years, the amount of money spent on online retail has increased by nearly 8% (Daugherty, 2011). This is evident, not least, in the increasing volume of traffic on our roads from the courier, express, and postal industries. Within the last three months, 82 percent of all consumers have shopped online. By 2021, 2.1 billion people are expected to buy goods online. Given that the average consumer checks their phone 25 times per day, mobile devices are likely to account for a large portion of these sales (Nisar, 2017). Data shows that e-commerce growth is outpacing offline revenue growth: While the latter is expected to grow at a 4% CAGR

between 2019 and 2023, e-commerce is expected to grow at a 17 percent annual rate, accounting for approximately 20% of the global retail share in 2023 (Einav, 2017). This will drive global parcel growth in both business-to-consumer (B2C) and business-to-business (B2B), with the latter growing at a faster rate than the former. In terms of regional development.

**The fourth factor on the list is the facility's location.** The structure and geographical location of a city influence urban freight activities because urban areas have space, access, and distance issues (Holden, 2005). There are impediments due to geographical difficulties, historical centers, population density, and truck movement restrictions. The performance of urban logistics systems is impacted by challenges such as urban narrow streets, strict regulations, and a lack of facilities for fast loading and unloading (Gros, 2013). It is difficult for existing cities to change road infrastructure to accommodate increasing freight volume. Alternative solutions, such as e-cargo bicycles, can be useful in such cases.

New technologies may necessitate the construction of new transportation and facility infrastructure. For example, there is insufficient road infrastructure for electric cargo bicycles/tricycles, capacity constraints in terms of weight and dimension, and customer concerns. Furthermore, there is insufficient charging infrastructure, cargo consolidation centers, and capacity constraints for electric light vehicles and bicycles (Iacono, 2010). Furthermore, such logistics infrastructures have a high investment cost. More centralized facilities are also possible. In this case, hubs are located on the city's outskirts. Logistics services are provided from there. Because the function of this hub is to deliver goods directly to the consumer, it is depicted in the system diagram.

**The level of urbanization is the fifth external influencing factor.** Cities are faced with increasing urbanization at a historically unprecedented rate. The global population is expected to reach 8.5 billion in 2030, of which 60% (equaling 5.1 billion people) will be living in cities. Increasing middle-class income and falling vehicle costs allow for individual mobility and will add millions of commuters per day to that figure (Gros, 2013). Unsurprisingly, mobility experts argue that the limiting factor for urban mobility will be land, not affordability, in the future. Congestion grows exponentially as urban density grows.

Amsterdam's population is expected to reach one million by 2032, representing a 20% increase over today. The number of jobs is expected to increase by 30% until 2040. The increased volume of traffic will cause severe bottlenecks on the roads and in public transportation. The city of Amsterdam is experiencing structural problems as a result of urban deliveries, which are primarily linked to the recent surge in e-commerce growth rates. Currently, one out of every eight vehicles in the city is a truck or van. Many old bridges and quays were not built to withstand heavy loads and intensive use. Delivery vans, which park on the street or in congested inner-city areas, also contribute to traffic congestion (Petri, 2013).

**The sixth and final external influence is the social priority of city livability.** Urban freight transport of goods has a significant impact on the live ability of cities, which house roughly 70% of the world's population. The effects of freight traffic, which has increased significantly in the last decade due to the growing share of e-commerce, are on the economic, environmental, and social sustainability of cities. The negative externalities generated by freight traffic have an impact on the city and the community, jeopardizing long-term development (Taniguchi, 2018). In terms of atmospheric pollution, it is estimated that it produces approximately 23 percent of CO<sub>2</sub> produced by transportation in urban areas. This factor is depicted in the system diagram as well.

## Driving Forces

**The changing demographic** is the first trend on the list. With increased population comes increased freight transportation, which accounts for 20% of road traffic, 30% of road congestion, and 30% of CO<sub>2</sub> emissions in urban areas (Brun, 2011). Policymakers want to create a sustainable environment for businesses and the public, distinguishing themselves from other cities by enacting appropriate regulations to reduce congestion, air pollution, and noise. Furthermore, because urban areas generate more than 80% of global GDP, it is reasonable for public authorities to improve freight transportation efficiency to support further economic growth (Brun, 2011).

The demographic change is expected to accelerate the rapid growth of e-commerce and thus impact urban logistics for two reasons: increased acceptance of online shopping and lower mobility of the elderly (Wu, 2021). Because online shopping is expected to grow further, service-to-shop services are expected to be less in demand in the future compared to other types



of delivery services. Furthermore, due to a decrease in population mobility, as the total population ages, it is likely that demand for face-to-face home and office delivery services, as well as non-face-to-face home and close-to-home delivery services, will increase.

**Sustainable & environmental concern** is the second driving force. People are becoming increasingly convinced of the importance of ecosystem health. Urban logistics has a significant environmental impact. It significantly contributes to road damage, as well as air and noise pollution, owing to CO<sub>2</sub> emissions (Petri, 2018). One reason for this is that the distances are relatively short, with frequent starts and stops. There are also a lot of delivery trucks on the road. Large fleets contribute to urban congestion, especially when vehicles and road space are not used optimally. This causes inefficiencies in logistics operations and raises delivery costs in the "first" and "last mile" (Arvidsson, 2013). Therefore, the importance of considering sustainability grows and has and will have a major influence on decisions to be made regarding all aspects of the urban logistics landscape.

**Climate change** is the third driving force. Climate change is a continuing trend that has an impact on many policymakers. The Netherlands has set an ambitious goal: it wants to reduce greenhouse gas emissions by 49% by 2030 (Salvia, 2021). To that end, the government unveiled a climate package in June 2019 that includes a climate tax levied on industrial companies, the closure of all coal-fired power plants by 2030, and a minimum price for CO<sub>2</sub> emitted during electricity generation. Indeed, starting in 2025, newly registered buses, delivery vans, light commercial vehicles, and trucks will only be allowed to drive in 'zero-emission zones' in up to 40 Dutch cities if they are emission-free (He, 2019). This is an ambitious goal, but those behind it are counting on manufacturers to produce more such vehicles and want to create a market for them. Pollution controls are tightened to avoid disastrous consequences. As a result, the need to consider environmental concerns grows.

**Technology advancement** is the fourth driving force. The concept of technological advancement in smart cities has prompted the incorporation of innovative transportation modes into the urban transportation system. Autonomous vehicles are one example (Zhang, 2022). The use of urban distribution innovations is an effective way to promote sustainable urban freight transportation. The definition of urban distribution innovations is the use of emerging transportation modes to reduce the negative impacts of urban freight movements, thereby promoting city logistics sustainability (Lebeau, 2016).

From the perspective of technology companies, integrated technologies of various distribution innovations are capable of developing brand new transport modes for future city logistics. Forecasting potential future transportation modes is also an important component of long-term planning for sustainable urban freight transportation. Because of the various modes of transportation that have influenced the freight network structure, forecasting future technologies helps to design a flexible network structure from a long-term perspective, thereby promoting sustainability. However, the future of technology is highly uncertain.

New and innovative freight delivery methods in the city evolve and new ones are in development in the coming years (He, 2019). This would have a large impact on the organization of city logistics and cause uncertainties for authorities wanting to issue regulations and companies wanting to invest in these new delivery methods in combination with arising new negative externalities for city inhabitants. For this reason, in the next chapter, this driving force of the advancement of new freight delivery methods within cities is analyzed more in-depth, as these distribution innovations determine for a large part how the city supply chain could look like in different scenarios.



## 4.3 Urban Logistics System Diagram

This section discusses the city logistics system diagram, which combines the means, external factors, and criteria. This is accomplished by mapping the relationships of factors identified in the system in a 'system diagram.' It depicts the system's causal chains that connect means to criteria (Van Heeswijk, 2017). This section shows the macro-level system diagram with only the factors that are relevant to the purpose of this research.

A system diagram depicts the causal relationship between the factors that affect freight distribution in cities. The diagram aids in the analysis of the effects of means and/or external factors on other factors, most notably the criteria. The causal map is as follows: composed on a high aggregated level to keep communication clear, hence the white ovals. This system diagram's primary function is to summarize the system demarcation by displaying the elements that are relevant to the problem analysis (Van der Lei, 2017). The diagram corresponds to the goals of the stakeholder analyses (Chapter 4), the means-end diagram, and the external factors discussed in this chapter. The external factors of the causal relation diagram are those that have only outgoing relationships with other factors.

The ovals represent the influencing factors that are interconnected. The legend indicates the type of factor for each color: green ovals represent the means, orange ovals represent external factors, blue ovals represent criteria, and grey ovals represent undefined sub-systems. The arrows in the diagram represent the factors' relationships. The relationship can be either positive or negative. A positive relationship exists when one factor increases and the connecting factor decreases, or when the first factor decreases, and the connecting factor decreases. A negative relationship is a contradictory link: if factor one increases, factor two decreases, or vice versa. The system diagram simplifies a complex system by depicting interconnected factors that influence the results of the criteria. This diagram is a simplified representation of reality: some factors may have an indirect influence on results, but these are outside the scope of this study.

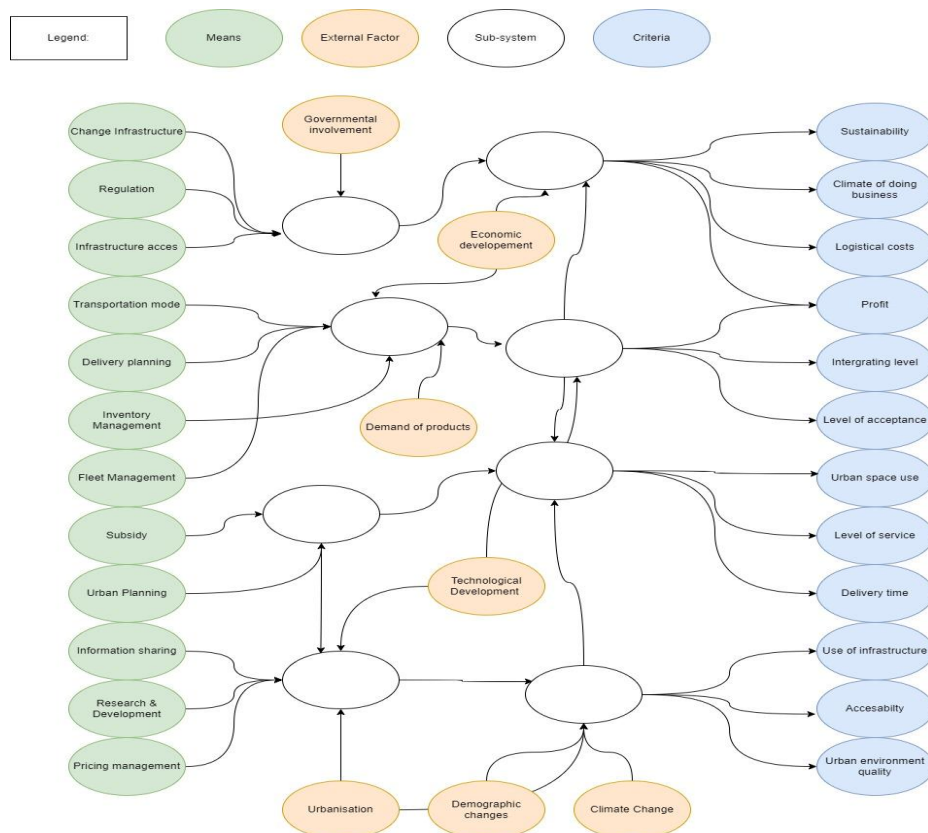


Figure 19: Urban Logistics System Analysis.

First, it is clear that technological and economic developments have had an impact on urban freight and are in charge of a growing scale of consumption and production. Several patterns have arisen, demonstrating that urban cargo is always increasing and that the freight industry as a whole makes a large amount of revenue portion of greenhouse gas emissions, which is growing faster than passenger vehicle emissions.

Globalization has resulted in more products circulating in the world due to fragmented spatial locations for production, distribution, and consumption. At the same time, cities are becoming more crowded as a result of urbanization. More people in a limited amount of space is a result of urbanization, which puts a strain on supply and delivery. Because of consumerism in a digitized society, city dwellers can order whatever they want 24 hours a day, seven days a week.

As a consequence, the volume of cargo traveling through cities is predicted to dramatically expand. Consumers want comprehensive, just-in-time, and reliable delivery, and it must be efficient to keep urban freight activities clean, safe, and less conspicuous while avoiding traffic congestion. The number of vehicles and vehicle kilometers traveling through cities is rapidly increasing, resulting in congested city streets. Cities must deal with an increasing number of negative externalities as a result of this. The combination of all of these identified external factors and driving forces makes it unavoidable that the future of urban freight necessitates a clear vision. These factors will be further used in the scenario analysis as input for the development of the different scenarios. More driving forces will be identified by experts in the field of urban logistics and the complete list of driving forces influencing the urban logistics landscape will be estimated on how much impact the factor has and how uncertain the outcome of the factor will be.

## 4.4 Concluding Remarks: System Analysis

The findings of the system analysis chapter are summarized in this section. The conclusion clarifies the importance of conducting thorough research before developing future visions for urban logistics. A city logistics system diagram delineates the scope and aids in understanding the complexity and dynamics of the city logistic system.

The system can be divided into three categories: criteria, means, and external factors. The criteria outline the trade-offs that must be made. Retailers require goods and should be supplied, but vehicle movements and emissions should be kept to a minimum. Meeting both objectives is impossible, so tradeoffs must be made. The identified driving forces, external influencing factors & means can be used to compare the actions from the workshop.

The system analysis aids in comprehending the complexities of city logistics. A system simplification aids in developing the scenarios by starting from the ground up. Bringing together a stakeholder analysis of system elements aids in determining which factors should be taken into consideration. A detailed examination of the system's elements' relationships in a highly detailed system diagram is not necessary for this research. For this research, the driving forces and external factors influencing the urban logistics system are input for the scenario analysis method. However, for new future visions, it can be useful to examine how the elements interact and influence the criteria in the future.

In the next chapter, the driving force of the technological advancement of new freight delivery methods within cities is analyzed more in depth, due to its influence on all aspects of the city logistics system, such as the organization of the city supply chain, regulation for new distribution methods, and negative externalities for the city inhabitants.

# 5

## Technological Innovations in Urban Freight Delivery

- 5.1 Innovations in Urban Logistics
- 5.2 Analysis of Implementation in Industry & Research
- 5.3 Concluding Remarks

# 5. Technological Innovations in Urban Freight Delivery

## 5.1 Innovations in Urban Logistics

As seen in the previous chapter, several driving forces and external factors have been identified that influence and have an impact on the urban logistics system in different ways. These factors cause uncertainty on how city logistics will develop in the coming decades. One key driving force is technological innovation within the city logistics system and more importantly, the development of new & innovative freight delivery methods. These methods will for a large part explain the future organization of urban logistics and are therefore analysed in depth in this chapter.

Exogenous trends that have exacerbated the challenges of the urban freight system are urban development trends. In order to address these challenges, urban logistics providers have focused on developing appropriate endogenous solutions that promote sustainability, effectiveness, and security (He, 2020). The use of emerging modes of transportation is a cost-effective solution for logistics providers. Using electric vehicles (EVs) to deliver goods to customers in urban areas, for example, can help to reduce air pollution. Regardless, various distribution innovations work together to form a system that has a significant impact on the traditional urban freight network (Guo, 2020).

The use of emerging transportation modes to develop new operational strategies and delivery concepts is referred to as urban distribution innovation (He, 2020). For example, the use of electric vehicles has the potential to reduce emissions, thereby achieving CO<sub>2</sub>-free city logistics; the use of cargo bikes contributes to reducing emissions in last-mile delivery but might cause more congestion in the inner city. Changing traditional freight modes is a key strategy for city logistics providers to reduce the negative environmental externalities caused by city logistics. Although widespread adoption of distribution innovations is a cost-effective solution for logistics providers, these applications have had a significant impact on the traditional structure of the urban freight network in terms of long-term planning (Taniguchi, 2016). Meanwhile, as seen in the previous chapter, technological advancement in future distribution methods has posed a challenge to the traditional urban freight system.

Even though significant research has focused on the use of one or two distribution innovations in the urban freight system, they are focused on short-term planning of about five to ten years. This observation implies that a thorough examination of the integration of urban distribution innovations and their implications for the conventional urban freight network is lacking (Rai, 2019). Several technology companies have also launched projects for future urban freight vehicles.

To summarize, both exogenous external influences as the growth of e-commerce and endogenous driving forces as the advancement of future freight delivery methods have exacerbated the long-term challenges and created uncertainties in the conventional urban freight network. As a result, researching scenarios about the future of city logistics contributes to the transition of city logistics and promotes future sustainable and liveable cities.

Much less research is being conducted to systematically select these various innovations, with a lot of uncertainties in how these urban distribution methods will develop in the city logistics landscape in the future, to develop delivery strategies for future urban freight transport. It should be noted that a systematic scenario analysis can help logistics providers develop efficient, long-term freight strategies for future cities.

Using urban distribution technologies to enhance urban transport facilities is an excellent strategy to do so. The utilization of developing transportation modes to lessen the overall adverse effects of urban freight movements, hence improving city logistics sustainability, is what urban distribution innovations are defined as. (Rai, 2019). According to Zhangyuan He (2020), there are eleven urban distribution innovations: electric vehicles (EVs), public transit logistics, taxi logistics, cargo bikes, parcel lockers, delivery drones, robotic vehicles, delivery robots, modular vehicles, mobile depots, and urban freight ships.

Freight Delivery Method	Description
Electric vehicles	Applied the E-vehicles to transport the goods in urban areas
Modular E-vehicles	The special type of vehicles is used to deliver the goods to consumers by carrying one or multiple cabin modules
Public transit logistics	Integrated the passenger and freight activities (i.e., tram, subway, bus)
Taxi logistics	Applied the taxi to transport goods; the purpose is reduced traffic congestion
Robotic vehicles	Use of autonomous (robotic) vehicles for freight distribution in city areas
Delivery robots	Use of small robots to delivery goods to the destination
Mobile depot	A mobile depot is a trailer fitted with a loading dock, warehousing facilities, and an office
Urban freight ships	Utilized a ship to transfer goods to the transit points by the inland waterway of the city
Cargo bike	Use of a cargo-bike for freight distribution in city centers
Delivery drones	Use of drones for freight delivery in city areas
Parcel lockers	The implementation of parcel lockers aims to reduce the traffic congestion in residential areas and enhance the efficiency of delivery
Urban Consolidation Centers	Urban Consolidation Centers (UCC) are operational concepts that reduce freight traffic circulating within a target area by fostering consolidation of cargo at a terminal.

Table 4: Urban Logistics Innovations Overview.

The use of innovative sustainable transportation modes in cities has been extensively discussed in research (Black, 2018). Despite this, little research has been conducted on the effects of these innovative modes of transportation on future urban freight transportation. The frequency of freight activities inside urban centers operating in the retail and postal sectors has increased since the year 2000 due to rising commodity demand and shifting consumer preferences. This has been accompanied by significant e-commerce growth, with online retail increasing by an average of 10–20 percent per year (Taplin, 2014). Given that package delivery is the primary method of delivering products to consumers for e-commerce, explosive growth predicts that high package delivery frequency may exacerbate pollution and urban congestion.

As a result, these effects have fundamentally mandated that the retail and postal businesses choose more suitable types of transportation and operational techniques for the different components of urban freight movement from the perspective of local authorities and urban citizens. Furthermore, corporations have been seeking to identify acceptable internal ways and new business models to handle the problems given by exogenous trends in the retail/postal industry as a result of rising commodities demand and changing customer behavior. (Digiesi, 2017). To deal with these environmental externalities in cities, several retail/postal enterprises have used emerging transportation modes while developing an innovative urban freight concept (Zhangyuan He, 2020).

As a result, implementing distribution innovations is a cost-effective solution for retail/postal companies in the future city, allowing for the provision of personalized logistics services and thus increasing enterprise competitiveness. Given that multiple distribution innovations are likely to be used in the future urban freight system, the selection and combination of these innovations is also an investigation topic for the future of urban logistics, which will be partly carried out in the next sub-chapter.

## 5.2 Analysis of Implementation in Industry & Research

Zhangyuan He (2020) used a by McKinsey created GE multifactorial analysis to classify the urban distribution innovations, which is a method used in business strategy to help a company decide what long-term strategic projects to pursue and which market opportunities to continue investing in. The two-dimensional matrix is created by categorizing each dimension into three levels. Because each product, service, and strategy is represented in this two-dimensional matrix, the GE matrix can help the distribution innovations evaluate their overall strength (Amatulli, 2011).

There are three steps of academic distribution innovation research: (1) following the conceptual stage, (2) the research and planning stage, and (3) the dissemination and assessment phase. The definitions are as follows:

- Scholars propose and design conceptual models throughout the following **conceptual phase**. It's the first step of new technology research. Instances are the employment of drone deliveries in last-mile delivery and autonomous cars in urban freight transport.
- **The analysis and planning phase** is focused on the tech's specific parameters, and it involves analyzing possible risks, costs, and potential repercussions of the technology application, as well as preparing the operational scheme and evaluation. The integrated passengers and cargo transportation system is one example.
- **The promotion and evaluation phase** includes scholarly discussions about how to encourage the use of technology breakthroughs in urban transportation services as well as the assessment of costs and impacts to improve the policy or strategy. Private companies routinely employ this tactic, and local governments have done so in the past. One illustration is the study of electric vehicles (Hannan, 2014).

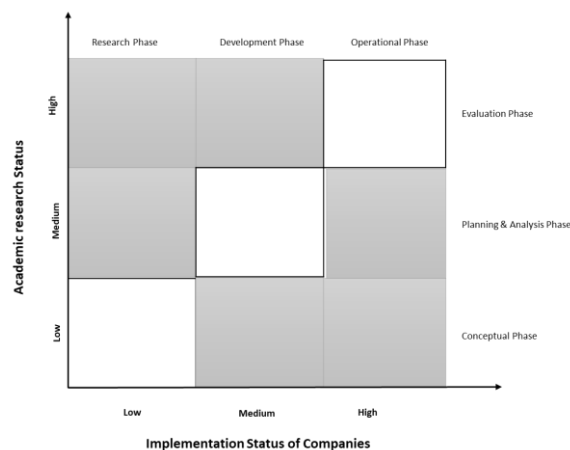


Figure 20: GE-Matrix Distribution Innovations.

The project could also be divided into three phases using this method: (1) theoretical study, (2) testing and development, and (3) operation and improvement. The following are the definitions in detail:

- The design and evaluation phase aims to build the simulation of the technologies based on the conclusions of the conceptual research phase. Both the performance and any potential risks are being assessed concurrently. A good example is the use of drones to transport things inside of cities (Hassanalian, 2017).
- For (logistical) companies, the theoretical research phase—in whereby the technology's conceptual approach and conceptual model are proposed—is the initial stage. The aim is to find the features and application of the technology. The objective is to determine the features and application range of the technology. For example, Audi proposed a project in 2018 to integrate AVs into the transportation system (Audi, 2018).
- The operations phase illustrates how organizations have leveraged existing technology to deliver logistical services while also enhancing them and cutting costs and hazards. One example is the usage of cargo bikes for last-mile deliveries.

As a consequence, the company's technology application process consists of three parts. These three phases also correlate to the degrees of academic technology application research. The GE grid of the deployment status analysis is created based on these.

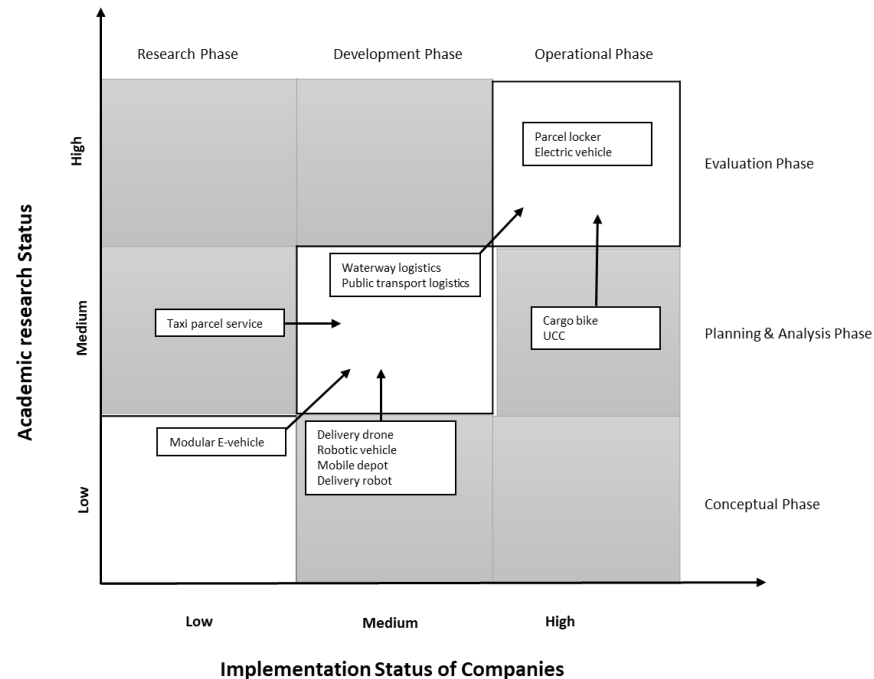


Figure 21: GE-Matrix Distribution Innovations.

According to a review of the literature and Zhangyuan He (2020), the use of **autonomous vehicles** in urban freight transportation is currently in the theoretical research stage. There were several articles about self-driving vehicles in urban logistics that examined and predicted the impact of various autonomous driving use cases on urban freight transportation (Faisal, 2019) & (Duarte, 2018).

Looking back on transportation history, the last-mile delivery problem is a hard and complex issue to solve (Bosona, 2020). A **drone parcel delivery** in the Netherlands could be essential to tackle this problem, due to its mobility and congestion circumventing capability. Delivery drones could become widespread in ten years. Private companies, such as the United Parcel Service (UPS), DHL, Amazon, Alibaba and even Google, are already conducting high-profile experiments for testing drone delivery systems (Zhu, 2018). The development of drone parcel delivery reached a milestone when the Federal Aviation Administration approved the first commercial drone delivery (Zhu, 2018). With these developments in play, drones could at first support truck fleets and at a later stage even replace the fleet. According to Yang (2020), drones could also have important implications for delivery costs, CO2 emissions, travel time, public safety, personal privacy and air pollution. The **delivery robot** is a new freight technology that reduces traffic congestion and labor costs. This cutting-edge technology is gaining traction in logistics firms. As a result, the delivery robot remains in the development and testing phase for the relevant companies (Chen, 2021). The most visible change in this segment is the increasing diversity of vehicles that are used for the last mile. The two most common types are small droids that depart from a van and autonomously driving lockers. Autonomous driving lockers depart from micro hubs located close to the delivery area. This one can be used in two ways. The recipient will receive a notification when the locker is nearby and can remove products from the locker themselves. A combination of robots and drones might be a possibility. The advantages of this system are; faster delivery to homes far from the road and possible delivery of two or three packages at once.

**Electric vehicles** are a significant innovation in urban freight transportation (EVs). This innovation has a high potential for addressing urban environmental, social, and economic impacts (Hannan, 2014). EVs have several advantages, including zero tailpipe emissions and low operating costs. However, the purchase costs are currently prohibitively expensive for many private stakeholders in urban freight transportation. The batteries of such an electric vehicle account for a significant portion of these costs. With battery costs falling, EVs are becoming a more viable option for urban freight transportation (Hannan, 2014). Other factors to consider when implementing EVs in urban freight transportation are the vehicle's range and charging times, as well as the charging infrastructure. As a result, the use of EVs in urban freight is still in its early stages of operation and improvement. **Cargo bikes** are in the same stage of development as electric vehicles. The studies have concentrated on operational strategies, impact analyses, and cost evaluation. Many logistics companies, such as DHL Germany, have used cargo bikes for urban freight transport in the real world. In addition, several manufacturers have developed a unique cargo bike to increase maximum load and transportation range in metropolitan areas. As a consequence, the cargo bike project is now in the operational and enhancement phase (Gruber, 2014).

**Reconfigurable vehicles (RVs)** are a vehicle that moves two or more cabin components from one location to another. The modular car is a one-of-a-kind electric vehicle (Chen, 2019). These articles, however, are in the following conceptual stage. Logistics network operators and producers are in the theoretical research phase, according to the case studies in these publications. **Urban waterway logistics** refers to the utilization of ships to convey commodities to transit points along a city's internal waterway (Inland waterway). Inland canal studies for urban freight movement are in the analysis and design stages, as per the literature study (Zhu, 2021). Due to the implementation requiring that the city have an inland canal, the system's application in the global logistics firm is limited. As a result, the organization is actively testing and developing inland waterway transportation. **The parcel locker** is widely used in the parcel or business-to-consumer (B2C) industry. According to the review of literature, much research is being conducted to analyze and evaluate the use of parcel lockers (Pinto, 2020). Indeed, many logistics service providers, including Amazon and DHL, have used parcel lockers in urban freight transport. At last, **urban consolidation centers** have the main objective of easing the switch from heavy trucks to zero-emission vehicles such as cargo bikes, light electric trucks, and zero-emission trucks. All carriers that distribute to numerous delivery locations throughout the city are served by the UCC. Three beneficiary categories are prioritized by the UCC: retail, private individuals, and the catering sector (Baldi, 2019).

All in all, drone deliveries, distribution robots, mobility depots, and autonomous vehicles have all stayed in the medium-low adoption range. Costs and other external reasons have greatly hampered their broad use in businesses. The development of modular E-vehicles is still in its early phases. The use of taxis in urban freight transportation is at a low-medium level, with undeveloped tech and local transportation rules being the main roadblocks. It's worth noting that public transit and inland waterway transportation are both on the medium-low end of the spectrum. Electric automobiles and parcel lockers are widely used, and academics and corporations have given them more attention as substitute strategies and urban promotion tactics. The usage of cargo bikes helps to reduce emissions in last-mile deliveries but may increase congestion in the inner city. For instance, using electric vehicles can minimize emissions, attaining CO<sub>2</sub>-free city logistics. An important tactic utilized by city logistics providers to lessen the unfavorable environmental externalities brought on by city logistics is changing traditional freight modalities. Although widespread adoption of distribution innovations is a financially viable alternative for logistics providers, these applications have had a considerable impact and rising uncertainty on the conventional structure of the urban freight network in terms of long-term planning and for a large part determine the future city supply chain organization (Taniguchi, 2016). Therefore, this chapter presents several city distribution innovations in different phases of application and research and the uncertain development of these innovations will be analyzed and part of the scenarios.



## 5.3 Concluding Remarks

Enterprises must actively promote the implementation phase of these emerging technologies, while academic research must consider all relevant elements to evaluate risks and develop operational measures and policies for local governments and private companies. The distribution innovations have had a significant impact and are creating increasing uncertainty on the traditional format of the urban freight network in terms of long-term planning and will largely determine the organization of the city supply chain in the future. As a result, this chapter covers several city distribution innovations that are now through various stages of research and application. The unpredictable course of these innovations' development will be examined, and scenarios will be included. The various distribution innovations are in various stages of implementation. Those inventive components have resulted in the development of new urban multimodal transportation concepts, which are an essential element in urban freight planning's prospective goal.

New technology typically has different strengths and weaknesses than the mature technology with which it competes. It's unclear which urban freight delivery method will eventually take the lead, or even if any single technology will be able to meet all demands. The scale of demand will drive the availability of new technology (timing, price, transport infrastructure), creating a chicken-and-egg dependency and uncertainty about timing. The logistics requirements of the city will vary greatly from segment to segment, necessitating a different sequence and timing for each distribution innovation. These identified new freight delivery methods and uncertainties coming with them will be explored using scenario analysis in the next chapter.

The findings show that research on different distribution innovations is extremely dispersed. The status has received little attention in a large amount of study of these innovations in terms of application. To that end, the GE multifactorial analysis approach is used to examine the implementation status from the perspectives of academia and businesses. During the asymmetric application phase, there were twelve types of emerging transport modes. This chapter, based on the GE matrix, depicts the future direction of these twelve types of modes from the perspectives of academia and industry, respectively. The position of adoption and research of these urban freight innovations in the matrix will change over time. This change will be seen in the to be developed different scenarios in the next chapters.

Next to that, there is a lack of a comprehensive approach to integrating all emerging technologies. The viability assessments and risk monitoring of urban transportation services using these developing technologies have received little attention in a large body of research. As a result, to consider the interrelationship and interplay of various innovative technologies in urban freight transportation, future visions in how these new freight delivery methods will develop are necessary. The application of emerging technologies and freight network structures are the primary influence factors that must be analysed in terms of the future development of urban freight. Understanding the status of these technologies' implementation contributes to exploring uncertainties around the future development of urban freight transport using scenario analysis.

# 6

## Scenario Analysis

- 6.1 Driving Forces & External Influencing Factors
- 6.2 Estimated Impact and Uncertainty of Driving Forces
- 6.3 Differentiate Scenario Plots
- 6.4 Full Scenarios and Development Paths
- 6.5 Concluding Remarks: Scenario Conclusions

# 6. Results of the Scenario Analysis

In the previous chapter, several new and innovative distribution methods have been identified and where they stand in the academic world and the logistics industry. These new freight delivery methods will change and adapt over time due to different influencing factors. These city freight distribution methods are part of the overarching urban logistics system. This system as a whole is, as seen in chapters 4 & 5, influenced by different external influences and driving forces. These factors and forces are fraught with uncertainty, because of the long lifetime of the driving forces influencing the city logistics system up to 20 years. In combination with many technical assets in the urban logistics supply chain having long lifetimes, an examination of future impact is required to answer the central research question.

As a result, a scenario analysis was carried out using the intuitive logics method. The methodology is described in paragraph 3.1, and the results of the scenario analysis are presented in this chapter. In this chapter, four main results will be discussed: first, the identified key factors and driving forces will be discussed, second, the scoring of the driving forces on impact and uncertainty will be discussed, third, the differentiation of the scenario plots will be discussed, and finally, the full scenario plots will be discussed.

## 6.1 Driving Forces & External Influencing Factors

The external factors and driving forces identified by the experts and in the academic literature are shown in Tables 5 and 6, respectively. The author of this thesis identified key factors as well, and a comparison was made in this paragraph because they were not given to the experts prior to the workshop to avoid bias. The goal was to explain the differences and compile a comprehensive list of the scenarios and their implications. The driving forces determine the direction and value of the key factors, which will be used to distinguish the scenarios. They will be expanded upon in paragraphs 6.3 to 6.5.

The key factors discovered by the 14 experts are linked in table 5 to the driving forces of Chapter 3's system analysis. The merged driving forces identified by the experts and from the system analysis, which were ranked by the experts, are shown in Table 6. In general, the expert panel's findings may be related to the framework's factors. Different factors were not treated as a separate component of the identified factors in the system analysis but were incorporated into the one to which they are related. The framework in Figure 19 and related content in chapter 4 represents the entire set of factors that could explain uncertainties and developments in the organization of the urban logistics system in large cities, and it is intended to be comprehensive.

Factors identified by experts	Notes by experts	Related to factors from System Analysis
Progress of the economy	<i>The proper functioning of the entire urban transport sector is affected by economic growth and promotes further development by encouraging investment and opportunities for market expansion. (Expert 1 and 7)</i>	Economic development
Relative cost	<i>Retailers competing online need to develop on-demand logistic capabilities to keep up with customer expectations which incorporate both high logistics service quality and low costs. (Expert 3 and 8)</i>	Economic development
Investments in urban logistical infrastructures	<i>Many investors have decided to support their occupier customers in all parts of the logistics chain, from very large regional platforms of 100,000 m<sup>2</sup> to urban logistics with surfaces often under 05,000 m<sup>2</sup>. The aim is to offer a range of solutions for all aspects of the sector. There is therefore a very strong demand today in urban logistics for location, whether for new developments or reconversions. The main difficulty is to find buildings or land and then to convince the community to accept the idea of setting up an urban logistics hub. (Expert 5, 9 and 2)</i>	Economic development
Energy costs	<i>The Russian invasion of Ukraine poses a new threat to commodity supplies and pricing and will have a ripple effect across global manufacturing and supply chains in 2022. Supply disruptions will trigger price increases for energy and transportation costs will continue to rise and this will have a significant impact on operating costs. In 2021, energy prices were rising rapidly and the war in Ukraine will put additional pressures on energy and fuel prices. (Expert 7, 12)</i>	Economic development
Level of e-commerce	<i>This explosion is primarily the increase in people using the internet. Today, the widespread use of the Internet is undergoing a further acceleration due to the epidemic crisis caused by COVID-19. Online sellers are having a huge success because of the price and perceived convenience of the service. (Expert 4)</i>	Development of e-commerce
Congestion	<i>A large portion of the total amount of externalities the transportation sector produces is due to urban logistics, by the congestion problem. (Expert 9)</i>	Development of e-commerce
Policy & regulatory environment	<i>Provision of a menu of traffic regulations or measures, such as allocation of curb space, loading time restrictions, truck routes regulations and truck access controls, transport regulations, like permits for entering certain areas, or vehicle regulations, to regulate vehicle sizes or emissions. (Expert 1)</i>	Active or passive government
Subsidy	<i>For the development of urban logistics innovations. Investment made in innovation in the logistics sector by public office is needed. (Expert 2 and 1)</i>	Active or passive government
Pricing	<i>Imposition of road pricing or charges on access or parking as means to allow market mechanisms solve traffic congestion. (Expert 10)</i>	Active or passive government
Urban density	<i>The increasing density of housing and new commercial paradigms such as e-commerce and on-demand economy exacerbate already detrimental phenomena such as air pollution, noise, accidents and congestion. (Expert 11 and 14)</i>	Level of urbanization
District characteristics	<i>City architecture and critical infrastructures. The physical distribution of the population and its structure affect the focus on regional distribution system, typology and frequency of delivery. (Expert 3)</i>	Level of urbanization
Ageing of the population	<i>Aging of the society drives the demand for a customized range of products and services and the need to ensure decent living conditions for the elderly. As a result, the needs of this population will have to be met efficiently and cost-effectively. This concerns both the supply of everyday use goods, medicines and medical care services. In the logistics area of the city, it means you need to adapt the offer to the specific requirements of seniors. (Expert 14, 9 and 2)</i>	Changing demographic
Segmentation of perception	<i>Citizens who perceive the infrastructure to be in poor condition also have a greater awareness of the negative externalities generated by freight operations. Having a higher perception of freight's negative externalities decreases citizens' perception of the overall performance of freight logistics in the city. (Expert 7, 9 and 12)</i>	Changing demographic
Robotization & Atomization	<i>Intelligent Transport Systems have been already applied with success while others could take off soon driverless technology. Digital twins, have Augmented reality or will follow Physical Internet. (Expert 3 and 6)</i>	Technological advancement
Progress of Artificial Intelligence	<i>AI can enable extraction of previously unknown patterns to anticipate demand, improve efficiency and enhance level of service. (Expert 2)</i>	Technological advancement
Operational cost dive towards a minimum	<i>Search for efficiency. An entire logistics industry is emerging or in the process of doing so and is based on ongoing technological advances in efficiency. (Expert 5 and 11)</i>	Technological advancement
Sustainability	<i>The increased requirement of environmentally friendly products put pressure on urban freight transport at the levels of assets used and delivery processes. Demand for ethical sourcing and local sourcing stresses urban freight transport at the informational and at the physical delivery level and may lead to an increase of the frequency of urban freight trips and to an increased share of short supply chains. (Expert 3 and 5)</i>	Environmental concern
International relations	<i>The knowledge on city logistics depends on a collaborative approach between the different cities worldwide, based on the continuous exchange and sharing, not only of information, but also of assets and on a standardization of the entire logistics chain. (Expert 6)</i>	Geopolitical climate
Distance to consumers	<i>Distance to consumers influences the development of the urban logistics ecosystem. The rise of on-demand freight and mobility require to manage curb-side space more efficiently, in a shared and dynamic way. (Expert 1)</i>	Central vs. local services
Number of UCC's	<i>The increase in commercial vehicles used for freight transport depends on the rise in demand for goods and services, due to the growth of city dwellers and to the additional spreading of logistic sprawl. Logistics sprawl is the relocation of parcel transport's hubs from the urban cores to the outer suburban areas causes a trend towards spatial deconcentrating of logistics terminals. (Expert 4, 5 and 11)</i>	Central vs. local services

Table 5: Key factors

Driving Forces	Notes by experts
Economic development	
Development of freight transport growth	urban population growth, city expansion, new business strategies
Policy & regulatory environment	They have organization and control over the execution of logistics chains.
Urbanization	scarcity of space in all scenarios, and the division of space between modes.
Globalization	Enhances worldwide exchange of technology and experiences
Changing demographics	e.g., income, wealth, digital divide and ageing.
Technological advancement	shortening delivery times, allowing for more efficient supply-chain processes and the introduction of alternative delivery methods.
Environmental concern	
Geopolitical climate	
Central vs. local services	logistics sprawl or sub-urbanization.
Cost of energy	Drive to zero marginal cost of renewable energy and batteries
Atomization & Robotization	

Table 6: Driving Forces

## 6.2 Estimated Impact and Uncertainty of Driving Forces

This section discusses the outcomes of the expert prioritization of the driving forces. This was accomplished by estimating the level of impact on the focal issue as well as the uncertainty of each identified driving force's future state. This estimation was done individually to avoid a single participant's dominance, and the combined outcome of each individual's estimation can be seen in Table 8. What is clear is that **the development of technological advancement and the regulatory & policy environment** is regarded as critical scenario drivers. The other driving forces appear to be more dispersed throughout the matrix.

As a result, the author computed the average impact, uncertainty, and standard deviation. This is shown in Table 9 and is used to analyze the driving forces of uncertainty and impact.

		Degree of Uncertainty		
		Low	Medium	High
Level of Impact	High	<ul style="list-style-type: none"> <li>• 4x Environmental concern</li> <li>• 5x Urbanization</li> <li>• 5x Changing demographics</li> <li>• 6x Central vs. local services</li> <li>• 2x Development of freight transport growth</li> <li>• Globalization</li> <li>• Economic development</li> </ul>	<ul style="list-style-type: none"> <li>• Economic Development</li> <li>• 2x Geopolitical climate</li> <li>• 2x Environmental concern</li> <li>• 2x Development of freight transport growth</li> <li>• 2x Urbanization</li> <li>• Changing demographics</li> </ul>	<ul style="list-style-type: none"> <li>• <u>11x Policy &amp; regulatory environment</u></li> <li>• <u>Changing demographics</u></li> <li>• <u>12x Technological advancement</u></li> <li>• Central vs. local services</li> <li>• 2x Atomization &amp; Robotization</li> <li>• 2x Economic development</li> <li>• 2x Development of freight transport growth</li> <li>• Central vs. local services</li> <li>• 2x Cost of energy</li> <li>• Urbanization</li> </ul>
	Medium	<ul style="list-style-type: none"> <li>• Economic development</li> <li>• 2x Cost of energy</li> <li>• 2x Globalization</li> <li>• Atomization &amp; Robotization</li> </ul>	<ul style="list-style-type: none"> <li>• Development of freight transport growth</li> <li>• 3x Urbanization</li> <li>• 4x Globalization</li> <li>• 3x Cost of energy</li> <li>• Development of freight transport growth</li> <li>• Geopolitical climate</li> <li>• Environmental concern</li> <li>• 3x Atomization &amp; Robotization</li> <li>• Economic development</li> <li>• Changing demographics</li> <li>• central vs. local services</li> </ul>	<ul style="list-style-type: none"> <li>• 2x Atomization &amp; Robotization</li> <li>• 3x Development of freight transport growth</li> <li>• 2x Geopolitical climate</li> <li>• 3x Cost of energy</li> </ul>
	Low	<ul style="list-style-type: none"> <li>• Cost of energy</li> <li>• 2x Globalization</li> <li>• 2x Geopolitical climate</li> <li>• 2x Atomization &amp; Robotization</li> <li>• 2x Economic development</li> </ul>	<ul style="list-style-type: none"> <li>• 2x Geopolitical climate</li> <li>• Atomization &amp; Robotization</li> <li>• Economic development</li> <li>• 2x Globalization</li> <li>• 2x Changing demographics</li> <li>• 2x Environmental concern</li> </ul>	<ul style="list-style-type: none"> <li>• Economic development</li> </ul>

Table 8: Estimated impact and uncertainty of driving forces

$$\bar{I} = \frac{\sum I}{N}$$

Equation 1: Average Impact

$$\bar{U} = \frac{\sum U}{N}$$

Equation 2: Average Uncertainty

$$\bar{S} = \bar{U} \times \bar{I}$$

Equation 3: Average Total Score

$$\sigma = \sqrt{\frac{\sum (X - \mu)^2}{N}}$$

Equation 4: Standard Deviation

Earlier research (Wins, 2017) used a scenario analysis method applied to the impact of DORS on urban mobility and developed the categorization of the driving forces in the following list, which establishes the categorization criteria and all relate to averages:

- **Critical scenario driver:**  $\bar{I}$  and uncertainty > 2,5
- **Important scenario driver:**  $\bar{I} > 2.5$  and  $2 < \bar{U} < 2.5$
- **Critical planning issue:**  $\bar{I} > 2,5$  and  $\bar{U} > 2$
- **Important planning issues:**  $2 < \bar{I} < 2,5$  and  $\bar{U} < 2,5$
- **Issues to keep an eye on:**  $\bar{I} < 2$  and  $\bar{U} < 2$
- **Monitor and reassess impact:**  $\bar{I} < 2$  and  $\bar{U} > 2,5$  or  $> 2$  if standard deviation > 0,5
- **Factor:** Is listed as a factor but not as a driving force

Driving Forces	Uncertainty	Expert	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average Uncertainty	S.D	Total Average	
Technological advancement				3	3	3	3	3	3	3	3	3	3	3	2	2	3	2,9	0,2	8,4
Policy & regulatory environment				3	3	3	3	3	3	2	3	3	3	3	2	3	3	2,9	0,2	8,0
Economic development				3	3	3	2	2	3	2	1	1	2	3	3	3	2	2,4	0,6	5,1
Geopolitical climate				3	2	3	2	2	2	1	2	3	2	3	2	2	3	2,3	0,5	4,4
Changing demographics				1	2	2	2	3	1	2	3	2	3	2	3	1	1	2,0	0,6	4,9
Atomization & Robotization				1	3	3	2	3	1	1	2	3	2	2	2	3	1	2,1	0,7	4,1
Central vs. local services				2	1	3	3	1	1	3	2	2	2	2	1	1	3	1,9	0,7	3,9
Development of freight transport growth																				
				2	3	2	1	2	2	2	1	2	3	3	2	3	1	2,1	0,5	5,3
Urbanization				1	3	3	1	2	1	2	2	2	3	3	3	1	3	2,1	0,7	5,2
Cost of energy				2	2	1	2	1	3	3	2	1	3	2	2	1	2	1,9	0,5	4,0
Environmental concern				1	2	1	1	3	1	2	2	2	2	3	1	1	3	1,8	0,7	4,2
Globalization				2	1	2	2	2	1	1	3	1	2	2	3	2	2	1,9	0,5	3,7

Driving Forces	Impact	Expert	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average Impact	S.D	Total Average
Policy & regulatory environment				3	3	3	3	3	3	2	3	3	3	3	3	3	2,9	0,1	8,4
Technological advancement				3	3	3	2	3	3	3	3	3	3	2	2	3	2,8	0,3	8,0
Central vs. local services				2	3	3	3	3	3	3	2	3	3	2	2	2	2,6	0,5	3,9
Development of freight transport growth				3	2	2	3	2	3	3	3	2	3	1	3	1	2,4	0,7	5,3
Urbanization				2	3	2	3	2	3	3	3	3	1	3	2	2	2,4	0,6	5,2
Changing demographics				2	3	1	3	3	3	3	1	3	3	2	3	1	2,4	0,7	4,9
Environmental concern				1	2	2	3	3	3	1	3	2	2	2	3	3	2,4	0,6	4,2
Cost of energy				2	2	2	2	1	3	2	3	1	2	3	2	2	2,1	0,4	4,0
Atomization & Robotization				2	3	2	1	3	1	1	3	2	2	2	3	2	2,0	0,6	4,1
Economic development				3	1	1	1	3	3	2	2	1	2	2	3	3	2,1	0,7	5,1
Globalization				3	2	1	1	2	1	2	2	3	2	3	2		2,0	0,5	3,7
Geopolitical climate				3	2	2	1	2	1	1	1	1	2	2	3	3	1,9	0,7	4,4

Table 9 &10: average impact and uncertainty scores

## 6.3 Differentiated Scenario Plots

Scenarios are built by first identifying specific sources of uncertainty and then using those to create alternative futures based on how the uncertainties play out based on the data gathered during the expert interviews and literature and the system analysis in previous chapters. Because it is unknown how these factors will evolve, the dimensions are determined by external factors. The uncertainties of external factors can be plotted as future dimensions. The scenarios for the future context are created by plotting two external factors.

The matrix is constructed with 2 degrees of uncertainty. The four cells alternately identify two uncertainties' four poles, which each encompasses a rationale of a plausible future (Bradfield, 2016). As a result, the scenarios are orthogonal and do not overlap. This aids comprehension of the scenarios because the various settings are made clear. The key factors and driving forces used in the scenarios reflect in the previous chapter's system diagram.

The 14 experts chose **the development of technological advancement and the regulatory & policy environment** as the scenario differentiating uncertainties as seen in table 9 & 10. The extreme ends of technological advancement in urban logistics were defined as a situation in which the urban logistics system has developed into a highly advanced technological system by 2040 and a situation in which the regular analog truck delivery system with high emissions will be dominant in urban logistics. The extremes of the policy & regulatory environment were defined by a government that wants to control the organization and development of the urban logistics system on one side and a government that wants to leave the development of urban logistics to the market.

When the two main uncertainties are plotted on two axes, four distinct scenario plots result, as shown in Figure 22. In the following paragraph, the author proceeds to the final result of the scenario workshop, which is the full scenario plots.



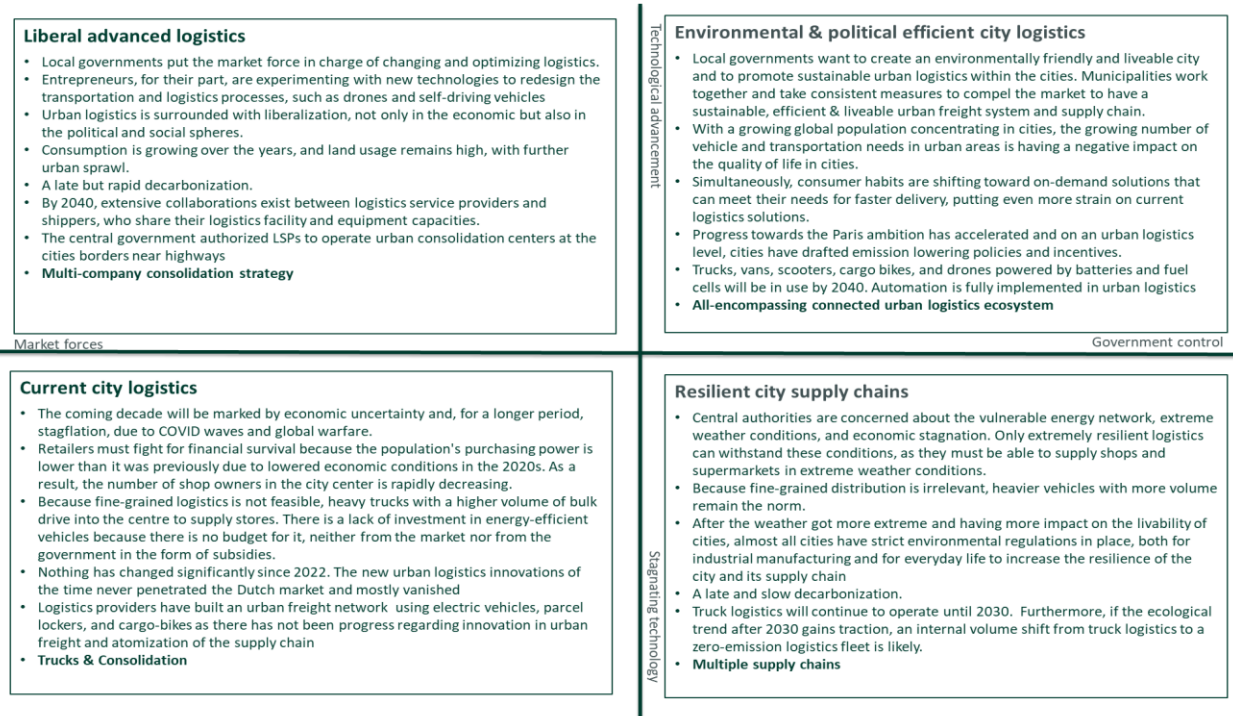


Figure 22: Plotting scenario axes and characterization of the scenario plots

## 6.4 Full Scenarios and Development Path

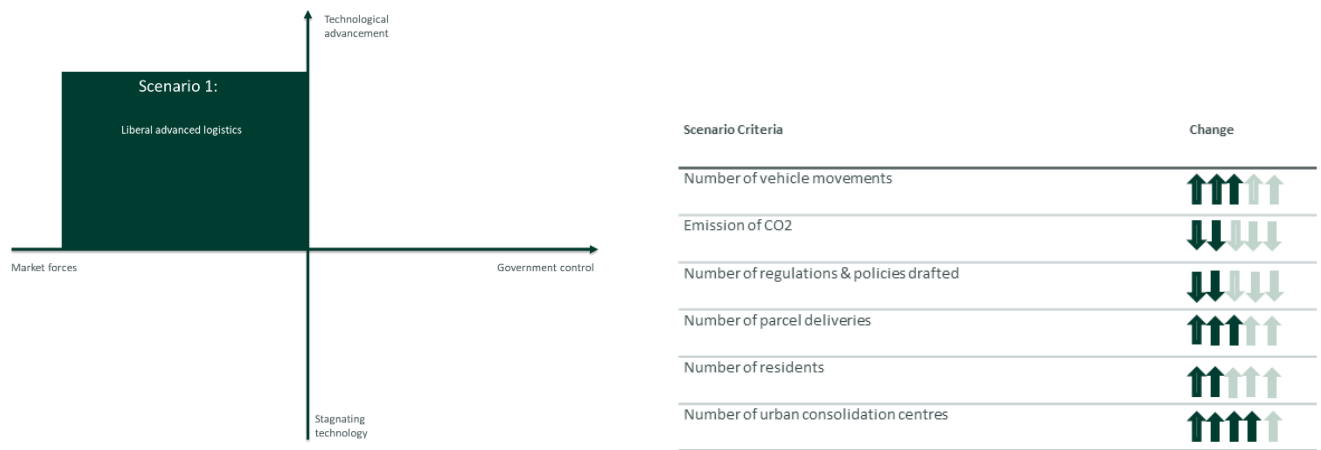
The scenarios of the city logistic systems inform stakeholders about the pitfalls they must avoid. They can assess whether their operations are robust enough to deal with the future. The following pages describe the future scenarios. The scenarios are based on professional input from the 14 expert interviews and the scientific backing of the driving forces.

Six key figures have been added to the scenarios to provide a view of the changes that will occur over the next decades. These figures include **vehicle movements, number of parcel deliveries, CO2 emissions, the number of residents, the number of retailers, and the number of urban consolidation centres**. The figures are only estimates, and the numbers are based on assumptions. The actual figures are not available.

Each scenario begins with a description of how the urban logistics system is organized and which urban freight distributions are used in this scenario. Following that, a development path is sketched using the two differentiating scenario drivers as a foundation and supplemented with other drivers and factors discovered during the workshop. The answer to the central question and an example of the possible organization of the inner city urban freight supply chain is provided in the final paragraph of each scenario. This is supplemented by implications for the development & operation of urban consolidation centres within cities in Chapter 8.

**Scenario 1** is dealing with city logistics in an environment with an advanced technological urban logistics system and mainly a market that should meet the expectations of high standards in the city. The difference between **scenario 2** compared to scenario 1 is that the government is interfering actively by utilizing the adoption of measurements and facilitating platforms. **Scenario 3** deals with a scenario in which the current organization of city logistics is still current in 2040. There are other problems to focus on than using highly advanced distribution methods but if there is advancement in the technology of the organization of the urban freight supply chain, it is initiated by a market force. **The 4<sup>th</sup> scenario** deals also with an environment where urban freight is still delivered by trucks with high emission levels. External events force the government to focus on drafting regulations and policies for the urban logistics system.

### Scenario 1: Liberal advanced logistics



People will continue to move to the city in the coming years. Cities are created as a result of urbanization. The importance of high quality of life in the city cannot be overstated. Both shop owners and customers can afford and are willing to pay for logistics services. There are numerous initiatives for entrepreneurs and residents to reduce their environmental impact, such as reducing emissions. Local governments put the market force in charge of changing and optimizing logistics. The city centre is the beating heart, where residents go for recreation. As a result, the catering and service industries, as well as the retail sector, are heavily represented in the centre.

Entrepreneurs, for their part, are experimenting with new technologies to redesign the transportation and logistics processes, such as drones and self-driving vehicles. However, as cities grow in size, they require an increasing number of vehicles. This has an impact on local PM and smog problems. The capacity of the road infrastructure is no longer sufficient, resulting in traffic jams and delays when entering the city. Urban logistics is surrounded by liberalization, not only in the economic but also in the political and social spheres. Consumption is growing over the years, and land usage remains high, with further urban sprawl. The latter trend has resulted in urban areas constantly expanding into previously rural areas and the Randstad area becoming one large metropolitan area.

## **Deregulation**

Deregulation began when the logistics industry observed a surge in logistical demand during the COVID-19 years (2020-2022) in the Netherlands and particularly in major cities. By collaborating with ICT companies and data companies, shippers and carriers were able to speed up the atomization and efficiency in the supply chain to handle the surge in delivery demand as citizens were not able to visit shops and must remain in their homes. After the COVID Crisis, the Dutch government emphasized the need for an efficient, resilient and robust inner city supply chain and become Europe's leading test ground for automated vehicles, electric vehicles, and smart city logistics. They relaxed regulations across the country and facilitated various pilots, and by 2025, the number and scale of providers and business models in the urban freight supply chain had grown due to increased competition. However, to keep the inner city supply chain resilient and robust in case of unforeseen events, basic regulations regarding standards for operations were introduced.

Furthermore, the need for an efficient and resilient inner city supply chain was observed due to the covid years, which was for a large part in the operation by private logistical service providers and shippers. These private companies had increasing popularity and bargaining power, the central government gradually lost the desire to feel responsible for the costly and complex urban logistics system. The central government authorized LSPs to operate urban consolidation centres at the cities borders near highways and use funds to improve the efficiency of UCCs using ICT technology, as well as to improve the liveability and economic attractiveness of large cities.

## **Energy & environment**

The use of energy, fossil fuels, and greenhouse gas emissions are increasing, but there are underlying currents that will eventually bring these waves crashing down. The apparent economic success masks a deeper story of growing inequality, which is fuelling social unrest and labor unrest. The general public is also beginning to react to more frequent and extreme weather events. The failure to address structural issues ranging from public health to social welfare to climate change is held responsible for societal and environmental stresses. Climate change is causing a societal and political backlash in transportation requiring rapid policy-driven reductions in fossil fuel use. The global consumption of coal, oil, and natural gas peaks in the 2030s. After a time of deregulation in the urban logistics supply chain, municipalities start to draft regulations and policies for more environment-friendly freight distribution methods to meet the Paris Agreement goal. A late but rapid decarbonisation.

## **Technological progress**

In 2040, goods for city areas are bundled via district-logistics platforms, which supply and dispose of goods for the area's households and businesses. A dense network of automated and neutrally operated pick-up stations with varying shelf sizes is in operation, allowing B2C and B2B goods to be sent and received from various LSPs. Building codes ensure that the necessary space is available. The use of 3D printing in the industrial manufacturing process allows for the bundling of raw material transports and keeps last mile distances as short as possible.

By 2040, extensive collaborations exist between logistics service providers and shippers, who share their logistics facility and equipment capacities. This increases utilization while decreasing transportation performance. Cost and revenue accounting and allocation are made possible by the internet of things. The introduction of new technologies has resulted in a thriving sharing economy that has become ingrained in the daily lives of individuals and businesses alike. Sharing business models are popular due to their cost effectiveness and consumer price advantages. Technological advancement allows for variable, new delivery concepts.

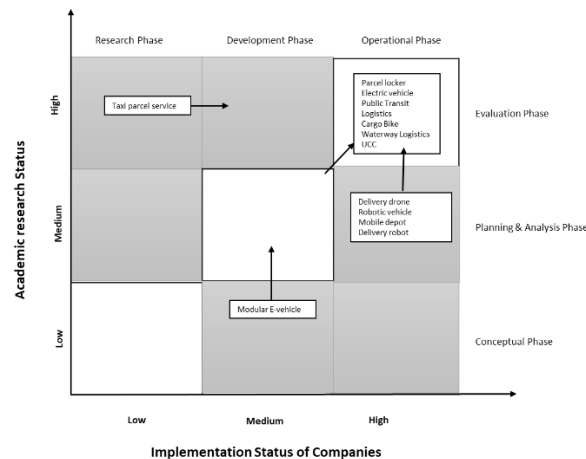


Figure 23: GE-Matrix Distribution Innovations.

Logistics providers extensively use high-high distribution innovations to transport goods within urban areas, and that partial high-medium distribution innovations are used concurrently. This assumes that the post logistics provider has extensively used electric vehicles and parcel lockers in the city. Meanwhile, in some areas, the company has used cargo bikes for last-mile delivery. After 15 years, technological advancement encourages the widespread application of distribution innovations. This finding implies that partial innovations are increasingly transitioning into the higher applied phase. Figure 23 depicts the state of distribution innovations after 15 years. Electric vehicles, parcel lockers, cargo bikes, public transit logistics, and urban freight ships are all used extensively by the logistics provider. Meanwhile, four high-medium distribution innovations are being used in partial urban areas: delivery drones, delivery robots, mobile depots, and robotic vehicles.

Along with the rise of cleaner or smarter vehicles, a wide range of smart traffic management mechanisms, such as autonomous vehicle strategies, dynamic traffic lights and volume-sensitive signage, could be deployed. According to a forthcoming CBRE study, Smarter Cities 2025, 27 percent of 14 UK cities considered themselves to be at an advanced or maturing stage across a range of smart mobility & logistics initiatives (CBRE, 2020).

So, in addition to lower pollution, there is a good chance that by 2040, we will be able to look forward to smarter travel and fewer delays. As seen earlier, different urban freight transportation modes each have advantages and disadvantages in different situations and for different trip motivations; having access to all of them, with little opportunity cost is an advantage for carriers, shippers, and consumers due to efficient market mechanisms in the urban logistics supply chain offerings.

### Supply chain organization: multi-company consolidation

The liberal policy of municipalities to leave the organization of the urban logistics supply chain to private companies in combination with demanding a certain level of resilience & robustness, makes logistics players want to reduce delivery costs while also promoting sustainable deliveries and avoiding excessive delivery-chain disruptions. For logistics players, a consolidation of the last mile is an important factor in creating a robust and efficient inner city supply chain. This consolidation of freight flows in cities is typically accompanied by interventions like urban consolidation centres (UCCs).

This intervention could include a multi-company consolidation strategy in which customers can pick up and return parcels from various players such as UPS and DHL. Multiple company consolidation solutions necessitate collaboration with competitors and the surrender of certain privileges in combination with last-mile start-ups to disrupt the last mile and launch convenient local delivery solutions. Furthermore, advanced analytics based solutions like load-pooling and dynamic re-routing could contribute to an overall scenario that reduces emissions and congestion.

Innovative approaches to existing solutions can be especially effective at times. Cargo bikes, for example, have the advantage of being able to weave through congested traffic or avoid it entirely by using dedicated bike lanes. They can

often be wheeled into drop-off locations rather than having to park illegally, which is a common problem with van deliveries. Semi-autonomous delivery vehicles could eventually be used to follow parcel-delivery personnel, allowing them to distribute more items and heavier loads. In the future, autonomous delivery EVs may not even need to be accompanied by human delivery personnel, representing the next frontier in tech-enabled parcel delivery.

The implementation of interoperable standard modular solutions for delivery logistics in inner-city areas, which contribute to the optimization of load units as well as inter-connectivity with physical movement throughout the entire supply chain, is a clear step in this direction, aspiring to the Physical Internet concept philosophy.

The operation of these types of solutions requires long-term new cooperative business models. When selecting from a variety of solutions (from freight-sharing to decoupling delivery and reception), decisions must be made to ensure that the adopted schemes are both sustainable and cost-effective. Horizontal collaboration models for sharing infrastructure and assets are among the most effective methods for optimizing urban land use and increasing load factors.

This approach necessitates the development of new concepts for consolidation and distribution centres, which have the potential to operate as multimodal cross-dock micro platforms, integrating mobility functions with urban freight delivery functions. They can be easily built on top of the existing transportation hub.

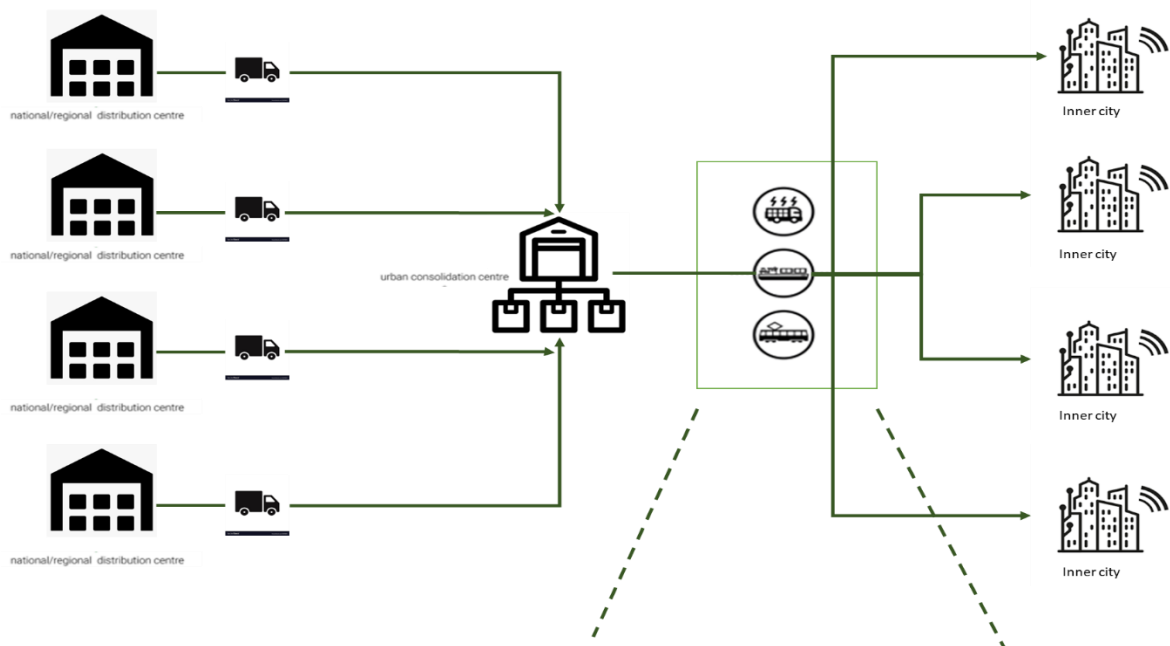


Figure 24 & 25: Supply chain organization in Scenario 1.

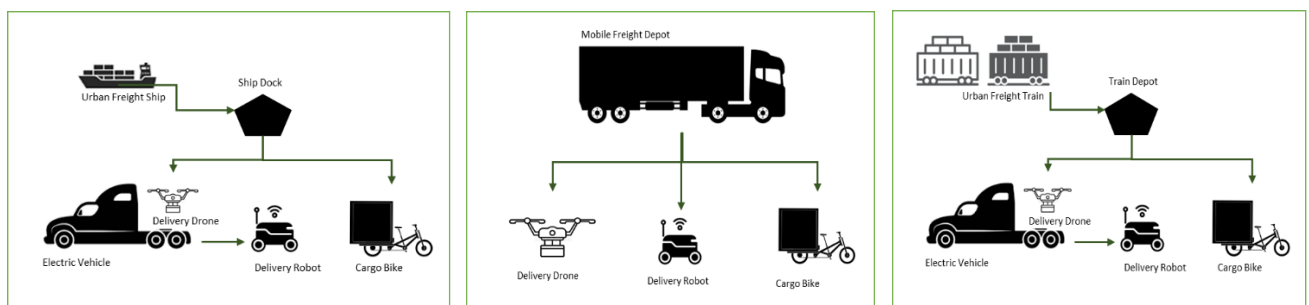


Figure 24 & 25 depicts the urban logistics system after 15 years in a large city in the Netherlands. The operational measures are as follows:



- The first module includes the urban freight ship. The freight ships are used by logistics providers to transport standardized small containers to the ship dock. Following that, EVs and cargo bikes will be able to transport these small containers to customers. Meanwhile, EVs can be outfitted with delivery robots or drones to collaborate on last-mile delivery. This collaboration has the potential to expand the delivery range and freight efficiency.
- The urban freight tram is used to build the other modules. The urban freight trams are used by logistics providers in the existing urban tram network. These trams are used to transport goods to UCCs and consolidate them into standard small containers. UCCs provide last-mile delivery using EVs and cargo bikes following transshipment transportation.
- The mobile depot is an important part of the module. The original capacity of UCC is unable to meet the increased freight demand due to the city population growth. To save money on infrastructure expansion, mobile depots can transport standardized small containers. To conduct last-mile delivery, mobile depots can be outfitted with cargo bikes and delivery drones.

## Scenario 2: Environmental & political efficient city logistics



The national and local governments share a common goal: to create an environmentally friendly and liveable city and the central authority's main goal is to promote sustainable urban logistics within the cities. Municipalities work together and take consistent measures to compel the market to have a sustainable, efficient & liveable urban freight system and supply chain. Zero emission is a widely supported and long-term goal of the authorities. Subsidies and restrictions are used to influence the market. There is money set aside for the development of new logistics technologies. The government is promoting the development of the internet of things. Central coordination enables the development of a system that reduces the transaction cost of transshipment.

The expanding number of vehicles and transportation in urban areas is exerting a negative effect on the overall life in cities, as the global population concentrates in cities. Nonetheless, as more people move to cities, there is a greater need for cars, and driving a vehicle is becoming more popular. The demand for additional services and items for business and private usage develops as the urban population grows and more shops arise. The consequences of city traffic bottlenecks and economic harm are unavoidable. Cities with more people require more urban freight and, as a result, more traffic.



In 2020, the urban roads and infrastructure, are already having difficulty processing current traffic flows. Traffic congestion is already harming the economy and the environment. With more people and traffic expected in cities, this issue will worsen. Simultaneously, consumer habits are shifting toward on-demand solutions that can meet their needs for faster delivery, putting even more strain on current logistics solutions. Municipal policies and regulations for creating a liveable city and sustainable inner city supply chain are needed.

### **Fast energy transition**

Due to environmental awareness, people can learn from green policies and investments that support a steady economic recovery while also reducing emissions. Technology-focused economies in Europe see the development and deployment of cleaner technologies as a key economic goal for increasing domestic industrial and technological competitiveness. The global economy is electrifying, with renewable resources driving growth. Demand for fossil fuels will reach a top in the period between 2025 and 2030, respectively. In heavy industry and transport, fossil fuels are incrementally decarbonised via H2. By 2040, leading economies will have achieved net-zero CO2 emissions. Progress towards the Paris ambition has accelerated and on an urban logistics level, cities have drafted emission-lowering policies and incentives.

### **Environmental policies & regulations**

The regulatory environment has changed as a result of an increase in mayoral power, allowing for more localized, context-specific solutions to the urban logistics supply chain. Private-sector companies will be expected to follow local mandates in the cities where they operate, possibly before national mandates are imposed. In the future, the logistics industry and fleet owners must anticipate and plan for increasingly stringent environmental regulations and legislation aimed at reducing not only emissions from individual vehicles but also the number of vehicles in use.

The Dutch government is pushing hard to achieve zero-emission status by 2030 and cities have set ambitious plans to decrease their carbon emissions over the next ten years. In city centre locations, vehicles are increasingly facing emissions charges, traffic congestion and parking restrictions. Several cities across the Netherlands have introduced charges for vehicles that do not meet certain emissions criteria. The roll-out of these low emission zones and other pollution-reducing schemes in cities across the Netherlands is accelerating. Urban logistics operators are therefore exploring cleaner, alternative methods of transportation such as EVs and bicycle couriers.

Next to municipal authorities, consumers and businesses are becoming more concerned with energy efficiency in the inner-city supply chain. Research and development foster innovations that improve the energy efficiency of logistics processes. The terms of public road use favor energy-efficient and CO2-free vehicles. An auction system with tradeable rights limits truck and van trips and local land-use plans guarantee logistics facility locations in industrial zones. The locations are chosen using a positive planning approach that considers key criteria such as accessibility, proximity, and environmental sensitivity. A mobility pricing system for urban freight transport is in place. Traffic management, fee collection and vehicle capacity-dependent processes are also supported by sensors. A significant proportion of the city population will prefer environmentally friendly products, providing an incentive for goods and services to be produced and transported in an energy efficient manner.

The sharing economy has evolved into an important component of society. A mobility pricing system has been implemented in transportation policy to better utilize transportation infrastructure capacity. These developments are beneficial to urban logistics in general. Improved transportation infrastructure utilization, logistical locations near centres, and a growing level of cooperation between shippers and logistics service providers enacted by municipalities enable a highly reliable and efficient supply of clients. Meanwhile, self-driving cars are becoming commonplace, and urban freight emissions are approaching zero.

## Technological progress

Logistics providers need to be prepared for drastic changes, especially in urban centres. Competition for land, traffic congestion and emissions are the drivers for changes to current distribution models, and innovative technologies are offering workable, cost-efficient solutions. The future of urban logistics will be dominated by connected, shared, autonomous, and electric solutions. These trends will be driven by emerging technologies such as IoT, connected devices and AI. Urban logistics operators can harness this data and technology to improve their operations. Technological innovation and digital capabilities are key to driving more sustainable and efficient urban logistics, both in terms of freight movements and warehousing operations. This is done to optimize delivery routes and transport modes in combination with fulfillment efficiency. New multi-modal delivery models are evolving as a response to road congestion and clean air initiatives. UPS launched London's first riverboat parcel delivery service in 2020 for example, aiming to reduce road traffic and improve air quality (Divieso, 2021).

Trucks, vans, scooters, cargo bikes, and drones powered by batteries and fuel cells will be in use by 2040. Automation is fully implemented in urban logistics. Better routing, fewer peaks, smoother traffic flow, and lower energy consumption will all result from automation. Last-mile delivery is also being done with drones. Furthermore, freight trains are fully automated, enabling quick coupling and decoupling as well as seamless deliveries to private sidings. The rolling stock is also lightweight and noiseless. Underground transportation is also used, but only for freight transportation. The systems connect distribution centres, terminals, large shopping malls, and airports. The IoT has established itself as a standard tool for managing freight flows. Sensors detect the utilization of vehicle and equipment capacity, inventory stock, and the quality status of goods; autonomous robots make operational and tactical decisions, and humans make strategic decisions.

These consolidation schemes also provide a platform for the simultaneous integration of freight and passenger transportation. Because of its great potential to optimize the use of city infrastructures in space and time. This helps to create appealing business opportunities because the same transportation needs can be met with fewer vehicles, reducing traffic and congestion. The integration of people and cargo can also help to make on-demand transportation options affordable and accessible to all users. Using subway networks for the last mile could be used in the future as the freight flows could run along transportation corridors beneath cities, with stations serving as entry and exit points. These tunnels, which are less than one meter wide, would allow zero-emission pods to transport parcels and groceries along a track powered by a magnetic motor.

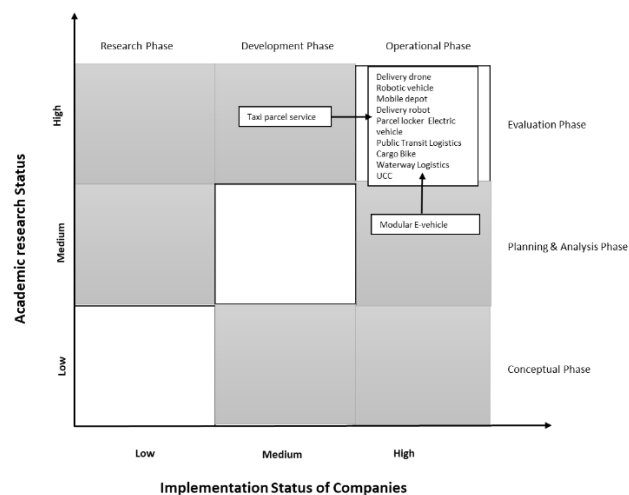


Figure 26: GE-Matrix Distribution Innovations.

### **Supply chain organization: All-encompassing connected urban logistics ecosystem**

In this scenario with more engaged governmental authorities and prosperous technological innovation in the city freight supply chain, the key is to think of urban logistics as a whole.

An urban logistics ecosystem is created in the city in which the various logistics players are all interconnected. All market participants, from major carriers to bike couriers, input their service capabilities into a consolidated ICT platform to do this. This platform allows the players to establish digital, physical, and operational connectivity and control their actions with standardized ICT standards based on adaptable sizes of shipment to enhance flexibility and efficiency. This platform would oversee all available transportation capacities in real time. Each urban transport movement is efficiently assigned to the right capacity fit. From large, planned shipments, to small deliveries made last minute, such as flash deliveries. Parcel companies would work on this system in collaboration with taxis doing courier trips or autonomous delivery robots. Real-time traffic planning will make it able to use efficient freight flows in the city and adaptable to disruptions or congestions.

All-encompassing urban logistics provides more than just efficiency. The technology must be available in less heavily inhabited areas with the same high quality and must have low emissions in combination with providing fair working conditions. Furthermore, policy and investment changes will be needed to guarantee that the system's potential to innovate remains intact and that technological advances can be incorporated promptly.

The system is regulated in a way that city authorities will create a space for urban logistics and grant access to selected companies that meet certain criteria and customers can pick up or drop off parcels themselves at parcel lockers, which improves planning reliability and lowers transportation costs for parcel delivery companies. Logistics companies negotiate with gas stations, supermarkets, and large corporations to gain access to locations that are not too far out of the way for users. The municipality could provide space for a dense network of parcel lockers that are accessible to all delivery companies. Municipal transportation companies' station's land and sidewalks would suit this perfectly.

Cities could purchase land on the periphery of densely populated urban districts and rent it out as consolidating centers, combining this with changes to parking spaces to create urban consolidation alternatives. Using UCCs is a good approach to cut down on the number of unnecessary vehicle journeys and kilometers driven. The primary function of the UCC is to facilitate the transition from large trucks to zero-emission transport, such as zero-emission (autonomous) trucks and light electric freight vehicles, and cargo bikes. The UCC serves all carriers that distribute to various delivery points throughout the city. Vehicles carrying a limited number of goods destined for the city center can now deliver their goods to the UCC rather than the receiver's door, which is often time-consuming due to roadblocks downtown. This saves time, fuel, and money for zero-emission vehicles. Carriers with zero-emission vehicles are permitted to enter the zero-emission zone. However, in terms of time, this is not the case. As a result, the UCC is essential for them to be able to deliver goods outside of the window times.

Public-private partnerships operate these platforms and offer bundled last mile services. For UCCs, policy alignment at the national or city levels is needed. In theory, this can be solved by this new infrastructure, which would be available to only a few companies. And they would not be chosen based solely on the lowest price. Municipalities would issue a tender procedure for logistics companies that provided a platform for organizing and pooling a diverse range of transport methods and availabilities. Because logistics providers are expected to prequalify for the tender, these companies will compete with one another in a regulated area. As a result, no one would be prevented from seizing newly created opportunities.

The municipality may place several conditions on the tendering process. Companies would be compelled to provide the same service in both highly and sparsely populated areas, and policies for operations in certain locations might be tied to the usage of low-emission vehicles. Pricing and quality standards for customers could also be considered. It would also be quicker and easier for a municipality to actively develop the system than it would be to introduce a licensing system from a legal standpoint.

Because numerous delivery firms are no longer delivering in the same part of town, on the same street, or to the same house at the same time, the stop density and shipment volume per stop has grown, as has the efficiency of this new system. While traveling a route, half-empty vehicles can be filled, including with the last deliveries. Urban consolidation centers can be utilized to aggregate shipments in the last meters in city centers.

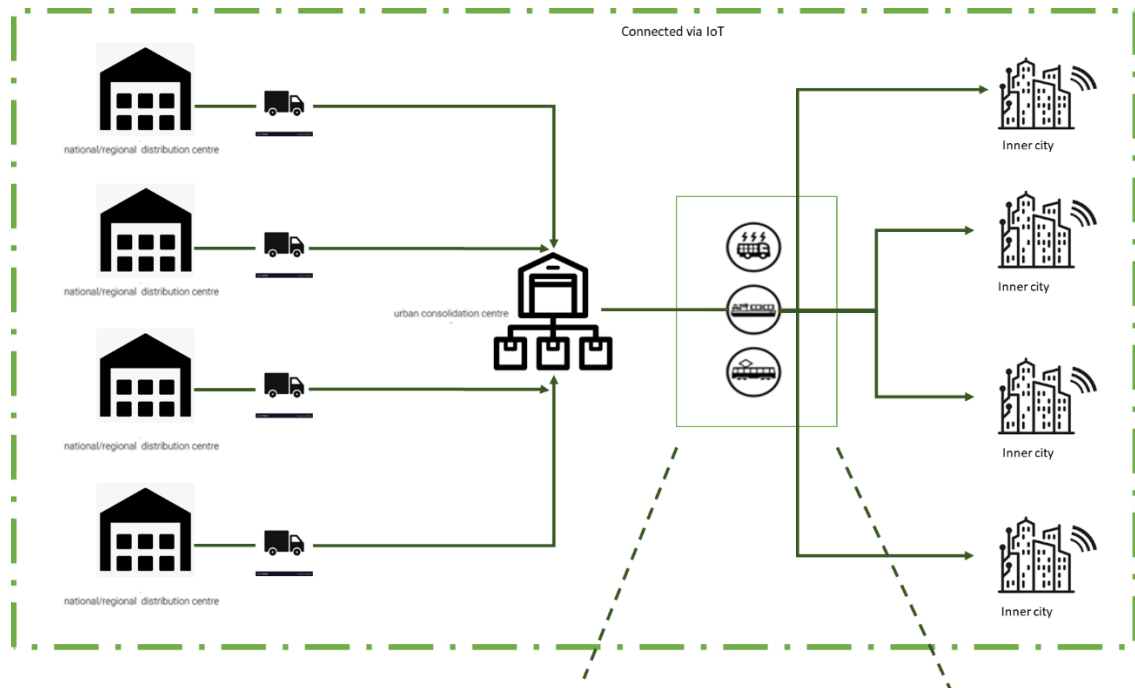


Figure 27 & 28: Supply chain organization in Scenario 2.

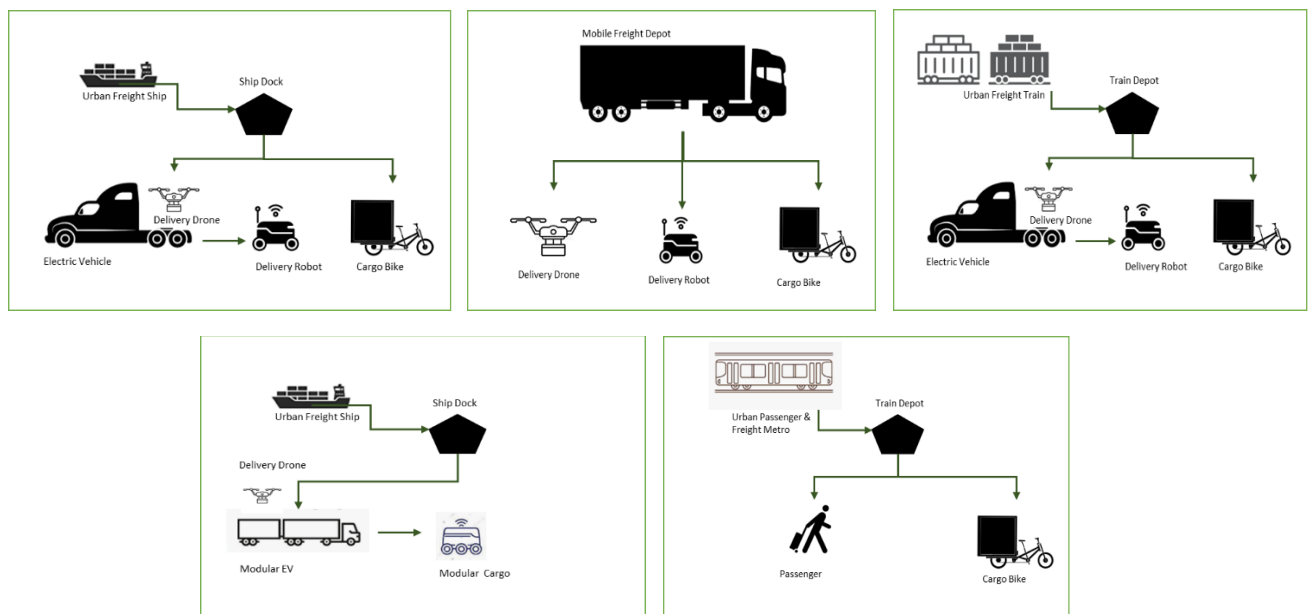


Figure 27 & 28 depicts the urban logistics system after 15 years in a large city in the Netherlands. The operational measures are as follows:

- Urban freight ships are in charge of transporting goods to the ship docks. Following transshipment transportation, modular E-vehicles are responsible for distributing relevant goods and services to the inner city.
- Urban freight trams are used for transshipment transportation from central DC to UCCs. This scheme assumes that no trucks or vans are driven in urban areas. It significantly reduced traffic congestion and parking problems on the narrow street. Furthermore, the delivery destinations of the two depots have shifted due to the increased freight demands of nearby residential and commercial areas. Furthermore, the urban passenger tram can be used for freight transportation.
- Delivery drones can be used to meet the freight needs of high-rise architectures. Meanwhile, the widespread use of delivery robots has the potential to increase delivery frequency. Furthermore, parcel lockers can accept packages from delivery drones and robots. This strategy can boost enterprise competitiveness by providing personalized logistics services.
- Although the modular E-vehicle is capable of reducing congestion in commercial areas, high costs have so far been a barrier to widespread implementation within urban areas. Furthermore, the modular E-vehicle can be outfitted with a delivery drone to transport goods to high-rise architectures in commercial areas.
- In the city, an urban logistics ecosystem is formed in which the various logistics players are all interconnected. This is accomplished by having all market participants, ranging from large carriers to bicycle couriers, enter their delivery capacities into a centralized ICT platform.

## Scenario 3: Current city logistics



After nearly a decade of low inflation, the COVID-19 pandemic and geopolitical events have reintroduced significant inflationary pressure. Prices began to rise as economies reopened, and this demand-pull inflation was welcomed by policymakers and recovering businesses. However, as COVID variants continue to disrupt global supply chains and the Russia-Ukraine conflict adds to supply shocks, cost-push inflation has raised recession concerns and policy uncertainties. As central banks seek to normalize inflation by raising interest rates and shrinking their balance sheets, the coming decade will be marked by economic uncertainty and, for a longer period, stagflation.

Today, central banks carefully manage policy rates to maintain a moderate stance. That is, a neutral rate must be determined based on the economy's capacity utilization, employment, and prices. The goal is to keep the policy rate at a level that best serves the economy in terms of achieving maximum output and full employment while maintaining stable prices. The neutral rate can sometimes be directly observed, but market-determined interest rates can be useful. Long-term bond yields had already generally fallen since the late 1980s, owing to slower growth in the economy, slower productivity growth, and shifting demographics. For the same purposes, neutral rates in developed markets have generally fallen.



The government's effectiveness has been hampered by economic stagnation. Her primary responsibility is to stimulate the economy and create jobs for the population. Retailers must fight for financial survival because the population's purchasing power is lower than it was previously due to lowered economic conditions in the 2020s. As a result, the number of shop owners in the city centre is rapidly decreasing. As a result, there are many shop vacancies and unappealing shopping streets. Next to that, traditional infrastructure is frequently in disrepair because it is nearly impossible to devote budgets to maintenance and refurbishment. Private infrastructure companies build and operate only a few high-traffic routes with high toll revenues. Congestion and malfunctions, such as temporary breakdowns of railway networks and overloads of vehicle movements in the large cities, wreak havoc on the urban supply chain.

Because fine-grained logistics is not feasible, heavy trucks with a higher volume of bulk drive into the centre to supply stores. There is a lack of investment in energy-efficient vehicles because there is no budget for it, neither from the market nor from the government in the form of subsidies. The air quality in cities is deteriorating, and regional roads are congested

It was concluded in chapter 4 that every retailer ships their goods from their distribution centre to their store, causing a lot of freight movement in the city if done frequently and for each store separately. At the same time, freight movements suffer from a lack of modal split because urban freight is primarily distributed by road. There is no distribution taking place on the water or by rail. The majority of the urban cargo utilizes the same major road corridors and city entryways as the vast bulk of the stores. Because distribution by type of good occurs only on a regional scale, there is no general, cooperative distribution of all goods on an urban scale.

Nothing has changed significantly since 2022. The new urban logistics innovations of the time never penetrated the Dutch market and mostly vanished, and the supply chains of different companies remain separate with little exchange and thus fewer efficiency gains. An example is a case with flash delivery companies, such as Getir & Gorillas, which have stayed in the inner city core and remain causing the disturbance in the city. Cities remain being supplied by different kinds of high emitting trucks and underinvestment in public transport, due to *laissez-faire* policies and gaps in budgets, which leads to increased car usage and congestion.

### **Economic stagnation**

Untethered inflation expectations and diminished central bank credibility Since the second half of the 2020s, inflation has consistently exceeded market expectations. Long-term inflationary pressures, as posited by global debt markets, have shifted significantly in recent years, owing to shifting geopolitical facts, the Russia-Ukraine war, and the United States' intervention in Taiwan, in mixture with hawkish central bank turns. If central banks do not provide clear and consistent forward guidance, markets will become even more disengaged from policymakers, and inflation expectations will become unanchored. For a longer period, the tension has pushed up inflation. The higher interest rates will make it harder for logistical companies to invest in technological innovations in the supply chain R&D. It will be more costly to develop new urban consolidation centres and new forms of urban freight delivery methods. This economic stagnation leads to slowing technological progress.

The Great Resignation is a term to describe the slow recovery of labour participation rate and increased quits and labour shortages, particularly in the services sector. At first, inflation may encourage more labour to return to the workforce either through the rising cost of living or wage growth. But as interest rates rise, presumably employment growth will soften. People who left work during the pandemic are more likely to stay out of the workforce, resulting in a permanent shrinkage of labour force and lower potential output of the economy. This trend in combination with the aging of the workforce, will result in need for atomization of the city supply chain as the workforce will be under strain for a longer period and will crack if processes are not automated.



## **Globalization & Urbanisation**

Because of the scattered spatial position for manufacturing, distribution, and consumption, globalization results in more products traveling around the world. At the same time, as a result of urbanization, cities are growing increasingly crowded. More people in a limited amount of space are a result of urbanization, which puts a strain on supply and the volume of freight moving thru cities is predicted to skyrocket. Users expect comprehensive, just-in-time, and frequent shipments, and urban freight operations must be efficient to be cleaner, safer, and less conspicuous while avoiding traffic bottlenecks. Cities are seeing an increase in the number of automobiles and vehicle kilometers they travel, resulting in congested city streets. The combination of all the drivers necessitates a higher level of sustainable and operational performance for urban freight from logistical companies.

Because of the decreasing availability of land in the city's dense areas, the increasing number of urban regions leads to a gradual absorption of urban areas and increasing land prices. As a result of these phenomena, urban deconcentrating occurs to cater to population increase. Despite the benefits of urbanization in related to resource efficiency, steadily increasing economic development is not the case due to high inflation and an unstable economic climate.

City livability and sustainability must be ensured but both the national government and municipalities proceed with a hand of manner of organizing urban logistics and leave it to market forces. This creates extra chaos in the supply chain as the size of cities increase due to urbanization. The urban logistics system is becoming more complex over time, while the logistics network's efficiency is decreasing. The quantity of complex and expensive return consignments is constantly increasing, while average truck loads and shipment sizes are falling as both established and developing suppliers make more direct deliveries. As a result of all of this, fleets are becoming larger and a greater need for an increased workforce, which reduces the need for supply chain atomization.

## **Technological stagnation**

There are a lot of ideas floating around concerning new technologies and strategies, as well as numerous strategies being explored, including decentralized warehousing or pooling goods flow, however, no scaling has happened since 2020: The same principles apply to urban logistics it did decades ago, with the exception that volumes have increased significantly. Traffic congestion and the higher operating costs for older, large petrol or diesel vehicles, are driving a trend toward smaller, electric fleet vehicles. These vehicles often have a shorter range, meaning a smaller catchment area per facility. At the same time, urban consumers are demanding faster turnaround times and the ability to select delivery windows. Together, these factors are driving an impetus for operators to adjust their operating networks.

## **Supply chain organization: Trucks & Consolidation**

Businesses are more inclined to move to suburban regions where land is less expensive and logistic facilities can be situated close to strategic infrastructures since there is a strong market for logistical land and because there is less available land due to the requirement for housing. Suburban areas have evolved into supporting territories for urban freight as the last stage of the supply chain preceding final distribution to city centers. In addition to rising prices, decentralization of transportation infrastructures such as freight rail has already shifted logistic facilities, such as urban consolidation centers, from urban to peripheral areas. Facilities are increasingly being clustered near highway networks to ensure access to labor and consumer markets. Companies use accessibility to compensate for the distance to the city center.

Consolidation should take place starting from small, personalized packages to small customers. So far, the effectiveness of the terminals in the city has not produced the desired effects, although their contribution to reducing the negative impact of transport on the environment can be enormous. Past failures of the concept of urban terminals seem to be a consequence of the complexity of logistics tasks, shortage of information and a large number of companies supplying the city. The key to success seems to be networking all players and taking effective control of the flow of goods based on consolidation and linear infrastructure. The municipality could have taken a role in coordinating the collaboration between all the stakeholders involved but over time has not been involved and let the urban logistics playfield develop under market forces.

The UCC is especially important for urban logistics in this scenario because it allows their goods to be consolidated and distributed using modes from different carriers to stop the decreasing efficiency. The UCC is set up as a multimodal transshipment point where various logistics parties store and are able to tranship. The UCC must offer space for the efficient transfer of heavy trucks too, for example, zero-emission vehicles and cargo bikes. In doing so, the UCC is open to different carriers and shippers can let market forces organize the inner city supply chain by bringing them together in UCCs. This is to ensure that the intricate zero-emission distribution in the cities can take place in an efficient manner, whereby different flows of goods can be achieved and can be combined from different companies to make the urban logistics system less complex.

Consider a neighborhood store, which is sometimes supplied by city distribution dozens of times per week by various suppliers. Smaller suppliers can sell their products more efficiently in the city to drop off by combining volumes as much as possible. Also, for retailers and catering companies that do not have delivery times and want to be dependent on the applicable window times, the UCC can be useful because it allows for smaller shipments in smaller vehicles at lower costs. In collaboration with cities that invest in future-ready infrastructure, UCCs could be implemented. This investment has come from certain logistical companies and retailers in the city as operational costs can be lowered due to efficiency gains.

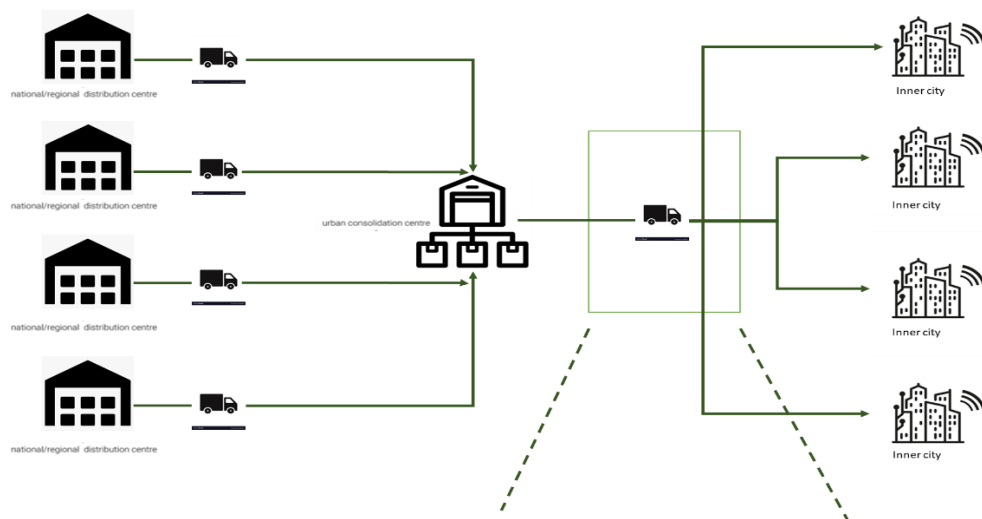


Figure 29 & 30: Supply chain organization in Scenario 3.

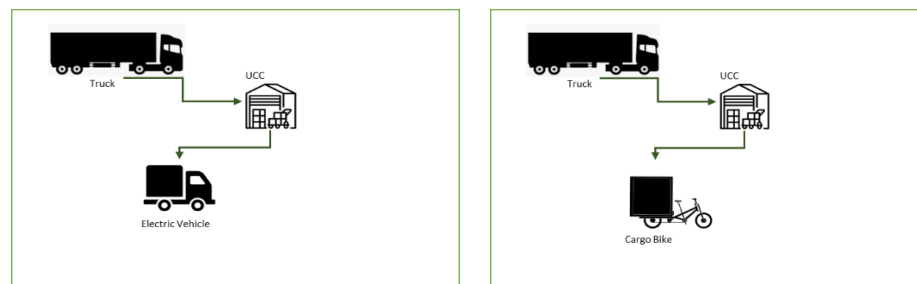
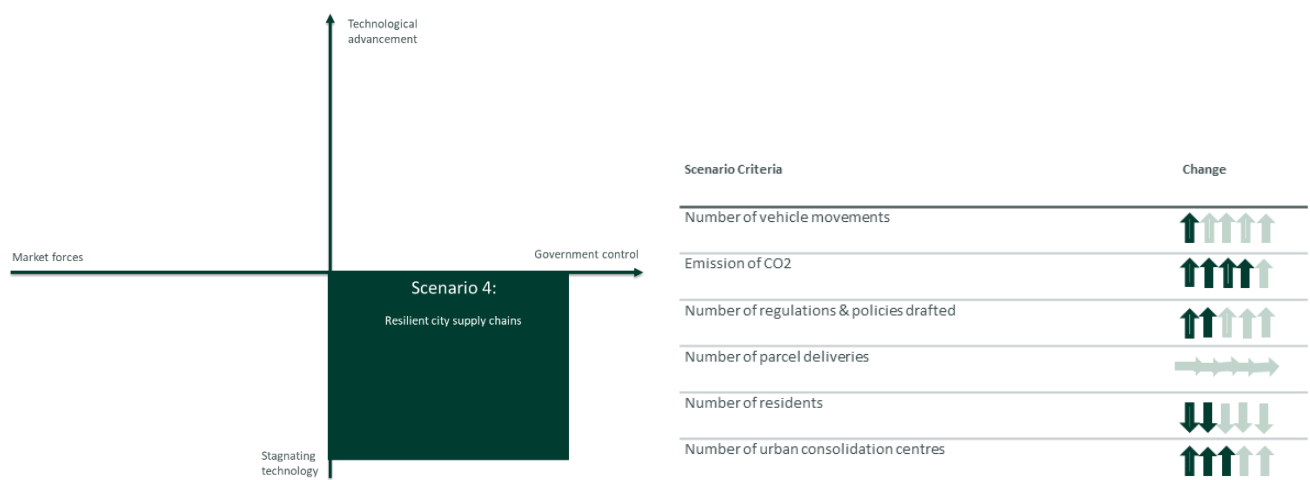


Figure 29 & 30 depicts the urban logistics system after 15 years in a large city in the Netherlands. The operational measures are as follows:

- Scenario 3 is defined as the logistics providers distributing goods to customers within cities using a traditional urban freight system. In this time dimension, logistics providers have built an urban freight network using electric vehicles, parcel lockers, and cargo bikes as there has not been progressing regarding innovation in urban freight and atomization of the supply chain in this scenario and the distribution modes used are already being used in 2022.

- The UCC is in charge of distributing goods to nearby residential and commercial areas following transshipment transportation. The carriers use trucks to transport goods from the central DC outside of the city to the UCCs. Following transshipment transportation, depots commonly use small/standard size EVs for last-mile delivery in further areas. One example is the use of EVs to transport goods from UCCs to customers. The carriers could use cargo bikes to handle last-mile delivery in the depot's surrounding areas.
- Indeed, the traditional urban logistics system helps to balance economic growth and environmental externalities caused by freight activities. However, urban spatial development has significantly exacerbated the challenges of traditional urban freight systems. As previously stated, many logistics providers frequently use short-term solutions to address these challenges.
- In this scenario, urban logistics providers currently lack a comprehensive consideration of urban spatial development in order to develop a long-term urban logistics strategy. Short-term solutions can help improve urban logistics performance in terms of delivery frequency and transportation coverage to some extent. However, in the long run, these approaches may stifle the further promotion of sustainable urban logistics. As a result, using short-term solutions within the traditional system results in an inflexible transformation of urban logistics.

## Scenario 4: Resilient city supply chains



Governments' top priorities are vulnerabilities in critical infrastructure and creating a resilient and robust city supply chain. Central authorities are concerned about the vulnerable energy network, extreme weather conditions, and economic stagnation. Highways are unprepared for the increased vehicle traffic, and traffic accidents can create traffic nightmares. Only extremely resilient logistics can withstand these conditions, as they must be able to supply shops and supermarkets in extreme weather conditions. Larger companies, in particular, can anticipate changes in logistic demand. The city's livability is less important than the residents' minimum standard of living. There is budget for subsidies, but companies are cautious when it comes to innovation. Because fine-grained distribution is irrelevant, heavier vehicles with more volume remain the norm. Globalization has been reversed as a result of economic hardship. Global trade volumes have decreased as a result of most countries raising protectionist barriers. Excessive nationalism dominates much of the world's political behavior.

As a second generation grows up in a protectionist world, the benefits of open global trade are fading from public memory and both policy & technical knowledge on the development of urban logistics remains within cities as protectionism makes it harder to exchange knowledge between large cities.

People are paying more for food, clothing, and electronic devices on average as a result of protectionism and the regionalization of value chains, as economies of scale derived from the division of labor and international specialization have suffered. Product selection is limited, and customers may be forced to wait for their desired product to be delivered. People prefer long-lasting products that can be repaired if necessary. Second and third-hand use is also common. Green production and consumption, on the other hand, are not a priority in the years building up to 2030.

### **Climate goals**

Only a few nations have taken action to combat climate change, and the world is on track for 3.5°C global warming by 2100 in 2027. Although global economic output has barely increased in comparison to previous decades, carbon emissions have increased as many countries increased the share of coal and lignite in their energy mix in pursuit of energy independence. Natural disasters are more common than in the past, and the poorest regions bear the brunt of the damage.

Governments and societies decide to focus on their security first, with a new emphasis. There is an islands-mentality with resilience understood as autonomy and self-sufficiency. These internally focused recovery efforts have mixed results. Nations focused on their short-term economic outcomes remain dependent on cheap fossil energy for a prolonged period, and global emissions decline only slowly. Extreme weather events eventually cause disruption and suffering. At first, cities were not paying much attention to changing climates and getting more extreme weather, but when the weather got more and more extreme, policies and regulations from national governments for combating climate change and reducing emissions came into action and municipalities started to regulate on diminishing emissions in the city. After this global wake-up call around 2035, the deployment of cleaner technologies brings progress and eventually net-zero emissions beyond 2100, late and slow decarbonization.

### **Regulations & safety**

After the weather got more extreme and had more impact on the livability of cities, almost all cities have strict environmental regulations in place, both for industrial manufacturing and for everyday life to increase the resilience of the city and its supply chain. This is accompanied by international climate protection agreements and their implementation in national policies to improve environmental and human well-being. Throughout a product's lifecycle, this type of regulation internalizes the external effects of its carbon footprint. All products are subject to carbon pricing. Any new product must meet the benchmarks established by the best available technologies in terms of energy consumption and material efficiency. The resulting carbon efficiency gains contribute to climate change mitigation.

Cities around the world are working together to combat the challenges that come with growth, such as infrastructure bottlenecks, emissions, and social tensions. To escape the congestion trap, a large portion of the public budget is directed toward infrastructure expansion and the construction of new transportation modes as companies do not invest in innovation in urban logistics due to the strict involvement of the government and municipalities. The majority of the world's megacities have also implemented stringent transportation regulations. To facilitate transportation consolidation, for example, logistic concepts must be proposed and approved for each new shop or manufacturing site. Infrastructure development stimulates the economy, allowing cities to flourish after years of a stagnating livable and economic environment and creating a resilient city.

## Technological flatness

Over the last four decades, technological progress has mostly consisted of small steps. R&D has only slowly recovered from the neglect caused by the decline in global scientific cooperation and the loss of R&D funding by large multinational corporations. In the years building up to the 2020s, the circular and digital economy appeared revolutionary in the aftermath of the global financial crises, but as the Dutch economy recovered, the dream of digitalization of the economy and the supply chain became more of a reality. With the rise of ICT, automation in combination with emitting trucks, carriers were in a good market position but continued to have a negative impact on the urban environment due to negative externalities, such as emissions and growing congestion. ICT companies, in collaboration with the logistical industry, shifted their focus toward making truck and van use more convenient with ICT. This eventually led to an extension of the technology currently used in urban logistics: using trucks with good connectivity. The "Internet of Things" resulted in massive amounts of data being used by businesses and governments alike. Not only goods, but also vehicles, infrastructure, and even people, are outfitted with sensors.

Eventually, this drive for efficiency with the lowest logistical costs, resulted in high emissions as trucks remained the cheapest inner city freight distribution method and in privacy issues related to the advanced analytics capabilities of the logistical companies. In combination with a more extreme climate, the government had to step in and started to regulate as mentioned in the last sub-section. Eventually, the logistical fleet in the city electrified and went from a large fleet of high emitting trucks to a fleet of more efficient electric zero-emission freight distribution methods.

## Supply chain organization: Multiple supply chains

At first glance, it appears that private and public players may have different goals that necessitate different interventions. Interventions that reduce delivery costs and minimize disruptions to current business models are more appealing to logistics players in the years leading up to 2030. Truck logistics will continue to operate until 2030. Their universal applicability to many different product types and existing business models will aid in their survival. Because of other evolving transport logistics operations and their reliance on humans, their market share will decrease in percentage. Furthermore, if the ecological trend after 2030 gains traction, an internal volume shift from truck logistics to a zero-emission logistics fleet is likely.

Reducing emissions and traffic congestion, for example, are undoubtedly top priorities for cities and municipalities after weather got more extreme and the cities livability deteriorated, which resulted in a more resilient urban logistics system. The priorities of cities revolve around sustainability-related topics such as meeting decarbonization targets, decongesting inner-city traffic zones, and improving overall street safety and quality of life for citizens. This scenario could include EVs, night deliveries and deliveries at odd hours, designated parking areas for delivery vehicles, and stricter enforcement of second-lane parking. Because EVs emit little noise, this intervention could result in interesting interactions with night deliveries.

In last mile logistics, Drop-off and Pick-up concepts and UCCs can prove to be a resilient part of the city freight supply chain. Points of Drop-off and UCCs can be maintenance-free and take the form of parcel lockers and take up less space than for example large distribution centers far away from the city. These UCCs can be developed to be weather resilient and can be dispersed in an urban area over multiple UCCs or drop-off points which increases robustness and resilience as there will be multiple UCCs.

The UCC is designed as a multimodal transshipment point where various logistics parties can store and transship their goods. It is critical that the UCC provides space for the efficient transfer of heavy trucks to zero emission vehicles, e-vans, and cargo bikes. As a result, the UCC becomes available to various carriers and shippers and distribution modes. This is to ensure that the distribution in cities can take place in an efficient manner, whereby different flows of goods can be achieved, whether or not via transshipment to smaller delivery vans, or by merging into larger trucks. This is significant because clean transportation should not result in significantly more transportation movements and it increases resilience.



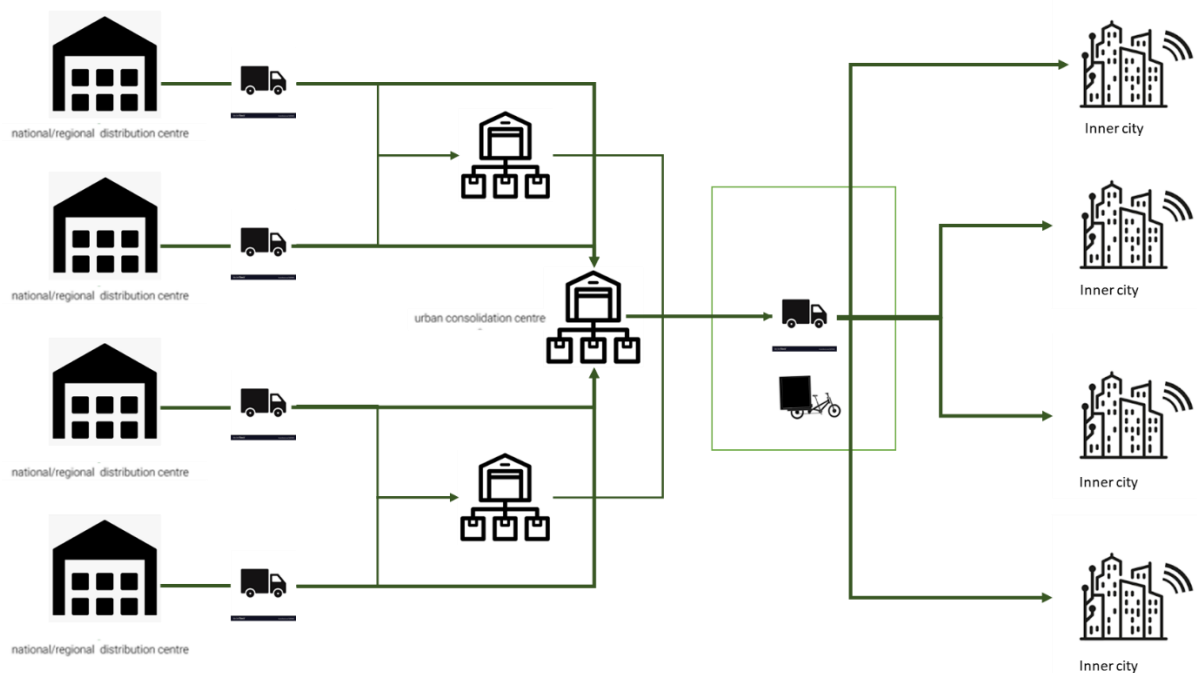


Figure 31: Supply chain organization in Scenario 4.

Figure 31 depicts the urban logistics system after 15 years in a large city in the Netherlands. The operational measures are as follows:

- Multimodal and sustainable transportation systems are the foundation for efficient freight mobility. Infrastructure, logistics, and network/traffic management, in particular, play a significant role in making urban logistics climate neutral. At the same time, because these three areas are vulnerable to climate change and other disruptions, resilience will be increased by developing multiple supply chain options in the cities.
- Optimize the potential mix of strategically located land owned by public or logistics service providers in urban areas for the development of a comprehensive policy on urban logistics.
- To enable the introduction of new vehicles, operations, and mobility services, new and advanced infrastructure across all modes of transportation is required. Furthermore, efficient and smart multimodal logistics are critical for urban freight transport movements that are resilient and robust.
- The introduction of innovative freight distribution lacks due to a lack of investments in the research and development in this scenario. However, to increase resilience, increased use of waterways and rail for urban logistics will be used to complement the classic urban logistics with trucks. Eventually, after 2030 to cope with the extreme weather and fight climate change, the growing impact of new modes, such as electric cargo bicycles, light electric freight vehicles and alternative fuel vehicles will be used.



## 6.5 Concluding Remarks: Scenario Conclusions

A scenario study was undertaken to analyze the uncertainties and predict the various possible futures of urban logistics in 2040 with various city supply chains. Four unique scenarios for examining the future of urban logistics were constructed with the help of an expert panel. Based on prioritized trends, the four scenarios depict the future of urban logistics and the organization of the inner city supply chain in 2040. The impact of technological innovation and the legislative and regulatory environment, according to the scenario analysis, are significant uncertainties that drive the impact into four scenarios.

The developed vision 2040 for urban logistics has shown significant changes regarding the use of technologies and infrastructure, the design of services and delivery concepts, market organization and cooperation, planning and regulation, and finally to a certain extent also behavior. In a complicated city supply chain, technological improvement in **scenarios 1 and 2** leads to a wide variety of novel urban distribution methods to be deployed. When municipalities begin to regulate and establish regulations impacting the organization of city logistics (**Scenario 2**), the city develops an urban logistics ecosystem in which all of the participants of the logistics are interrelated. The system is set up so that local governments can create a zone for urban logistics and offer access to enterprises that meet certain criteria. These networks are run by public-private partnerships, which use a tender process to offer packaged last-mile services.

**In scenario 1**, Due to rapid technical improvement, unmanned vehicles, robotics, and unmanned aerial vehicles (UAVs) could be increasingly deployed to provide urban freight services shortly. This could pave the way for the integration of digitization and intelligent technology in the logistics industry, including freight. Technology alone will not be able to overcome the complicated difficulties of urban logistics. **In scenario 2**, governments issue tenders for the inner city supply chain to logistical firms, and the management aspect of the inner city supply chain design should be fully integrated, which comes forward in the all-encompassing urban logistics ecosystem. City characteristics and final recipient traits influence the economic effectiveness of urban logistics processes, and the adoption of smart technology and more autonomous delivery may result in a labor force decrease. Furthermore, autonomous delivery and electric vehicles (EVs) may eliminate the need for human delivery employees in the future, resulting in a more cost-effective supply chain, but with the risk of job losses, which could prompt government involvement. **Even in scenario 1**, where autonomous delivery thrives thanks to technological advancement and limited government involvement, the government must intervene due to severe economic effects.

**In scenario 3**, global conflict, pandemics, and economic recessions are combined with no adjustments from 2022. The innovative urban logistics technologies of the time never made it to the Dutch market and have mostly vanished, and different enterprises' supply chains remain separate, with minimal trade and consequently fewer efficiency improvements. In this context, logistical enterprises are now unable to build a long-term urban logistics plan due to a lack of comprehensive analysis of urban spatial growth. These techniques may, in the long run, suffocate future efforts to promote sustainable urban logistics. As a result, relying on short-term fixes within the existing system leads to a rigid restructuring of urban logistics.

Vulnerabilities in vital infrastructure and building a resilient and robust city supply chain are major objectives for governments. **In scenario 4**, the weak electricity network and extreme weather conditions are causing alarm among central officials. The foundation for robust freight mobility is multimodal and sustainable transportation systems. Infrastructure, logistics, and network/traffic management, in particular, play a key role in achieving climate-neutral urban logistics. At the same time, because all three locations are sensitive to climate change and other disturbances, creating different supply chain choices in the cities will boost resilience.

All in all, eventually in 2040, we will not be worse off in terms of CO<sub>2</sub> emissions than in the current scenario as climate change will pressure us to increase regulation, even in **scenarios 1 & 3** where market forces dominate. **Scenario 2** might be the best future outcome for increasing the city's liveability but less good for logistical businesses due to heavy regulation in the urban logistics system. A strong government is needed in combination with investments in logistics R&D to have technological progress, would this be the preferred future outcome. **Scenario 4** might be the worst for businesses due to increased cost and economic headwinds and city inhabitants due to reduced living conditions caused by extreme weather.

This scenario could be averted if there would be a drastic reduction in emissions to stop climate change. What also came forward, is that in all scenarios, urban consolidation centres play an important role in the city supply chain: from increasing resilience due to extreme weather to lowering emissions due to freight consolidation.

Criteria	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Number of vehicle movements	<b>Higher</b> (New distribution method)	<b>Higher</b> (New distribution methods)	<b>Lower</b> (Economic stagnation)	<b>Higher</b> (Extreme weather, but increased resilience)
Emission of CO2	<b>Lower</b> (A late but rapid decarbonization)	<b>Lower</b> (Emission lowering policies and incentives)	<b>Higher</b> (Economic stagnation)	<b>Higher</b> (A late and slow decarbonization)
Number of regulations & policies drafted	<b>Lower</b> (Liberalization)	<b>Higher</b> (Government intervenes)	<b>Lower</b> (Governmental budgetary constraints)	<b>Higher</b> (Governmental concerns)
Number of parcel deliveries	<b>Higher</b> (Growing consumption)	<b>Higher</b> (Growing consumption)	<b>Lower</b> (Economic stagnation)	<b>Stable</b> (Traditional truck logistics)
Number of residents	<b>Higher</b> (Urbanization)	<b>Higher</b> (Urbanization)	<b>Higher</b> (Urbanization)	<b>Lower</b> (extreme weather)
Number of urban consolidation centres	<b>Higher</b> (Technological advancement)	<b>Higher</b> (Technological advancement)	<b>Higher</b> (Technological flatness: Low-tech UCCs)	<b>Higher</b> (Increased resilience)

Table 11: Scenario Criteria Differences.

Due to the diversity of the driving forces influencing the future of urban logistics and the distribution innovations, urban logistics could have different city supply chain organizations in the future as seen in the different scenarios. **Supply chain consolidation:** To disrupt the last mile and introduce convenient local delivery alternatives, many firm consolidation solutions demand collaboration with competitors. This might involve a multi-company consolidation plan in which customers can pick up and return packages from different companies. Solutions based on sophisticated analytics, such as load-pooling and dynamic re-routing, could contribute to an overall scenario that minimizes emissions and congestion. **All-encompassing connected city supply chain:** The city develops an urban logistics ecosystem in which the many logistical operators are all interrelated. In real time, this software would monitor all available transportation capacity. This system would be developed in partnership with parcel delivery firms, taxis, and autonomous delivery robots. It will be able to employ efficient freight flows in the city and react to disruptions or congestions thanks to real-time traffic planning. **Trucks & consolidation:** Logistic facilities are increasingly being clustered near highway networks to ensure access to labor and consumer markets. The key to success seems to be networking all players and taking effective control of the flow of goods. They aim to ensure that different flows of goods can be achieved and can be combined from different companies. Logistics providers have built an urban freight network using electric vehicles, parcel lockers, and cargo bikes. The traditional urban logistics system helps to balance economic growth and environmental externalities caused by freight activities. **Resilient supply chains:** Drop-off and Pick-up concepts, as well as UCCs, can prove to be a resilient aspect of the city freight supply chain in last mile logistics. These UCCs can be designed to be weather resistant, and they can be scattered around an urban area increasing robustness and resilience. The UCC is now available to a wide range of carriers, shippers, and distribution channels. This is to ensure that distribution in cities is efficient & resilient, allowing for multiple flows of commodities to be realized. In the next chapter, economic, environmental & societal implications & recommendations for policymakers, logistical businesses and investors are formed based on the developed scenarios.

# 7

## Discussion of the Scenarios: Implications & Recommendations

- 7.1 Implications & Recommendations: Policymakers
- 7.2 Implications & Recommendations: Logistical businesses
- 7.3 Implications & Recommendations: Investors

# 7. Discussion of the scenarios: Implications & Recommendations

The previous chapter presented four scenarios giving an overview of the future of urban logistics and the organization of the inner city supply chain in 2040, based on ranked trends. These scenarios should assist businesses, policymakers and investors in imagining future developments, exploring relevant uncertainties, and studying the implications for their merit. As a result, studying (economic, sociological, and environmental) trends and various new types of transportation via exploratory scenarios is beneficial to a wide variety of stakeholders to gain a greater understanding of city logistics. With the help of this vision, municipalities can modify their urban logistics policy plans and logistical firms & developers can increase their investments in infrastructure and supply chains.

As part of answering the second part of the main research question, the main implications for policymakers, logistical businesses and investors based on the different scenarios regarding environmental, societal and economic aspects are elaborated first in this chapter. As a result, recommendations for the stakeholders are presented based on the developed scenarios and implications for large cities.

## 7.1 Scenarios Implications & Recommendations: Policymakers

The municipality has an interest in having a safe, attractive city center with a reliable supply chain. Along with the municipality, the local economy also gains from it. They could use incentives to reward sustainability and sustainable logistics solutions and limits such as time access windows, road fees, and unloading and parking restrictions. In other words, the job of municipal authorities is to control, encourage, facilitate, and/or coordinate. There are numerous implications for policymakers based on the different future visions of urban logistics. From the different scenarios, most implications and recommendations for policymakers were found regarding the collaboration between the stakeholders, regulation and financing.

### Collaboration

Overall, the situation in large cities is one of escalating demand for warehousing and freight transit, which results in increased traffic and pollution as well as a shortage of land as seen in **the first two scenarios**. As a result, firms are under pressure to develop new models for more effective logistical operations, while city authorities are under pressure to enhance the local environment by decreasing congestion, pollution, and noise and enhancing safety. These two goals are frequently pursued independently, but new business models and technological advancements present the possibility of securing both environmental and overall efficiency improvements with more cooperation among the policymakers and logistical businesses, which is seen in the all-encompassing supply chain system between logistical companies and public stakeholders in **the second scenario**.

When cities do not compete with one another, they could benefit from collaboration as seen in the driving force of globalization in **chapter 5 and scenario 2**. Cities can serve as real time laboratories, accelerating learning and innovation through city platforms. Companies can assist in the transfer of solutions from one city to another. Ideally, cities and businesses develop plans that fit together like a glove. This means that municipal policies are supplemented by concrete corporate actions. If a city establishes low-emission zones and invests in parking lots with charging infrastructure, the transition to electric vehicles will be accelerated. Consistency between the municipalities on regulation and public-private

partnerships needed to be considered in the development of the urban logistics system. This could establish more clarity in who has what responsibilities in the urban logistics system and overcome lock-ins as seen in the stakeholder analysis and comes forward in the public-private urban logistics system in **the second scenario**.

The policymakers could also draft policies for working together with investors and logistical companies for developing and operating urban consolidation centers. The municipality could work with investors in developing the logistical infrastructure via tender procedures if they have sufficient land available. Certain demands regarding sustainability and livability from the local government can be tender criteria when selecting investors. For operation, municipalities would hold a tender process for different logistics companies that could organize and pool a varied range of transportation techniques and resources, as seen in the **second scenario**. The logistical businesses operating the UCCs would have business-specific demands that need to be communicated to the investors and developers. The municipality could take a leading role in this procedure for bringing together and aligning the criteria of the investors and the logistical businesses and improving their tender criteria based on these communications. Taking this role could take away the challenge to develop collaboration amongst various efforts due to passive behavior between actors as seen in chapter 3.

### Regulation

Uncertainty for logistical companies arises in the future when mobility pricing systems for urban freight, traffic management, and vehicle capacity-dependent processes are implemented by municipalities. A significant proportion of the city population will prefer environmentally friendly regulations, which supports this trend for this kind of regulation. The local policymakers can take away these uncertainties for logistical companies by drafting long-term policy plans, in that way the companies can adjust their long-term business plans, and at the same time cater to its inhabitants supporting more environmentally friendly regulations. This comes forward in **the first scenario**, where this regulatory uncertainty disappears due to a municipal hands-off process in regulating the inner city supply chain.

However, If the federal government and local governments loosely organize urban logistics and leave it to market forces as seen in **the third scenario**, this could have negative consequences when cities grow in size owing to urbanization which adds to a more complex supply chain. The efficiency of the logistics network is declining as the complexity of the urban logistics system is increasing due to increased populations which leads to the logistics network's efficiency decreasing seen in **the fourth scenario**. Municipalities should impose constraints on what level of complexity the urban supply chain could reach until it is at the expense of logistical efficiency in this scenario due to economic headwinds and high urbanization.

In **the third scenario**, the stimulation of renewable energy for cars, as well as vehicles with greater capacity for filtration of vehicle engine exhaust is one example of technological innovation aimed at reducing the impact on the environment. Promoting the sharing economy and cooperation among stakeholders by the municipality improves resource utilization efficiency. The impact of urban freight movements is reduced by replacing passenger vehicle travel with goods delivery routing schemes using smaller and electric vehicles.

The shifting urban logistics landscape has altered freight transportation patterns, putting more strain on traffic and resulting in negative environmental consequences, as seen in **the fourth scenario**, with the environment worsening and resulting in extreme weather. More sustainable policies necessitate a socio-technical solution rather than a purely technological approach that calls for collaboration between public and private actors. The local policymakers could stimulate the implementation of car-sharing, bike-sharing, and increasing the use of electric vehicles are some measures that could improve urban air quality in **scenarios with low technological advancement**. The municipality should work actively together with logistical businesses via subsidies for emission-neutral vehicles. Electric vehicles also reduce noise and allow for late-night deliveries. Fully autonomous vehicles, for example, can reduce driver stress. Because of lower CO2 emissions and other air pollutants that cause health problems, the growing use of (electric) light vehicles increases job creation and quality of life. Urban logistics services using light vehicles and bikes create more jobs and more relaxed working conditions for vehicle drivers. When technology advancement stagnates, the municipality should start stimulating electric vehicle usage for businesses and consumers and not let it to the market, to bring back emissions and reach the climate goals and not let **scenario 3** experience the extreme weather formed in **the fourth scenario**.

It is important for municipalities in the large cities in the Netherlands for national alignment in these constraints and regulations as otherwise there might be discrepancies between cities which would result in a distorted urban logistics market mechanism. Logistical businesses find it easier and more efficient to supply when the restrictions are clear, aligned, and consistent across municipalities.

These regulations could be regarding congestion charges on specific roads or areas of the city that can entice both transporters and vehicle drivers to alleviate congestion in those regions, resulting in less congestion. Diminished air pollutants and greenhouse gas emissions are secondary benefits. Toll roads, electronic toll collection systems based on vehicle detection, or the installation of a means of communication in the vehicle can all be used to collect the fees. Tax breaks and others incentivize the integration of infrastructure, equipment, or demand-driven levers, which would mean that the toll is zero if there is no traffic but rises proportionately to traffic volume. To increase logistical efficiency and lessen congestion and interruptions as seen as problems in **the first three scenarios**, policymakers should consider city zoning and building design regulations. The majority of freight routes begin or terminate at buildings, however, these structures frequently require better freight handling architecture. This is particularly true with huge buildings or structures housing several enterprises, such as enormous office complexes or shopping centers. In the future, time constraints can also be used to regulate freight traffic in the form of time slots in load zones, night deliveries, or time windows. All these constraints serve as the foundation for environmentally and socially responsible delivery zones especially important in **the first two scenarios**.

### Financing & stimulation

Because retailers, shippers, and carriers are unwilling to pay extra for green logistical solutions, funding must come from a different source, such as local governments and investors. As a result, it is necessary to push logistical enterprises to adopt green technologies to cut down emissions based on multiple scenarios. There are several approaches to use in doing this. Companies that invest in green technologies may be given the chance to deliver outside of predetermined delivery windows or enter the city with goods before a conventional truck utilizing sustainable distribution methods. This could create whole new market opportunities for parties with green vehicles and aid in the achievement of upcoming zero-emission objectives. This spurs economic activity in the city could be beneficial in **the third scenario** as it does not require monetary incentives, which were scarce due to budgetary constraints.

The government must provide financial incentives for businesses to make the necessary investments in green freight due to high sunk costs associated with logistical infrastructure, distribution vehicles, and R&D. This is especially the case in the **third scenario** when companies stall investments due to economic hardships and halts technological innovation. If a profit is not guaranteed, businesses frequently lack the cash to make investments or decide not to take on significant economic risk. Currently, in 2020, many municipalities have budgetary constraints and companies have large financial resources (Żołądkiewicz-Kuzioła, 2021) & (Harris, 2020). These green city hubs or sustainable delivery methods might also be financed by investors, but to bring them on board, city governments must take the initiative because investors are risk-averse and seek to reduce default risks.

Public-private partnerships play a role in reinventing the last mile, especially in **the second scenario** when the municipality takes an active role in the urban logistics system. The most typical tactic for private initiatives is private funding. Public intervention is nevertheless a possibility. Public authorities provide a private enterprise with the necessary infrastructure and cover a portion of the costs of investments. The operational costs must be covered by the private enterprise in some circumstances, which is the case in the city supply chain in **the second scenario**. Subsidies are financial aids that are nonrefundable. In this instance, low interest credits are being used to support the growth of urban logistical networks. The public authority must receive their money back from those financial aids. This could work in **the first scenario**, where the municipality could still profit while keeping a hands-off approach. The approach that uses an authority's portion contribution as a subsidy is the most popular. In other words, a public subsidy helps to offset some of the investment costs associated with creating urban logistics solutions. These expenses typically cover feasibility studies and a portion of the investment. Since platforms and vehicles make up the majority of investment expenditures, public authorities can grant the service provider a concession on them as seen in **the second scenario**.

The municipality could offer tender procedures for both operation and development of logistical infrastructure. The operational tender procedure comes forward in **the second scenario**, where the municipality selects certain logistical businesses on criteria regarding sustainability, livability, robustness and resilience and with a stable long-term business model. For development, cities with plots of land in and around the city in ownership could be offered for lease to real-estate investors for the development of urban consolidation centers. Criteria could be based on building time, sustainability and building costs. They could stimulate sustainable development via subsidies or funds from the central government. Cities with fewer free plots available could work with investors by financing part of the costs. Based on these scenario implications, several recommendations have been made for municipalities.

#### Policymakers Recommendations

- Make urban design changes to facilitate the operation of commercial logistics companies. Installing short-term parking spaces, designing dedicated lanes for cargo bikes, or renting space for micro-depots are some examples.
- Create a clear set of regulations that forbid anyone from impeding traffic and impose fines on those who do. The severity of the disturbance to the overall flow of traffic should also be taken into consideration when determining the level of fines.
- Develop the specialized knowledge necessary to manage platform creation and development, as well as to put platform operation out to bid. A public-private partnership might be used to accomplish this.
- Create uniform delivery standards (in conjunction with business groups, other local governments, the national government, the EU, etc.)
- Specify the logistical areas where shared micro-depots will be located.
- Implement a dynamic city toll for all road users (increased fees during peak commute times), or even limit the hours of the day when commercial logistics providers can access the city, to ensure that the laws are followed.
- Consistency between the municipalities on regulation and public-private partnerships are needed to be considered in the development of the urban logistics system. This could establish a more clarity in who has what responsibilities in the urban logistics system and overcome lock-ins as seen in the stakeholder analysis and comes forward in the public-private urban logistics system in the second scenario.
- For operation, municipalities would hold a tender process for different logistics companies that could organize and pool a varied range of transportation techniques and resources, as seen in the second scenario.
- The municipality could take a leading role in this procedure for bringing together and aligning criteria of the investors and the logistical businesses and improve their own tender criteria based on these communications.
- It is important for municipalities in the large cities in the Netherlands for national alignment in constraints and regulations as otherwise there might be discrepancies between cities which would result in a distorted urban logistics market mechanism.
- The government must provide financial incentives for businesses to make the necessary investments in green freight due high sunk costs associated with logistical infrastructure, distribution vehicles and R&D.



## 7.2 Scenarios Implications & Recommendations: Logistical businesses

There are numerous implications for logistical businesses based on the different future visions of urban logistics. From the different scenarios, most implications and recommendations for logistical businesses were found regarding the distribution methods and systems, operating costs, supply chain requirements and collaboration between the businesses and the other stakeholders.

### Intelligent & connected systems

As seen in **the first two scenarios** with high technological advancement, unmanned vehicles, robots, and UAVs could be widely used to provide urban freight services shortly. This could open up possibilities for integrating digitization and intelligent systems across logistics industries, including freight. Digitization allows for the creation of more efficient, adaptable, and consumer supply chain solutions. To efficiently manage entire supply chains, digital supply chains could provide interconnected logistics operations, smart warehousing, and advanced information analysis tools.

**In scenario 2**, the Suitable use of intelligent automation in urban logistics networks might considerably reduce the inability in delivery service situations and facilitate product transport system maximization, such as route optimization. Firms can, for example, combine routing optimization with electric vehicles to improve supply chain efficiency. In recent years, there has been an increase in simulation model-based evaluations of urban freight solutions. To develop and evaluate various urban freight supply chains, these kinds of models can come in handy.

Intelligent planning and real-time optimization of urban logistics operations are enabled by IoT technology in logistics, such as detecting vehicles, Global positioning, and device tools. It allows businesses and service providers to increase their productivity. The adoption of IoT technologies leads to increased collaboration among shippers and carriers. This type of collaboration could reduce the amount of energy used and the time it takes to complete orders. When maximizing energy savings in city logistics, consider the goods delivery time frame and vehicle loading capacities, as these factors can have a significant effect on the stability, versatility, expense, and environmental efficiency gains of product delivery companies.

Various supporting technologies, such as connected cars, GPS navigation (GPS), smart cards, and congestion and freight management systems, have arisen in the field of urban freight. Logistics companies and municipal governments can use the provisions of these maps and systems to go further than multimodality and into synchromodality. Synchromodality is a system of interconnected transportation that optimizes the use of numerous modes of transportation under the oversight of a third party (Yang, 2018). Without consulting the store, this party determines which form of transportation is most appropriate for the situation. Next to that, traditional supply chain models are still incapable of accounting for innovative urban freight distribution solutions (Chen, 2018).

### Operating costs

Electric vehicles have a high purchasing cost compared to regular vehicles, but their costs of operation are lower than those of conventional vehicles (Hannan, 2014). If the delivery area is close to the distribution center, there is a high density of residential units, and the delivery volume per stop is low, electric cargo bikes can be cost effective. Delivery trucks are more cost effective when the delivery area is large and the delivery volume per stop is high. **In Scenario 3**, when logistics providers distribute goods to customers within cities using a traditional urban freight system. In this scenario electric delivery trucks can be cost effective options as there has not been progressing regarding innovation in urban freight and atomization of the supply chain in **scenario 3** and the distribution modes used are already being used in 2022. **In the first three scenarios**, electric cargo bikes are part of the inner city supply chain. They have lesser depreciation costs and lower operating costs than fuel vans due to reduced power consumption. Bikes and light commercial vehicles do have the benefit of allowing for more flexibility in delivery times while also reducing traffic congestion, and saving money and resources.



In urban areas, delivery drones do have the potential to make the shift from pickup truck delivery of products to drone-based delivery. The use of UAVs for urban cargo has some disadvantages, such as many countries have legal restrictions on drone-based goods delivery, the service area is limited due to the small delivery radius and has less productivity than van-based delivery due to the small delivery capacity compared to trucks. Adoption of smart technologies and more autonomous delivery may result in a labor force reduction. Autonomous delivery EVs may not even require human delivery personnel in the future and results in a more cost effective supply chain. Next to that, **in the first scenario**, businesses use the sharing economy business model to address logistics issues associated with rising freight transport demand. The sharing economy promotes resource sharing and provides quick delivery performance. Employing drivers who own vehicles allows businesses to avoid fixed costs, empty moves, and idle-time costs. Sharing business models are popular due to their low cost and lower consumer prices.

### Supply chain requirements

Several modes contribute to the trend of buildings getting higher due to scarcity of land as seen in **the second scenario**. Delivery drones can be used to meet the freight needs of high-rise architectures. Parcel lockers can accept packages from delivery drones and robots. This strategy can boost enterprise competitiveness by providing personalized logistics services. Furthermore, the modular E-vehicle can be outfitted with a delivery drone to transport goods to high-rise architectures in commercial areas. Trucks and drones can complement each other as seen in **the first scenario**. **In the third scenario**, with extreme weather and low technological advancement, drones will not be optimal for playing a part in the urban logistics system.

According to Dong, (2017), several authors have emphasized the importance of freight unit standardization for multimodal urban freight operations. They contend that standardized containers are a crucial component for the incorporation of distributing advances, particularly for urban logistics, just as containerization of products (sea containers) has benefitted multimodal long-distance shipping. This standardization can contribute to the increased resilience needed in **the fourth scenario** as it gets easier to switch between urban consolidation centers when extreme weather hinders other supply chains.

### Collaboration

In cities with ongoing urbanization, more pedestrian space appears to be the desired outcome in this regard. However, there are no simple solutions because the waterway or passenger transport freight can save space due to its larger corridor capacity in **the second scenario**. A mobility pricing system for urban freight transport is in place in this scenario as well. This leads to improved transportation infrastructure utilization and a growing level of cooperation between shippers and logistics service providers enacted by municipalities enabling a highly reliable supply of clients.

Logistical service providers are gathering massive amounts of data on freight movement and congestion that would aid in the development of supply chain optimization models. However, because they are very protective of their data, it is unknown whether it will be available for independent research and collaboration between companies. The models' results will help businesses decide whether to take steering or facilitating role in urban logistics and will thus indicate the likelihood of the scenarios. In a public-private urban logistics system **in scenario 2**, both the companies operating the city supply chain and municipalities could combine their insights and develop future supply chain strategies and policies. The future of urban logistics will be dominated by connected, shared, autonomous, and electric solutions. These trends will be driven by emerging technologies such as IoT, connected devices and AI. Urban logistics operators can harness this data and technology to improve their operations.

Municipalities emphasize the need for an efficient, resilient and robust inner city supply chain. **In scenario 1**, they relaxed regulations which lead to an increased number of providers in the urban freight supply chain. Logistics players want to reduce delivery costs and investors want high returns on their investments and resilience & robustness comes second for these stakeholders. For municipalities, inhabitants and retailers, a consolidation of the last mile is an important factor in creating a robust and efficient inner city supply chain. This necessitates the collaboration of public and private stakeholders to align their goals and make tradeoffs in cost efficiency and resilience & robustness. Furthermore, companies need to work

together and could do this with a multi-company consolidation strategy. Multiple company consolidation solutions necessitate collaboration with competitors in combination with advanced analytics based solutions like load-pooling and dynamic re-routing, which could contribute to an overall scenario that reduces emissions and congestion. Based on these scenario implications, several recommendations have been made for logistical businesses.

#### Logistical Businesses Recommendations

- Create the necessary technology interfaces and delivery standards, for instance, to construct the technical and operational foundation for using a shared platform.
- Integrate their own warehouses and vehicles for use throughout the platform to create shared demands with the city and other businesses. To remain competitive with other platform users, create and enhance efficient platform operations.
- Establish the technical and operational framework for using a shared platform, for example, by developing suitable technological interfaces and delivery standards. Create and improve effective platform operations to maintain competitiveness with other platform users.
- Agree to cooperate and establish shared standards for certain areas like package sizes, delivery lead times, or joint collective salary agreements.
- Identify organizations that make excellent candidates for collaboration or acquisition (more expertise, more capacity, more users) and establish a shared IT platform with standardized interfaces and smart delivery route management. Consistently grow the client base to ensure optimal delivery capacity usage.
- Suitable use of intelligent automation in urban logistics networks might considerably reduce inability in delivery service situations and facilitate products transport system maximization, such as route optimization.
- If the delivery area is close to the distribution center, there is a high density of residential units, and the delivery volume per stop is low, electric cargo bikes can be cost effective. The sharing economy promotes resource sharing and provides quick delivery performance.
- The modular E-vehicle can be outfitted with a delivery drone to transport goods to high-rise architectures in commercial areas.
- In the third scenario, with extreme weather and low technological advancement, drones will not be optimal for playing a part in the urban logistics system.
- Standardized containers are a crucial component for the incorporation of distributing advances, particularly for urban logistics, just as containerization of products (sea containers) has benefitted multimodal long-distance shipping.
- This standardization can contribute to the increased resilience needed as it gets more easier to switch between urban consolidation centers when extreme weather hinders other supply chains.
- In a public-private urban logistics system in scenario 2, both the companies operating the city supply chain and municipalities could combine their insights and develop future supply chain strategies and policies.
- Multiple company consolidation solutions necessitate collaboration with competitors and the surrender of certain privileges in combination with advanced analytics-based solutions like load-pooling and dynamic re-routing, which could contribute to an overall scenario that reduces emissions and congestion.

## 7.3 Scenarios Implications & recommendations: Investors

The urban logistics sector as a whole has grown quickly over the past ten years and will account for more and more real estate investment volumes in the future. Real-estate investors, which range from development companies, asset managers and banks, have a deep interest in logistical assets, such as warehouses and urban consolidation centers concluded from the stakeholder analysis. As seen in the supply chain organization of multiple scenarios, urban consolidation plays an important role. Investment in urban consolidation should contribute to city accessibility and an efficient supply chain. The role of investors would thus be mainly related to logistical infrastructure such as urban consolidation centers, in combination with the dominant role of UCCs in future scenarios, the implications for investors are related to the operational and development of logistics city hubs.

Cities like London are under tremendous pressure to release industrial land for residential development due to the high demand for new homes (Feng, 2021) and as seen in **the first scenario**. Despite the fact that there is a growing need for their products and services, this is causing last mile fulfillment companies and industrial occupiers to move away from their client base. To stop the loss of industrial buildings and create the ideal conditions for the sector to grow, a strong and adaptable urban logistics infrastructure should be developed according to Fossheim (2017).

The demand for land in urban centers is on the rise, and elevated uses like residential construction frequently push out comparatively low-value logistics applications. One outcome among these processes is logistics sprawl, or the radial spread of storage to cities' outskirts and beyond. This trend can be seen in a lot of major cities across Europe, including Paris. In turn, this frequently lengthens the local delivery length from storage to clients (Lagorio, 2016). The growth of e-commerce in **the second scenario** is substantially driving the warehouse demand from parcel carriers. To maximize the number of items per drop-off in this industry, high volumes and few delivery sites are desirable. E-commerce has raised volumes, but it has also increased the number of possible delivery sites.

The need for more logistical infrastructure due to e-commerce growth and land scarcity lead to more investments in UCCs. The primary function is to facilitate the transition from large trucks to zero-emission transport, such as zero-emission trucks, light electric freight vehicles and cargo bikes. The UCC serves all carriers that distribute to various delivery points throughout the city (Baldi, 2019). The UCC is designed as a multimodal transshipment point where various logistics parties can store and transship their goods. The UCC must provide space for the efficient transfer of heavy trucks to electric vehicles, e-vans, and cargo bikes. Logistical city hubs are expected to have a required size of 5.000 to 10.000 m<sup>2</sup> according to Buck Consultants International in 2018.



Figure 32: Urban Consolidation Center Hollandsche Hoogte

Type / scale level	Location	Size	Characteristics
1. E-fulfilment centre	Corridor	> 40.000 m <sup>2</sup>	Decoupling point towards urban centers
2. Regional distribution centre	In large cities Between cities	> 20.000 m <sup>2</sup>	Combined store delivery and home delivery Combined with intermodal
3. Urban distribution centre	Edge of cities Medium-sized cities	>5.000 - 10.000 m <sup>2</sup>	Decoupling point towards urban centers
4. Freight transfer hub	Within cities	1.000 m <sup>2</sup>	Flexible and sometimes mobile Multiple hubs per city possible
5. Pick up / drop off points	Shops, apartments	100 m <sup>2</sup>	Work unmanned with codes via mobile communication

Figure 33: Real Estate surface of distribution hubs.

To investigate the financial implications of urban consolidation centers for investors, (Gogas, 2017) identified and classified the revenue and cost elements associated with their operation into the following categories: **revenue, infrastructure costs, vehicle costs, personnel costs and equipment costs**. costs can be divided into two categories: development costs and operating costs. The following table compares these aspects per scenario with the current situation in 2022. Between the brackets are the driving forces behind the different scenarios, which cause the change from the current situation.

Type	Object	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Land (Development)		<b>Higher</b> (Land scarcity)	<b>Higher</b> (Land issuance regulations)	<b>Lower</b> (Economic stagnation)	<b>Higher</b> (Extreme weather)
Real Estate (Development)	Building Requirements	<b>Higher</b> (Urbanization)	<b>Higher</b> (Urbanization & Building requirements)	<b>Lower</b> (Economic stagnation)	<b>Higher</b> (Extreme weather)
	Other Infrastructure	<b>Higher</b> (Technological advancement)	<b>Higher</b> (Technological advancement)	<b>Stable</b> (Technological flatness)	<b>Higher</b> (Extreme weather)
Vehicles (Operational)		<b>Higher</b> (Atomization)	<b>Higher</b> (Atomization)	<b>Stable</b> (Technological flatness)	<b>Stable</b> (Technological flatness)
Personnel (Operational)		<b>Lower</b> (Atomization & no personnel regulation)	<b>Higher</b> (Technologically advanced systems & Personnel regulation)	<b>Lower</b> (Job scarcity)	<b>Higher</b> (Ageing)
Equipment (Operational)		<b>Higher</b> (Technological advancement)	<b>Lower</b> (Public-private partnerships)	<b>Stable</b> (Technological flatness)	<b>Stable</b> (Technological flatness)

Table 12: UCC Development & Operational Differences.

## Development costs

**Land:** Renting is considered a better option rather than constructing additional infrastructure compared to infrastructural costs. Indeed, numerous authors (Gogas, 2017) emphasize the importance of limiting investments by establishing consolidation centers based on existing transshipment centers. A UCC should be located as close to the edge of the zero-emission zone as possible. Conventional transport is possible from the distribution center to the zero emission zone. Parties involved in logistics who do not have zero emission vehicles are not permitted to enter the zone, but they can deliver goods to the UCC. This distance must be kept to a minimum. The boundaries of the zones in cities must be clearly defined. All shopping and historic districts in cities will be affected. become zero-emission and car-free, with time constraints for larger vehicles, for example. This closeness to the zero-emission zones will be of high importance according to **the first two scenarios**. A business park is a natural location for a UCC. Business parks can accommodate large vehicles and are frequently easily accessible; they are typically located outside of the city or on the outskirts of the city. Residents will be less bothered as a result of this. If possible, the UCC should be located on a quay so that electric ships can supply the city center. **In scenarios 1 and 2**, there might be increased land prices as scarcity increases due to economic prosperity and urbanization. **In scenario 2**, An auction system with tradeable rights limits truck and van trips and local land-use plans guarantee logistics facility locations in industrial zones. The locations are chosen using a positive planning approach that considers key criteria such as accessibility, proximity, and environmental sensitivity, which can be considered by investors in selecting plots for the development of logistical infrastructure.

**Real Estate:** Technological advancements are allowing the rise of narrow, automation systems consolidation centers in cities. Reduced costs, scalable automation solutions enable faster results and turnarounds, and retailers can offer faster delivery options by locating close to consumers. Urban consolidation innovation is expected to accelerate due to its ease of replication and deployment across a system of locations. Mechanization in small, urban storage facilities known as micro-fulfillment centers enables retailers to expand their click-and-collect offering by leveraging a portion of their established retail footprint and supply chains, as well as trying to convert or expand their stores to accommodate urban consolidation centers to accommodate increased customer purchases. This modification of stores for logistical operations affects the business model for UCCs, as retailers could take away revenue for the UCCs by offering their own miniature urban consolidation. It could also be an extension of the business model of a UCC as it gets the delivery from the UCC even closer to the consumer. It could also contribute to a more resilient supply chain as the stores could be another supply chain important in **the third scenario**.

**Building requirements:** Vertical space will become more important as the availability of land drives up prices in urban areas as seen in the **first two scenarios**. As last-mile configurations become more sophisticated, operators will look for infrastructure where they can optimize operational efficiencies. Automation advancements are allowing for more efficient use of vertical space. When particularly in comparison to the big box business, urban logistics facilities have much lower eaves heights, but as m3 volume becomes more important than square footage, there is likely to be a deviation in renting price growth. While forklifts have an operational height limit, automation systems can be integrated into mezzanines (Paddeu, 2018). This is driving up demand for high buildings. Building height limits are often less restrictive in urban areas (when compared to suburban or rural areas), which may drive the adoption and implementation of taller urban logistics facilities, particularly where starting to fall mechanization costs mean better cost-efficiencies for operators. As advances in technology and automation enable operators to make better use of vertical space, and mezzanine floors are installed, the floor loading requirements will increase. Heavy, large-scale automation equipment will have major considerations for floor loading requirements. While the use of autonomous vehicles in the UCCs will have implications for the floor finish and serviceability.

### Operational costs

**Vehicle costs:** The cost of owning a vehicle (such as devaluation and financing), insurance, and vehicle tax are all included in the annual fixed cost. Automated package sorters can cut parcel processing times in half. Due to the rise in e-commerce in **the second scenario**, parcel carriers are facing increased demand for parcel handling, and technological advancements are allowing for accurate checking of parcel dimensions and weight, automated label application, and scanning for verification and routing. Conveyors, IoT technology, and possibly robotics will be used in these systems. Magnetic strips or a track laid in the warehouse are usually followed by these vehicles. Mobile robots create their routes based on data from sensors such as cameras and lasers and will reroute as needed to avoid obstacles. The vehicle costs will go up at first in **the first two scenarios** as technology becomes more advanced. Eventually, the cost of operation of these vehicles will go down due to efficiency gains and obsolescence of human drivers

**Personnel:** The cost of human resources consists of drivers, administrative and clerical personnel, and management of the UCC. Automation can help unlock urban locations where limited and costly labor pools exist. Issues of labor cost and availability are generally more acute in urban areas. Companies must look at ways to enhance their operational efficiencies through the adoption of mechanization and automation and thus reduce their workforce requirements. In the **third scenario**, where there is economic stagnation, the labor pool will be larger due to a high jobless rate and the need for automation will not be as large as in **the first two scenarios**. In **the second scenario**, where more technologically advanced systems require more skilled personnel, salaries will be higher due to less availability of a technically educated labor pool. The difference with **the first scenario** is that in this scenario, market forces dominate thus there will be fewer regulatory constraints on how far atomization will go and even personnel might be obsolete in the operation. The bargaining power of business might be higher, due to this atomization, in salary negotiations and drives down personnel costs.



**Equipment:** A warehouse management system collects valuable, real-time data to assist operators in managing warehousing processes, monitoring efficiency levels, and detecting flaws. Warehouse Management Systems can be used to plan order fulfillment and calculate labor, vehicle, and picking sequence requirements. Having orders arrive at the shipping dock in trailer load sequence, will reduce the need for dock staging space and allow for faster, more efficient throughput. Sensors can be used to track goods at all stages of the supply chain, as well as to ensure that the proper storage conditions are used, both in the warehouse and inside trucks. Inventory data can be collected using RFID tags or sensors, then stored on a cloud-based platform. Advances in these systems are allowing them to be installed in consolidation centers, and as the technology advances, UCC operators will be able to use higher levels of automation, lowering per-unit labor costs. Cost increases in logistics are difficult to sell because many customers see logistics as a cost item rather than an extension of their offering, and because the sector's margins are small. However, **in the second scenario** in densely populated cities, the UCC may be viewed as a service provider for further city growth and quality of life, rather than a commercial option. However, this is an added value that is difficult to quantify financially.

UCCs in the early stages would require external assistance due to the need for a minimum throughput to ensure the financial viability of these schemes with subsidies or investments from the private sector. On the one hand, optimal resource utilisation in the operational phase necessitates a very precise estimation of UCC demand and, on the other hand, some resource utilisation flexibility. Indeed, UCC operations will only be profitable if the resources can closely track potential demand variations. To some extent, a variable cost policy, such as lease plans for vehicles, equipment, and infrastructure, can help with this. A company must know how to realize and capitalize on benefits and cost savings for its customers and drivers. Public-private collaboration is a viable entry point. The optimal strategy of municipalities is to partially fund the system during its investment phase and create an access limitation policy that supports the formation of a UCC without prohibiting the other operators. To ensure the balance of operating expenses by the advantages of the service, it is crucial to request the UCC operator establish a solid business model and effective operational management follow-up.

As last-mile formats become increasingly specialized, operators will seek facilities in which they can maximize their operational efficiencies. The risk of obsolescence for older buildings will increase, though strong land value growth and demand for logistics space are likely to support robust rental growth, in urban locations over the next five years. When consolidating from a hub, extra costs incurred for work-related activities on the hub are compensated for by the efficiency gains obtained by the city moving forward with condensed and light transportation that moves quickly in the busy streets. The UCC must provide value to the shipper and the carrier.

The implications for the future of urban consolidation centres, based on the different scenarios aid comprehension and give a robust look into the future of urban logistics, and assist CBRE Investment Management in deciding on a course of action.

#### Investors Recommendations

- A UCC should be located as close to the edge of the zero-emission zone as possible. Conventional transport is possible from the distribution center to the zero-emission zone. It is critical that the boundaries of the zones in cities be clearly defined. A business park is a natural location for a UCC.
- Technological advancements are allowing the rise of narrow, automation systems consolidation centers in cities. Reduced costs, scalable automation solutions enable faster results and turnarounds, and retailers can offer faster delivery options by locating close to consumers.
- Floor loading requirements will increase. Heavy, large-scale automation equipment will have major considerations for floor loading requirements.
- To ensure the balance of operating expenses by the advantages of the service, it is crucial to request the UCC operator to establish a solid business model and effective operational management follow-up.
- Parking spaces that can accommodate smaller vehicles, such as cargo bikes and delivery vans and an adequate infrastructure and capacity for electric vehicle charging.
- Request that your carrier deliver zero emissions to the recipient and discuss the associated expenses and calculate the costs of purchasing transportation both with and without a UCC and inform your customers about the city's and your transportation's effects on the environment.

# 8

## Conclusion

- 8.1 Conclusions
- 8.2 Recommendations for Further Research & Limitations
- 8.3 Company Background Information



# 8. Conclusions

This thesis will focus on the future of urban logistics in large cities. It will provide a generalized vision for policymakers, businesses and investors based on long term societal, economic & environmental trends and new distribution methods & supply chain organizations. The study's final deliverable is a future vision of the different forms of urban logistics organizations with different delivery methods under different scenarios and its implications for policymakers, businesses and investors under different scenarios. Different scenarios provide a platform for the logistics industry and policymakers to analyze various measures and strategies to mitigate external developments and explore the future of urban logistics in the face of uncertainty.

With the help of an expert panel, four distinct scenarios for exploring the future of urban logistics were developed. The four scenarios giving an overview of the future of urban logistics and the organization of the inner city supply chain in 2040, based on ranked trends. These scenarios should assist scientists and policymakers in imagining future developments, exploring relevant uncertainties, and studying the implications for their merit. The main implications in different scenarios regarding economic, environmental and societal aspects are presented for policymakers, logistical businesses and investors. Overall, this yielded intriguing results and motivated further research.

## 8.1 Conclusion

In 8.1 Conclusion, the sub-questions and central research question will be addressed. Reflections and recommendations for future research will be made in paragraph 8.2.

The central research question in this thesis is: ***What could be the future of urban logistics in 2040 in large cities & what could be the implications for municipalities, logistics companies & investors in different scenarios?***

This question is divided into sub-questions, which will be addressed individually before the core research question is answered at the end of this paragraph.

### 1. What are the stakeholders involved in the urban freight transportation system and their interdependencies?

The identified stakeholders with their objectives and interdependencies provide boundaries for the urban logistics system and provide input for the scenario analysis in which certain long-term trends influence certain stakeholders on decision making, objectives and goals affecting the organization of the city supply chain. The identified stakeholders with their objectives and relations will aid in forming recommendations for the municipalities, logistical companies and investors based on the different scenario outcomes.

In this study, urban logistics is defined as transporting freight along the last part of the supply chain from the distribution center or retailer to the consumer's address within densely populated urban environments. The final leg of delivery from business to customers. Based on the literature, six actors are considered in the urban logistics system: carriers, shippers, residents, retailers, municipalities and investors. Residents are interested in city logistics, but they have few ways to influence decision-making or the system.

Municipalities indirectly represent the interests of residents, while retailers represent the needs of customers. Municipalities, logistical businesses and investors have the most influence and vested interest in changing city logistics. Cities copy each other's freight regulations rather than sharing their experiences. Multiple stakeholders are willing to change; however, expectations on initiatives are not clear to each other, and the duties for urban freight are transferred to other parties because the interests of the several parties involved in the issue are not clearly understood, nor do they feel accountable for its resolution. Different stakeholders have different interdependencies and objectives and conflicts

between them are unavoidable. Conflicts occur when people, planners, and regulators decide that externalities caused by urban freight distribution on local communities for ongoing or proposed projects are no longer acceptable. Sometimes disagreements over particular concerns occur between locals and planners, evoking traditional NIMBY reactions. Officials predict that private stakeholders would create long-term operations to suit customers' and merchants' rising needs. At the same time, businesses anticipate government-led and subsidized controls on such operations. Changes in the behavior of logistic stakeholders are slow as a result of their awaiting and passive attitudes. The idea of city logistics allows for the implementation of several plans while also taking into account the fact that each stakeholder has unique goals and viewpoints. Asymmetries of power and unclarity of who is responsible for drafting urban freight strategies could create path dependency and lock-ins.

The above-mentioned problems can be solved by the involved stakeholders defining their well-considered urban logistics strategy aided by creating insights, implications and future visions of the city logistics landscape for different stakeholders.

## 2. Which of the future delivery methods & uncertainties in city logistics are relevant for the exploratory scenario analysis?

During an expert workshop and from the system analysis, key factors and driving forces related to this question were identified and assessed to answer this question. It will aid in understanding the relationships and effects of urban logistics elements because external factors & driving forces are used to design scenarios. According to the expert panel, **the development of technological advancement and the regulatory & policy environment** are critical uncertainties that drive the potential impact into four outcomes.

First, it is clear that technological and economic developments have had an impact on urban freight and are in charge of a growing scale of consumption and production. Several patterns have emerged and have demonstrated that urban freight is constantly growing and that a sizable share of carbon dioxide emissions, which are expanding more quickly than emissions from passenger vehicles, are generated by the entire freight business. Globalization has resulted in more products circulating the world due to fragmented spatial locations for production, distribution, and consumption which influences the city supply chain organization. At the same time, cities are becoming more crowded as a result of urbanization. More people in a limited amount of space is a result of urbanization, which puts a strain on supply and delivery. As a consequence, the volume of cargo traveling through cities is predicted to dramatically expand. Customers desire thorough, just-in-time, and reliable delivery, and it must be effective to make urban freight activities tidy, secure, and less noticeable while preventing traffic congestion. The number of vehicles and vehicle kilometers traveling through cities is rapidly increasing, resulting in congested city streets. Cities must deal with an increasing number of negative externalities as a result of this. The combination of all of these identified external factors and driving forces contributes to a clear vision of the future of urban freight.

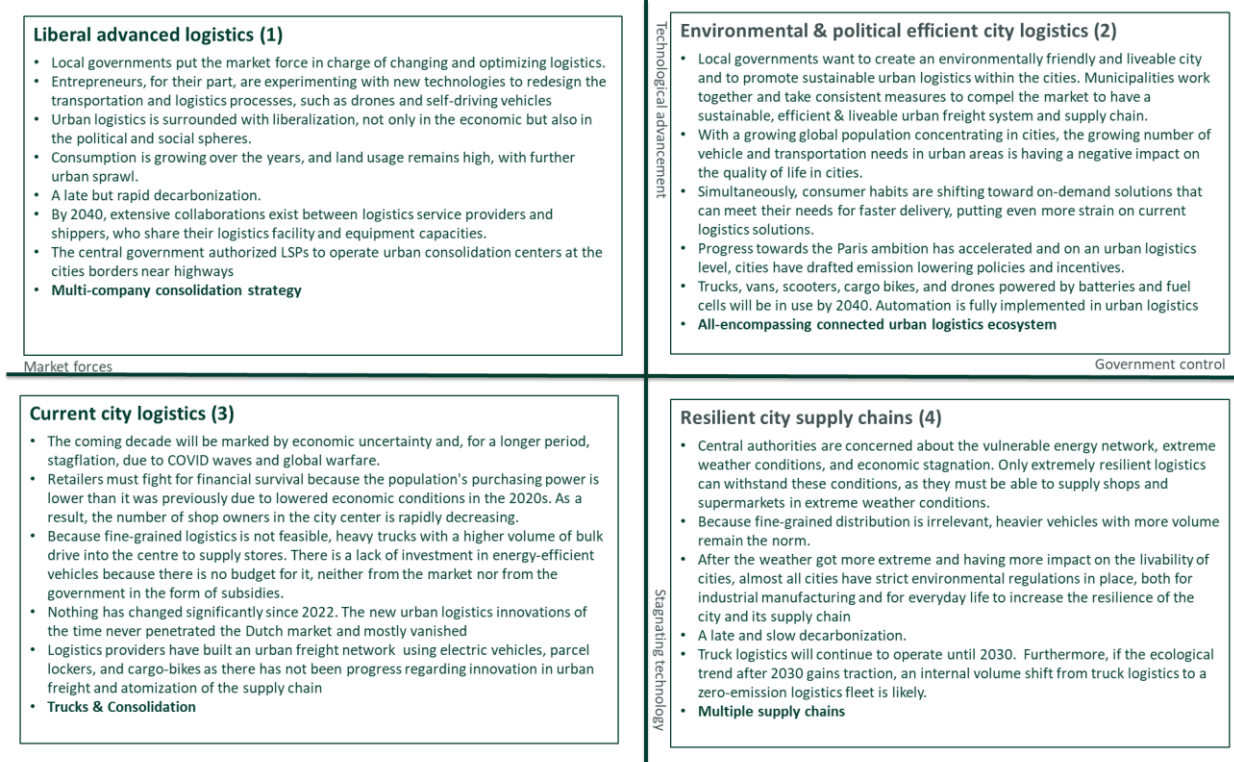
One key driving force is technological innovation within the city logistics system and more importantly, the development of new & innovative freight delivery methods. The distribution innovations have had a considerable impact and rising uncertainty on the conventional structure of the urban freight network in terms of long-term planning and for a large part determining the future city supply chain organization. Therefore, city distribution innovations in different phases of application and research and the uncertain development of these innovations have been identified in the literature review and analyzed in the different supply chain organizations in the scenarios.

The use of **autonomous vehicles** in urban freight transportation is currently in the theoretical research stage. Looking back on transportation history, the last-mile delivery problem is a hard and complex issue to solve. A **drone parcel delivery** in the Netherlands could be essential to tackle this problem. The **delivery robot** is a new freight technology that reduces traffic congestion and labour costs. **Electric vehicles** are a significant innovation in urban freight transportation. This innovation has a high potential for addressing urban environmental, social, and economic impacts. **Cargo bikes** are in the same stage of development as electric vehicles. **Modular vehicles** are a type of vehicle that transports goods to consumers by transporting one or more cabin modules. **The use of ships to transport goods** to transit points via a city's inland waterway

is referred to as urban waterway logistics. **Urban consolidation centers** have the main objective of easing the switch from heavy trucks to zero-emission vehicles such as cargo bikes, light electric trucks, and zero-emission trucks.

### 3. What are possible scenarios of city logistics in the Netherlands?

The four following scenarios have been developed based on the information gathered in the system, stakeholder & GE analysis, and the 14 logistical expert workshops. **Scenario 1** is concerned with city logistics in a technologically advanced urban logistics system and, more importantly, a market that must meet the city's high standards. The difference between scenario 2 and scenario 1 is that in **scenario 2**, the government is actively intervening through the adoption of measurements and facilitating platforms. **Scenario 3** considers a future in which the current city logistics organization is still in place in 2040. There are more pressing issues to address than using cutting-edge distribution methods, but a technological advancement in the organization of the urban freight supply chain is driven by market forces. **The 4<sup>th</sup> scenario** deals with an environment where urban freight is still delivered by trucks with high emission levels. External events force the government to focus on drafting regulations and policies for the urban logistics system.



### 4. What are the implications of these scenarios for the urban logistics system and its stakeholders?

To answer this sub-question, the main implications for policymakers, logistical businesses and investors based on the different scenarios regarding environmental, societal and economic aspects have been presented. As a result, recommendations for the stakeholders are presented based on the developed scenarios and implications for large cities.

#### Policymakers

Cities can serve as real-time laboratories, accelerating learning and innovation through city platforms. If a city establishes low-emission zones and invests in parking lots with charging infrastructure, the transition to electric vehicles will be accelerated. Consistency between the municipalities on regulation and public-private partnerships is needed to be considered in the development of the urban logistics system. The policymakers could draft policies for working together with investors and logistical companies for developing and operating urban consolidation centers (UCCs). The municipality

could work with investors in developing the logistical infrastructure via tender procedures if they have sufficient land available. Certain demands regarding sustainability and liveability from the local government can be tender criteria when selecting investors. If the federal government and local governments loosely organize urban logistics, this could have negative consequences when cities grow in size owing to urbanization. Municipalities should impose constraints on what level of complexity the urban supply chain could reach until it is at the expense of efficiency of the urban supply chain in this scenario due to economic headwinds and high urbanization. The municipality could stimulate the implementation of car-sharing, bike-sharing and increasing the use of electric vehicles. More sustainable policies require a socio-technical solution rather than a purely technological approach which calls for collaboration between public and private actors. The impact of urban freight movements is reduced by replacing passenger vehicle travel with goods delivery routing schemes using smaller and electric vehicles. When technology advancement stagnates, the municipality should start stimulating electric vehicle usage for businesses and consumers and not let it to the market. It is important for municipalities in the large cities in the Netherlands for national alignment with these constraints and regulations.

It is important for municipalities in the large cities in the Netherlands for national alignment in these constraints and regulations as otherwise there might be discrepancies between cities which would result in a distorted urban logistics market mechanism. This could establish more clarity on who has what responsibilities in the urban logistics system and overcome lock-ins. The government must provide financial incentives for businesses to make the necessary investments in green freight. City governments must take the initiative because investors are risk-averse and seek to reduce default risks. The approach that uses an authority's portion contribution as a subsidy is the most popular. Cities with plots of land in and around the city in ownership could be offered for lease to real estate investors for the development of urban consolidation centers. Based on these scenario implications, several recommendations have been made for municipalities.

### **Logistical businesses**

Logistical businesses using Intelligent planning and real-time optimization of operations are enabled by IoT technology in logistics, such as detecting vehicles, global positioning, and device tools. Digital supply chains could provide interconnected logistics operations, smart warehousing, and advanced information analysis tools to efficiently manage entire supply chains. Delivery trucks are more cost-effective when the delivery area is large and the delivery volume per stop is high. In urban areas, delivery drones do have the potential to make the shift from pickup truck delivery of products to drone-based delivery. Adoption of smart technologies and more autonomous delivery may result in labour force reduction. In cities with ongoing urbanization, more pedestrian space appears to be the desired outcome in this regard. E-vehicles can be outfitted with a delivery drone to transport goods to high-rise commercial areas. Parcel lockers can accept packages from delivery drones and robots. The future of urban logistics will be dominated by connected, shared, autonomous, and electric solutions. Urban logistics operators can harness this data and technology to improve their operations. Multi-company consolidation strategies could contribute to a multi-model scenario that reduces emissions and congestion.

### **Investors**

The urban logistics sector as a whole will account for more and more of real estate investment volumes in the future. As seen in the supply chain organization of multiple scenarios, urban consolidation plays an important role. Investment in urban consolidation should contribute to city accessibility and an efficient supply chain. The role of investors would be mainly related to logistical infrastructure such as urban consolidation centers (UCCs). Logistical city hubs are expected to have a required size of 5,000 to 10,000 m<sup>2</sup>. The UCC is designed as a multimodal transshipment point where various logistics parties can store and transship their goods. A UCC should be located as close to the edge of the zero-emission zone as possible. Conventional transport is possible from the distribution center to the zero emission zone. Parties involved in logistics who do not have zero emission vehicles are not permitted to enter the zone, but they can deliver goods to the UCC. Residents will be less bothered as a result of this. Technological advancements are allowing the rise of narrow, automation systems consolidation centers (UCCs) in cities. Urban consolidation innovation is expected to accelerate due to its ease of replication and deployment across a system of locations. Micro-fulfillment centers enable retailers to expand their click-and-collect offering by leveraging a portion of their established retail footprint and supply chains, as well as converting or expanding their stores to accommodate urban consolidation centers. This modification of stores for logistical operations affects the business model for UCCs. UCCs in the early stages would require external assistance due to the need for a minimum throughput to ensure the financial viability of these schemes. Public-private collaboration is a viable entry point. The optimal strategy of municipalities is to partially fund the system during its investment phase.

The primary research question is addressed in the final step by applying scenario analysis to look into the future of urban logistics: ***What could be the future of urban logistics in 2040 in large cities & what could be the implications for municipalities, logistics companies & investors in different scenarios?***

To conclude and answer the main research question, the development of innovative urban distribution methods and identified driving forces can have a substantial impact on the future urban logistics system. Developing scenarios is a good first step toward getting a clearer vision of the future of city logistics by exploring different driving forces and new forms of transportation with exploratory scenarios. This benefits a wide range of stakeholders. Different scenarios provide a platform for the logistics industry and policymakers to analyze various measures and strategies to mitigate external developments and explore the future of urban logistics in the face of uncertainty. To investigate the uncertainties and determine the different possible futures of urban logistics in 2040 with different city supply chains, a scenario analysis was conducted.

With the help of an expert panel, four distinct scenarios for exploring the future of urban logistics were developed. The four scenarios giving an overview of the future of urban logistics and the organization of the inner city supply chain in 2040, based on ranked trends. According to the scenario analysis, the **development of technological advancement and the policy & regulatory environment** are critical uncertainties that drive the impact into four outcomes.

The developed vision 2040 for urban logistics has shown significant changes regarding the use of technologies and infrastructure, the design of services and delivery concepts, market organization and cooperation, planning and regulation, and finally to a certain extent also behavior. The technological advancement in **scenarios 1 & 2** causes a wide diversity of innovative urban distribution methods to be used in a complex city supply chain. When the municipalities start to regulate and draft policies affecting the organization of city logistics (**Scenario 2**), an urban logistics ecosystem is created in the city in which the various logistics players are all interconnected. The system is regulated in a way that city authorities will create a space for urban logistics and grant access to selected companies that meet certain criteria. Public-private partnerships operate these platforms and offer bundled last mile services using a tender procedure.

In **scenario 1**, Unmanned vehicles, robots, and UAVs could be widely used to provide urban freight services in the near future due to high technological advancement. This could open up possibilities for integrating digitization and intelligent systems across logistics industries, including freight. The complex challenges of urban logistics cannot be solved solely through technology. The management aspect of the inner city supply chain design should be well integrated, which comes forward in the all-encompassing urban logistics ecosystem in **scenario 2** where municipalities offer tenders for the inner city supply chain to logistical businesses. Variables that influence the cost-effectiveness of urban logistics processes include city characteristics and final receiver attributes and the adoption of smart technologies and more autonomous delivery may result in labor force reduction. Also, autonomous delivery and EVs may not even require human delivery personnel in the future and results in a more cost-effective supply chain, but could lead to job losses, which could be a reason for governmental intervention. Even in scenario 1 where autonomous delivery flourishes under technological progress with little government intervention, negative economic consequences require the government to step in.

Global warfare, pandemics, and economic recessions in **scenario 3** in combination with no changes from 2022. The new urban logistics innovations of the time never penetrated the Dutch market and mostly vanished, and the supply chains of different companies remain separate with little exchange and thus fewer efficiency gains. In this scenario, logistical businesses currently lack a comprehensive consideration of urban spatial development to develop a long-term urban logistics strategy. In the long run, these approaches may stifle further promotion of sustainable urban logistics. As a result, using short-term solutions within the traditional system results in an inflexible transformation of urban logistics.

Governments' top priorities are vulnerabilities in critical infrastructure and creating a resilient and robust city supply chain. Central authorities are concerned about the vulnerable energy network and extreme weather conditions in **scenario 4**. Multimodal and sustainable transportation systems are the foundation for resilient freight mobility. Infrastructure, logistics, and network/traffic management, in particular, play a significant role in making urban logistics climate neutral. At the same time, because these three areas are vulnerable to climate change and other disruptions, resilience will be increased by developing multiple supply chain options in the cities.

All in all, eventually in 2040, we will not be worse off in terms of CO<sub>2</sub> emissions than in the current scenario as climate change will pressure us to increase regulation, even in **scenarios 1 & 3** where market forces dominate. **Scenario 2** might be the best future outcome for increasing the city's liveability but less good for logistical businesses due to heavy regulation in the urban logistics system. A strong government is needed in combination with investments in logistics R&D to have technological progress, would this be the preferred future outcome. **Scenario 4** might be the worst for businesses due to increased cost and economic headwinds and city inhabitants due to reduced living conditions caused by extreme weather. This scenario could be averted if there would be a drastic reduction in emissions to stop climate change.

Implications and recommendations for policymakers, logistical businesses, and investors based on the different scenario outlooks were that consistency between the municipalities on regulation and public-private partnerships needed to be considered in the development of the urban logistics system. This could establish more clarity on who has what responsibilities in the urban logistics system and overcome lock-ins. It is important for municipalities in the large cities in the Netherlands for national alignment in these constraints and regulations as otherwise there might be discrepancies between cities which would result in a distorted urban logistics market mechanism. Tax breaks and other incentivizing the integration of infrastructure, equipment, or demand-driven levers could help reduce pollution and greenhouse gases in cities. In the future, time constraints can also be used by city planners to regulate freight traffic. For development, cities with plots of land in and around the city in ownership could be offered for lease to real-estate investors. Cities with fewer free plots available could work with investors by financing part of the acquisition costs for municipalities wanting to oversee the city supply chain and own the logistical infrastructure.

Furthermore, connected cars, GPS navigation, smart cards and congestion and freight management systems can be used to improve urban freight distribution. Logistics companies and municipal governments can use the provisions of these maps and systems to go further than multimodality and into synchromodality. Investors are risk-averse and want to lower the danger of default, thus city governments must take the initiative in financing urban logistics infrastructures or low-emission vehicle research & development. Cities that hold land parcels in and around the city may rent those parcels out to real estate developers for the construction of urban consolidation hubs. Future real estate investment volume will be more accounted for by the urban logistics industry. Investments in urban consolidation should improve supply chain efficiency and city accessibility. Investors' major responsibilities would revolve around logistics infrastructure like urban consolidation centers.

To sum up and respond to the main research topic, the use of novel urban distribution techniques and economic, societal & environmental driving forces can both significantly affect the future urban logistics system. Creating scenarios is a useful initial step in investigating various driving factors and novel types of transportation to gain a greater understanding of the future of city logistics. This is advantageous to many different parties. The logistics sector, policymakers and investors can study different methods and strategies to temper outside developments on various scenarios, and they can also explore the uncertain future of urban logistics.



## 8.2 Recommendations for Further Research & Limitations

The findings of this thesis can be applied in both practice and research. The identified implications & recommendations may be useful to those formulating policies for the city supply chain organization. The effects of the scenarios on urban logistics also reveal which driving forces have different impacts on the city and its supply chain network. Furthermore, policymakers, logistical businesses and investors may find inspiration in the suggested (investment) policy measures. However, there are certain limitations to the study presented in this thesis. Due to the exploratory nature of the approach used and the novelty of the issue, the research findings are subject to significant uncertainty. The limits and recommendations for future study will be presented in the following subchapter to wrap up this thesis.

### Scientific Relevance & Gap Contribution

Many researchers agree on the fact that the future of city logistics is influenced by different factors: from new delivery methods to changing city architecture and climate change. Current research mainly focuses on the future of specific distribution innovations or specific factors influencing city logistics. In comparison to other research, multiple factors and innovative urban freight methods influencing the future of urban logistics have been taken into consideration in a scenario analysis in this thesis. This thesis seeks to integrate them with a socio-technical view, whereas earlier studies exclusively concentrated on the social or technological components. Next, this thesis establishes a framework for driving forces and key factors. An exhaustive overview hasn't been provided in prior publications. This thesis approaches the research gap to apply a scenario analysis method to this uncertain future of city logistics to be able to analyze the implications of societal, economic and environmental factors and disruptive freight innovations on the urban logistics system. Different scenarios provide a platform for the logistics industry and policymakers to analyze various measures and strategies based on the scenario outcomes to mitigate external developments and explore the future of urban logistics in the face of uncertainty. This research contributes to this by providing a view into the future in which long-term trends & forms of freight transportation affect the urban logistics system over time in combination with the implications for municipalities, logistics companies & investors in certain scenarios.

### Scenario Analysis Method

Scenarios can aid decision-making in this challenging environment by bringing potential long-term implications to life, making them more likely to spur action. Two aspects of the scenario are very crucial. First, scenarios include narrative arcs that engage people's imaginations and help them imagine what the future may hold. Such involvement helps to drive near-term actions that can help to avert negative outcomes and bring about desired outcomes. Second, scenarios imply plausibility rather than certainty. Scenarios, on the other hand, can have substantial flaws in terms of educating and encouraging action. The finest scenarios are limited in number, as more than a few will be perplexing. However, condensing the huge range of possible futures into three or four scenarios can be difficult. The decision may appear arbitrary, especially to those whose interests are jeopardized by the scenarios' consequences. Furthermore, a limited number of scenarios may overlook what may turn out to be the most significant and unexpected. These issues can be best addressed by describing scenarios as vulnerabilities of proposed policies, or groupings of future situations of the world in which a policy will fail to achieve its objectives.

### Quantify the key factors with weights

The framework for substitution created in this thesis aids in comprehending the potential influence of different societal, economic, technological or environmental driving forces on urban logistics. Although the many components have been elaborated, no importance weighting has been ascribed to them. As a result, policymakers may be forced to pay attention to unimportant factors. As mentioned, 14 experts from different disciplines have partaken in this research and their insights are given. In the future, it may be interesting to look at what certain experts from specific disciplines assign weights to certain key factors and how that differs from other disciplines. How does the viewpoint of the future of urban logistics differ between logistical businesses and the academic world. Studying the weight and intricacies of different expert groups would be a recommendation. A choice experiment could be a good way to go about it, and the key factors presented in Chapter 5 of this thesis can help with that.



### **Quantification of the scenarios**

Urban freight is a quantitative system, it is primarily considered mathematically. Based on specific operational logistic assumptions, the result is now a more qualitative and exploratory look at this fairly mathematical topic. The outcomes of this thesis could have been more illustrative and useful to policymakers if they had been quantified. As a result, it is proposed that the possibilities be quantified for policymakers to use them in cost-benefit studies for policy analysis, for logistical businesses to get insight into the probabilities will be per scenario will be for vehicle investments, and for real estate developers for having a quantified result in what an urban consolidation center could cost in specific scenarios. The ranked driving forces can be assessed on having certain probabilities of influencing the urban logistics system and the innovative distribution methods can also have probabilities of implementation. This way, a computer model or simulation could calculate the exact probability for which scenarios might be true in the future.

### **City differences**

The research we have conducted focuses on the future of urban logistics in large cities with 500.000 + inhabitants, which resulted in four different scenarios of the future of urban logistics with different city supply chains based on different ranked trends and expert input. A limitation of our results is the fact that this research is focused on large cities in general which, in comparison with other cities, do not show a high level of specificity. Therefore, it is worth extending our analyses to other smaller cities with different levels of city architecture and long-term trends affecting the future of urban logistics. This direction of further research will be enabled by the universal research methodology. A comparative case study between cities of different scales might be a recommendation for further research.

### **Quality of the experts**

To create the scenarios in this thesis, the intuitive logic method was used. The knowledge and commitment of specialists participating in the scenario workshop are critical to the method's value. 14 experts participated in the workshops and interviews. They came from the logistical industry, academics, and the government. At first, it was the idea to invite all the experts to one workshop where they all came together. It was not feasible to bring them altogether due to COVID-19 regulations and the experts are executives at large companies or highly regarded researchers and all have a busy schedule. Therefore it was decided to organize several individual workshops with experts and this way interaction between the different experts was missing. Eventually having feedback on the scenarios in smaller groups overcame this drawback but it was better to have all the experts together to drive informative insights and challenge them with their different perspectives. This will give the scenarios and their implications and recommendations greater weight. Adding more experts, would require having more scenario development workshops but would not have a real impact on the scenario analysis method used in this thesis.

### **Scenario implication validations**

The thesis author has logically deduced the effects of the studied scenarios on urban logistics. It would have been good for the quality and scientific weight of this thesis to ask specialists with a more specialist background in specific distribution methods, such as drones or autonomous vehicles. As a result, this is suggested for future research. These experts could provide more information and certainty on which distribution method in which scenario would be used and better options. The distribution methods have been analyzed with a GE analysis and on scientific and grey literature, adding experts for certain distribution methods would provide more detailed insights and certainty for the different urban supply chains in the different scenarios.

### **Stakeholder analysis**

Shippers, carriers, retailers, city centers, municipalities and investors are the six primary stakeholders in this study. The identified stakeholders with their objectives and interdependencies provide boundaries for the urban logistics system and provide input for the scenario analysis in which certain long-term trends influence certain stakeholders on decision making, objectives and goals affecting the organization of the city supply chain. Next to that, the different futures for urban logistics,

developed using scenario analysis, will help induce collaboration and counter passive behavior between the public and private sectors, by alignment of the stakeholder interdependencies and objectives. Because customers are represented by retailers and residents are represented by municipalities, consumers and residents are not explicitly considered. Due to their ability to affect the sector, including these two stakeholder groups will bring unique information into these two stakeholder groups. Stakeholder analysis may have been augmented with surveys to verify and help determine the unique exchanges and replies to numerous comments, as stakeholders' behavior is the most essential driver. This stakeholder analysis could be improved if the stakeholder objectives were explained in more detail. This way, it will be easier to identify the stakeholders' drivers. Also, it will be easier to identify what will be necessary to get all stakeholders on board.

## 8.3 Company Background Information

CBRE Investment Management is a global real assets investment management firm with \$146.8 billion in assets under management\* as of June 30, 2022. The firm sponsors investment programs across the risk/return spectrum for investors worldwide. CBRE Investment Management is an independently operated affiliate of CBRE Group, Inc. (NYSE:CBRE). It harnesses the research, investment sourcing and other resources of the world's largest commercial real estate services and investment firm (based on 2020 revenue) for the benefit of its investors. CBRE Group, Inc. has more than 100,000 employees serving clients in more than 100 countries. For more information about CBRE Global Investors, please visit [www.cbreglobalinvestors.com](http://www.cbreglobalinvestors.com)

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