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The impact of emerging technologies on efficiency and sustainability in last mile home deliveries - An exploratory study of e-commerce home deliveries in Norway

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BI Norwegian Business School

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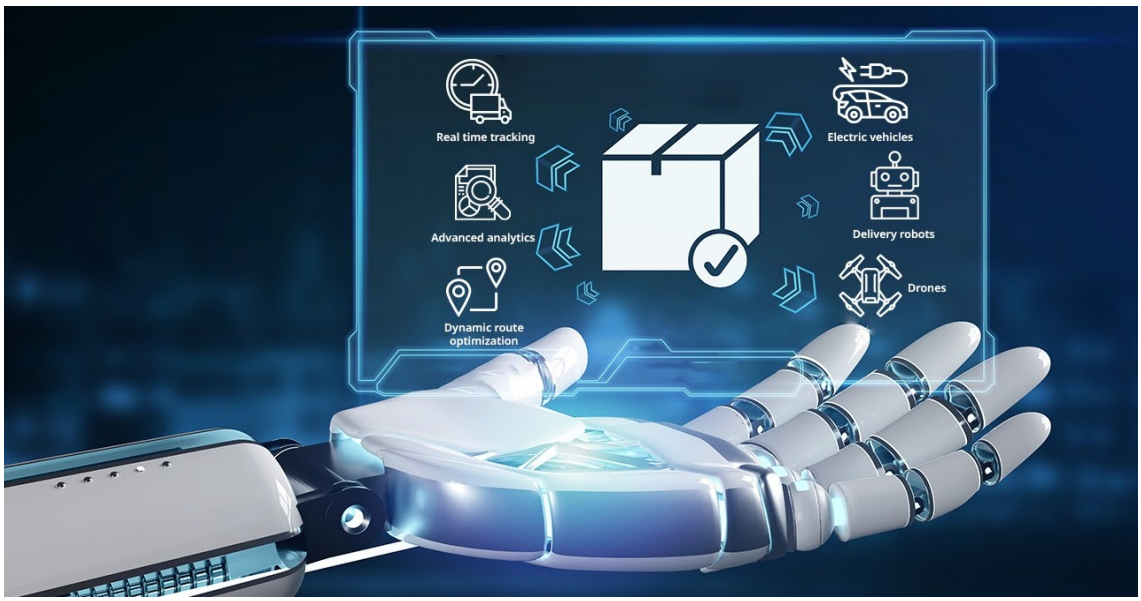

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ABSTRACT

Last mile logistics is considered to be the least efficient part of the home delivery process and has the most pressing sustainability concerns. The rise of e-commerce and the growing trend of online shopping has made this a key challenge in e-commerce and logistics. There is great potential for emerging technologies to increase the efficiency and to improve the sustainability in home deliveries.

The purpose of this research is to explore the impact of emerging technologies on efficiency and sustainability in last mile home deliveries. Additionally, this thesis aims to highlight challenges and barriers for the implementation and adoption of these technologies. Hence, the research question of this study is: *"How can emerging technologies increase efficiency and sustainability in last mile home deliveries?"*. To fully understand the implications, the authors found the following sub-question to be relevant: *"What are the barriers hindering a successful implementation of emerging technologies?"*.

An exploratory study in the form of systematic combining was conducted to answer the research questions. After reviewing the literature, the authors conducted semi-structured interviews with experts within logistics, and experts within emerging technologies. On the basis of expert interviews and the literature, four hypotheses were formed in relation to the research questions. As a final step in the data collection process, these hypotheses were discussed and assessed with insights from industry practitioners.

The thesis presents a systematic overview of the relations between selected emerging technologies and relevant performance indicators within efficiency and sustainability. The thesis uses the definition of efficiency as cost efficiency and service level, while sustainability is measured in the three pillars of the triple bottom line; *people*, *planet*, and *profits*. The findings show that emerging technologies can increase the overall efficiency and improve the overall sustainability in last mile home deliveries. A systematic overview of the barriers for implementing emerging technologies is also presented. The barriers are categorized as *political*, *economic*, *socio-cultural*, *technological*, *environmental*, and *legal*.

ACKNOWLEDGEMENT

The submission of our Master thesis marks the finale of five years of higher education at BI Norwegian Business School. The process of writing this master thesis has been very educational, exciting and challenging. The writing process was especially challenging due to the COVID-19 pandemic. However, this thesis became a reality with the kind support and help of many individuals, and we would like to extend our sincere gratitude to them all.

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Last but not least, we would like to thank our families for their continuous love, patience, and for being our biggest supporters throughout our study period at BI Business School. We are forever grateful!

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LIST OF ABBREVIATIONS

1G	First generation of mobile communications; analog systems
2G	Second generation of mobile communications; digital systems
3G	Third generation of mobile communications; multimedia-capable systems
4G	Fourth generation of mobile communications; enhanced multimedia systems
5G	Fifth generation of mobile communications; systems suitable for connected society
AI	Artificial intelligence
AR	Augmented reality
VR	Virtual reality
IoT	Internet of Things
SCM	Supply chain management
EØS	European Economic Area
AHD	Attended home delivery
RB	Reception boxes
CDP	Collection and delivery points
LSP	Logistics service provider
AHD	Attended home delivery
RB	Reception boxes
CDP	Collection and delivery point
COVID-19	Coronavirus disease of 2019
B2B	Business to business
B2C	Business to consumer
E-commerce	electronic commerce
3PL	Third party logistics service provider
TBL	Triple bottom line
EU	European Union

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1 INTRODUCTION

1.1 Background for the thesis

Surviving and thriving in the highly competitive landscape of consumer retail is not easy. A change in consumer demand and behavior has put immense pressure on traditional brick-and-mortar retailers who formerly relied on in-store shoppers as their primary source of business (Chopra, 2016). Over the past 10 years pure-play online retailers such as Amazon and Ocado have set the new standard for shopping with just a few clicks and a quick delivery right to the customer's doorstep (Lim & Winkenbach, 2019). In 2007 Amazon launched their Prime membership program and experienced huge growth in sales. As Amazon originally relied on third party logistic service providers, the expected delivery time was unreliable and could be up to 14 days. The Prime membership program involved an annual fee, and a guaranteed delivery within two business days. The delivery time was later reduced to same day delivery for millions of items in many American cities (*Amazon Prime*, 2018; Føyen, 2019).

The global retail e-commerce sales have grown from 1.34 trillion in 2014 to 4.28 trillion in 2020. Further growth is expected, as experts predict sales of 6.39 trillion by 2024, amounting for almost 22% of total retail sales (Cramer-Flood, 2021). Traditional businesses with physical stores have been forced to catch up with this trend, often by adapting omni-channel retail models which integrate their physical stores with online fulfillment operations (Chopra, 2016). However, providing this kind of convenience comes with a cost to supply chain efficiency. The research paper by Tetteh and Xu (2014) revealed a major challenge for omni-channel solutions to be the complexity of dealing with both bulk shipping to stores and last mile deliveries to consumers as seen in *Figure 1*. Major players in the retail market have centralized distribution centers strategically placed to ensure the efficiency of their primary business models. These locations are often not viable when it comes to last mile logistics, as it is the most complex and costly part of the entire supply chain (Joerss et al., 2016).

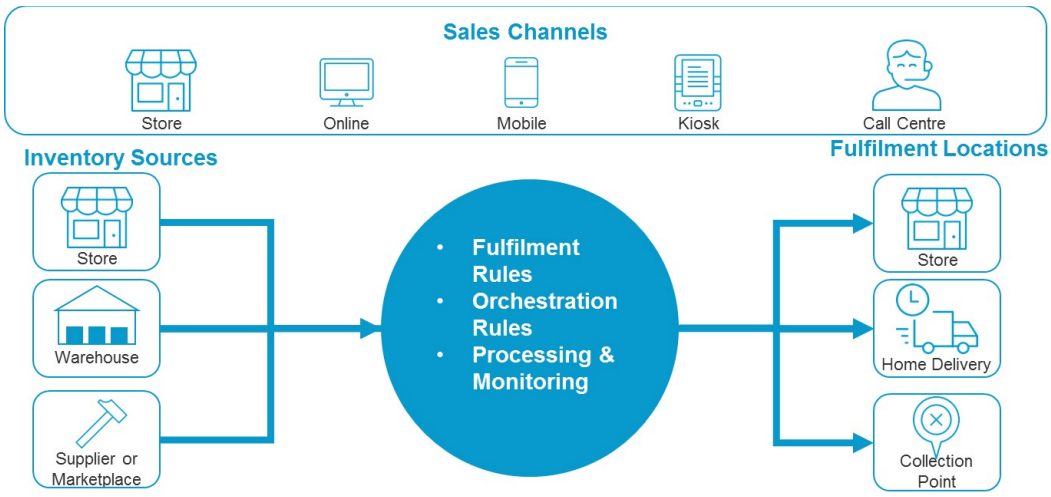

Figure 1: Illustration of an omni channel distribution process (Nguyen, 2018)

Last mile delivery is considered to be the most critical logistic process as it refers to the "last stretch" of the order fulfilment; from the distribution center to the final consumers doorstep (S. Lim et al., 2018; Mangiaracina et al., 2019). Currently this step is considered to be the least efficient and most expensive part of the delivery process with the most pressing environmental concerns (S. Lim et al., 2018). The cost of last mile logistics often exceeds 50 percent of the total supply chain cost, making it a key process for those seeking to gain a competitive advantage (Joerss et al., 2016). Retailers that want to compete in this highly complex marketplace are facing a brand-new set of challenges as they need to carefully consider their last mile supply network.

Norway is experiencing a shift in consumer behavior as well, where the growth has been significant. PostNord has recently made an extensive e-commerce report on consumer behaviour which reveals that the COVID-19 pandemic has further accelerated the e-commerce growth and possibly caused lasting changes in consumer behavior even after the pandemic (PostNord AS, 2021). Retail e-commerce sales grew by 37% from 2019-2020, amounting for almost 15% of total retail sales (PostNord AS, 2020b). These market changes have caused major retailers in Norway such as *Gresvig Retail AS*, *Enklere Liv Retail AS* and *Wagno AS* to shut down over 300 physical stores due to bankruptcies in 2020 alone (Solem, 2020).

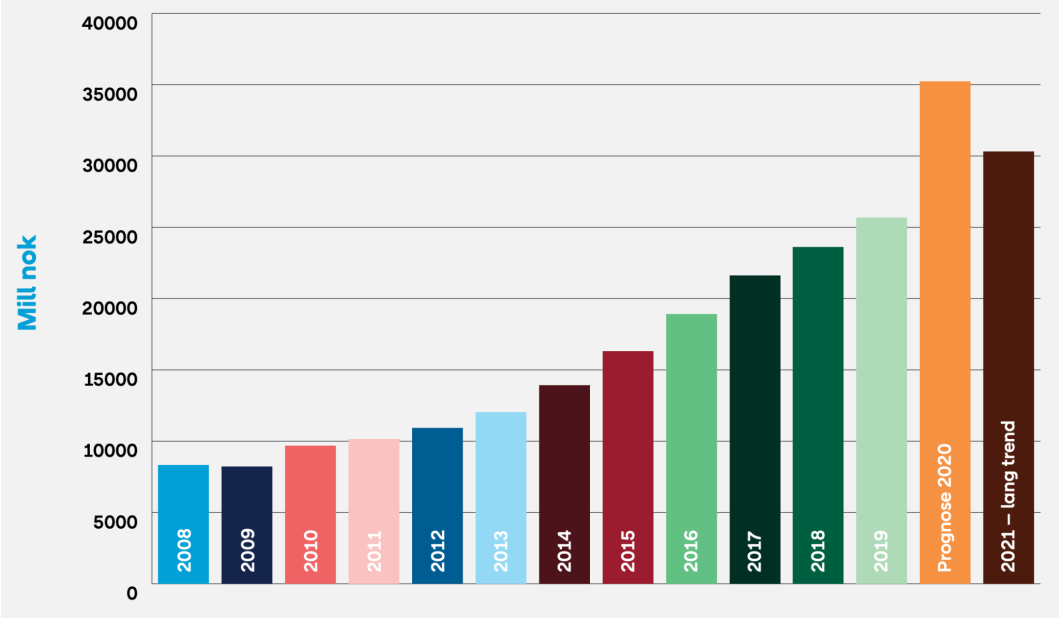

Figure 2: Overview of revenue growth in norwegian e-commerce from 2008-2021. The table is made by PostNord`s forecast department as well as some input from Statistics Norway (PostNord AS, 2020b).

Major logistics companies in Norway are expecting that e-commerce will continue to increase even after the pandemic is over. PostNord AS is therefore investing in new terminals, developing smarter solutions, and increasing their services in both store and home delivery. They have planned to triple their sorting capacity in Norway by 2025 (PostNord AS, 2020b). To meet the increasing demand, Posten Norge is building a 36.000 square meter, fully automated distribution center near Oslo (Posten Norge, 2021b). They have recently started to offer return solutions from customers' homes, and plan to establish 1.000 automated reception boxes across the country (Engebretsen, 2020; Posten Norge, 2021b).

Norwegian consumers are demanding faster home deliveries, such as same day delivery or within specific timeframes. A survey conducted by PostNord in 2020 showed that 39 percent of consumers preferred home delivery (PostNord AS, 2020b). For consumers, it is convenient to be able to receive a wide range of goods delivered at their doorsteps within a short timeframe, but the authorities are rather concerned with this development. Fast home deliveries are difficult to collect and coordinate, causing a fragmentation in the flow of goods. Without the right strategy, solution and coordination, this development can lead to increased traffic and

disadvantages such as increased greenhouse gas emissions and increased local pollution (Transportøkonomisk institutt, 2020).

Norway is closely linked to the EU's climate policy through the EØS agreement, and in December 2019, EU Commission President Ursula Von Der Leyen launched a new climate plan with the name "European Green Deal" (*The European Climate Pact*, 2020). The plan aims to make a total transformation of the countries involved in the EU by the year of 2050 and deals with decreasing all forms of pollution. A clear commitment to the European Green Deal is that "transport should become drastically less polluting", highlighting, in particular, the urgent need to reduce greenhouse gas emissions in the transport, distribution, and logistics sector (European Commission, 2016). The EU Green Deal signals a major shift for Norwegian businesses as the country supplies goods and services to the EU and needs to meet the new climate requirements and environmental standards. As a contribution to the EU Green deal, Norway is committed to halve their greenhouse gas emissions from the transport sector by the year 2030 (Norwegian Government Security and Service Organisation, 2020) . In order to meet the new climate requirements, Norway and all countries under the EU need to deal with environmental issues such as pollution and environmental degradation caused by improper logistics processes and the use of old and environmentally unfriendly transport technology.

However, it is demanding to establish good and efficient solutions for effective last mile deliveries in Norway. A study conducted by the norwegian government elaborates on the consequences of demographic challenges in the rural districts of Norway. The study shows that effective last mile solutions are challenging to implement partly due to the challenging demography with a small population and large transport distances, and partly because distribution centers are located far from end consumers (Regjeringen, 2020). With the EU green deal approaching and the increased competition from international actors such as Amazon, norwegian retailers need to reconsider their last mile logistics supply chain.

1.2 Emerging technologies in SCM

Digital transformation is all around us, and many companies have embarked on their journeys to digitize their business. Technology has long been considered to be an important driver in relation to efficient and well-functioning supply chains (Yang et al., 2021). A supply chain exists mainly to supply customers and meet their demands. As customer expectations increase, so do the demands on the supply chain. The changes that are being seen in the marketplace are dramatic, and as the research article by Yang.et al (2021) portray it; if organizations are not looking for how they can become industry disruptors, then they are going to become disrupted themselves.

Time and process-based management got a strong focus in the 90s, meaning that one was more dependent on a good flow in the supply chain (Acar & Uzunlar, 2014). A consequence of this approach was the realization that key business processes often are significantly influenced by suppliers of goods and services. This laid the foundation of the supply chain management concept, particularly focusing on networks, position, interaction, and relationships as major components in achieving a competitive advantage (Acar & Uzunlar, 2014). This also characterizes today's supply chains, especially those dealing with last mile logistics, with a strong focus on cost-efficiency and flexibility while putting pressure on coordination and delivery performance (Gripsrud et al., 2006). Retailers focusing on e-commerce are more than ever dependent on third-party logistic service providers as the delivery process is just as important, if not more important than the process of submitting an order online (Singh, 2014).

Last mile supply chain has grown tremendously in the last decade (PostNord AS, 2020b). The emerging technologies are here and will more than ever blur the lines between the physical, the digital and the biological sphere (Schwab, 2016). According to a recent report from the accounting and consultancy firm KPMG, technologies believed to make the biggest impact on the future of last mile supply chains are artificial intelligence, big data, automation, drones, zero-emission mobility and 5G (KPMG, 2018). The report shows that these technologies have shown great promise in recent years, both in terms of improving human decision-making processes and the subsequent productivity in various business activities.

1.3 Purpose of the thesis

The purpose of our master thesis is to investigate and find ways in which emerging technologies can improve the efficiency of last mile logistics, and hence make businesses more efficient and sustainable. There are many dimensions to this challenge, and we will start by elaborating on the term "emerging technologies". Schiavi & Behr (2018) explain the term as technologies whose practical application and development are still unrealized, and although the technologies are new, they include older technologies with undeveloped potential. Rotolo et al., (2015) takes the term a step further and describes it as a "continuous challenge of status quo" and enhances the ability of businesses to create value by uniting disruptive technology and innovations into new business models. This leads us to the organizational and environmental dimensions as creating new technology is not enough, it needs to be applicable and sustainable to create value and growth (Gerlitz, 2016).

The motivation behind this study lies in the author's mutual interest in exploring new technology and understanding the foundation of mechanisms. By specializing in Logistics, Operations, and Supply Chain Management the authors aimed to understand how value chains operate at both macro and micro levels. The master program has enhanced our analytical mindset and given us tools to solve complex challenges. Furthermore, the SCM field is constantly reshaping by new technology, business processes, and external factors such as the current pandemic. On top of that, a new industrial revolution is taking place, and the authors believe this revolution will have a long-lasting impact on the way supply chains are organized today. Because of this, we authors want to study and understand how this change will take place and what the implications will be for future supply chains. We are truly interested in the new innovations and technologies that potentially will change our lives in the future. By studying this subject, we are aiming to get a glimpse of the future.

1.4 Research question

Based on the background information and purpose presented above, the following research question is derived:

RQ: *How can emerging technologies increase efficiency and sustainability in last mile home deliveries?*

The research question is based on the assumption that the demand for home deliveries is increasing, this assumption is aligned with the facts and numbers presented in the introduction above. Last mile logistics cause various externalities such as greenhouse gas emissions, air pollution, noise and congestion (Olsson et al., 2019). Therefore, a better understanding to create a climate-smart delivery solution is required, which takes into account the economic, environmental and social impact of home deliveries. The research question covers the sustainability aspect, and we aim to explore how emerging technologies can contribute to sustainability of delivery processes. Further, an understanding of the specific issues of implementing new technology in last-mile operations is seen by the authors as essential to include to answer the primary research question. By getting insight from field experts and practitioners on our research topic we aim to answer the following sub-question:

SQ1*: What are the barriers hindering a successful implementation of emerging technologies?*

1.5 Thesis structure

The thesis is outlined in six chapters and several sections, whereas the first chapter is the introduction part where the authors discuss the background and motivation for the research. In the following chapter, existing theory and research on the thesis topic is presented. The purpose of chapter two is to create a solid foundation of theoretical background to support the further discussion, analysis of the data and the conclusion. While chapter three presents the methodology used for this thesis, which includes verification on the choice of research strategy and design, along with explanations on the methods used for collecting and analysing the data. Next, in chapter four, the results from the qualitative data collection are presented and

sorted in four sections. In chapter five, main findings are discussed in line with the research question and the theoretical background from chapter two. Finally, in chapter six, the researchers present a conclusion of the research question, discuss implications, address limitations and provide direction for future research. The following *Figure 2* illustrates how the thesis is structured along with the interplay between the different chapters.

1.5.1 Illustration of thesis structure

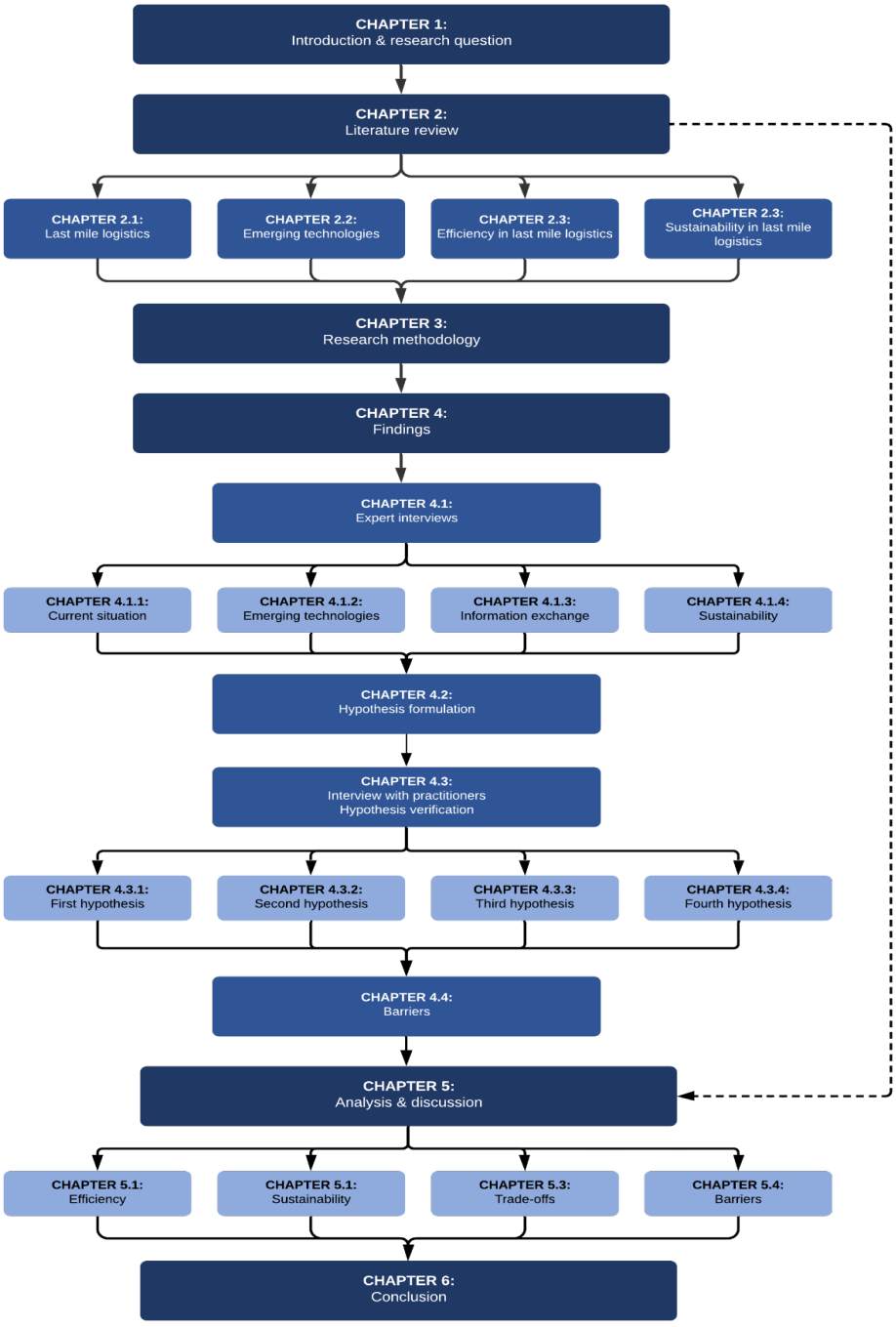

Figure 3: Illustration of the thesis structure made by the authors

1.6 Limitations

Despite choosing a broad research topic, the authors realized the need to narrow the topic down due to time constraints of the thesis project. The first limitation was made regarding the context, this thesis has LM B2C as its core focus from the supply chain literature. The second limitation becomes apparent when the authors discuss efficiency in LM context, efficiency is mainly being discussed in terms of cost-saving initiatives. Then there is a third limitation on the sustainability aspect of the research area. The authors have decided to target the EU Green deal as an overarching aim, and the emerging technologies are discussed in line with how they can contribute to reducing climate footprint in the transportation sector. Moreover, there is a fourth limitation as some selections have been made when discussing the term of emerging technologies. This thesis focuses on innovative tech solutions in LM such as the use of robots, drones and autonomous vehicles, as well as the technologies that make these solutions possible, such as AI with machine learning, big data and 5G technology.

2 LITERATURE REVIEW

In this chapter, a discussion of previous, relevant literature and theories is presented. The discussion is based on the research question, *"How can emerging technologies increase efficiency and sustainability in last mile home deliveries?"*. By reviewing and discussing the literature we expect to gain knowledge and understanding of the relevant research that is conducted with respect to our research topic. Furthermore, this will indicate which topics that need further research and which areas that are not covered by theory today. Hence, the literature review will develop a basis for the analysis in our research. At the end of this chapter, a theoretical framework is applied to illustrate the findings in the reviewed literature and our further research

2.1 Logistics

Multiple sources agree that logistics management has become a significantly important part of the business supply chain (Christopher, 2016; Hugos, 2018; Mangan, Lalwani, & Lalwani, 2016). Throughout the history of mankind, wars have been lost and won through logistical strengths and capabilities. It has been argued that the defeat of the British in the American war of independence was largely attributed to logistical failure (Oliver & Webber, 1982). According to Martin Christopher (2016), logistics is the link between the marketplace and the supply base, spanning across the organization, from the management of raw materials to the delivery of the final product. Logistics is therefore an essential concept to manage under the domain of supply chain management.

2.1.1 Last mile supply chain structure

Ollson et al., (2019) have proposed a framework (*see Figure 4*) that depicts the relationships and interdependencies in last mile logistics. In addition, the framework gives a systematic approach to organize the literature. The framework depicts five components, namely; last mile logistics, last mile distribution, last mile fulfillment, last mile transport, and last mile delivery. The framework has gained academic acceptance and serves as a good model to depict the relationships (Aljohani & Thompson, 2020; From & Mangan, 2020; Wu, 2020).

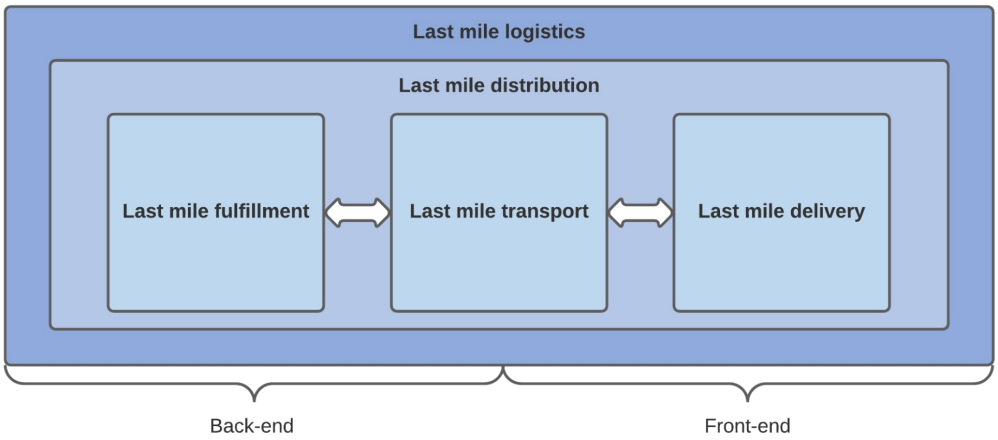

Figure 4: Framework of relationships and interdependencies in last mile logistics (Olsson et al., 2019).

2.1.1.1 Last mile logistics

The literature describes last mile logistics as the operation of planning, initiating, and coordinating efficient (i.e. cost-effective) and effective (i.e. with a high service level) transportation and storage of goods, from the order penetration point (i.e. the point in the material flow where a product becomes earmarked for a specific customer) to the final customer (Olsson et al., 2019). By being the umbrella term, last mile logistics has had the most contribution in last mile literature. The reviewed literature also confirms the strategic nature of this component. The literature focuses on new perspectives on collaboration and emerging business models - e.g., integration of traditional and green business models and crowdsourcing logistics (Akeb et al., 2018; Lindawati et al., 2014; Park et al., 2016). In addition, it emphasizes supply chain design and structure - e.g., strategy, distribution systems, and urban freight models (Aized & Srai, 2014; Nenni et al., 2019; So et al., 2006). We also find that the literature focuses on the aspect of last mile performance in terms of customer-, environmental-, and economical performance (Kämäräinen & Punakivi, 2002; Thirumalai & Sinha, 2005; Van Loon et al., 2015).

2.1.1.2 Last mile distribution

The term “last mile distribution” is defined by Olsson et al., (2019) as the handling, movement, and storage of goods to the point of consumption. Last mile distribution consists of the three core components in last mile logistics, namely “last mile fulfillment”, “last mile transportation” and “last mile delivery”. However the literature on last mile distribution is mainly concentrated around operational

optimization, thus emerging technologies and innovations are weakly represented. The literature deals with routing challenges, transport planning, scheduling, and distribution center and hub location (Boysen et al., 2018; Greasley & Assi, 2012; Veličković et al., 2018; Zhou et al., 2018). Last mile distribution consists of a front- and back-end. The front-end consists of the interface between the LSP and the receiver, while the back-end consists of the interface between the retailer and the LSP (Olsson et al., 2019).

2.1.1.3 Last mile fulfillment

The term "last mile fulfillment" is defined as the process of executing an order by making it ready for delivery to the recipient (Olsson et al., 2019). According to Zhang et al., (2019) this process consists of three cost drivers. Primarily of vehicle-dispatching cost - e.g., the cost such as of the driver, loading operation, etc. Fixed and variable shipping - e.g., such as making delivery sequences, routing, optimization, and calculating expected waiting time. Lastly, the inventory cost - e.g., the cost suffered due to failed and postponed deliveries. Inventory costs are also important in terms of consolidation of logistical operations (Venkatadri et al., 2016). The academic contribution towards last mile fulfillment is limited, resulting in a lack of literature on this topic. However, this process is often researched in combination with last mile transport since they are strongly interrelated (Olsson et al., 2019).

2.1.1.4 Last mile transport

Last mile transport focuses on the mode of which the movement of goods in the last mile is conducted - e.g., heavy goods vehicles, light goods vehicles, electrical vehicles, bicycles, tricycles, robots, and drones (Olsson et al., 2019). By acting as the interface between last mile fulfillment and last mile delivery, last mile transport arguably plays the most important role in defining the operational efficiency in the last mile (Olsson et al., 2019; Wang et al., 2014). Great attention has been given to this topic in last mile literature, thereby confirming its importance (Olsson et al., 2019). A large share of the literature focuses on emerging technologies and innovations in terms of transport mode selection (Morganti & Browne, 2018, 2018; Oliveira et al., 2017). Lebeau et al., (2015) argue that a fleet with a combination of different transportation mode technologies has the opportunity of reducing the

operational costs of the last mile. However, there is not a "one size fits all" approach when it comes to the choice of transport mode, different modes of transport are suitable for different scenarios (Klumpp, 2014). The literature on last mile transport also emphasizes operational optimization (Olsson et al., 2019). The literature is particularly concerned with route optimization challenges, for instance, such as routing problems - e.g., routing with time windows, lunch breaks, etc. (Boyer et al., 2009; Cattaruzza et al., 2016; Coelho et al., 2016). In addition, the literature evolves around route optimization of innovations such as electric vehicles, drones, and trunk deliveries (Murray & Chu, 2015; Reyes et al., 2017; Verma, 2018). The literature is also increasingly permeated with sustainability. Andersen (2020) has conducted a case study with a regional LSP in Norway. His findings suggest that the case might be that home deliveries lead to overall lower emissions compared to pick-up locations since the individual consumers are probably using their car to get to the pick-up location. According to Aditjandra et al., (2016) the use of consolidation centers in combination with zero to low emission vehicles contributes substantially to reduce the environmental impact.

2.1.1.5 Last mile delivery

Last mile delivery refers to the mode by which a physical delivery takes place and the activities concerning the delivery to the receiver. This process has been defined by Olsson et al., (2019) as the front-end of last mile logistics, where the last mile meets the receiver. According to Vakulenko et al., (2019) the last mile delivery experience, greatly influences customer satisfaction. The role of the LSP is therefore crucial as it mediates the relationship between the customer and the e-retailer. Based on this, last mile delivery and last mile transport are strongly interrelated and often researched in combination (Olsson et al., 2019). The majority of the literature on last mile delivery focuses on emerging technology and innovations, particularly in terms of delivery modes - i.e. goods reception solutions. Wang et al., (2014) explores the competitiveness of various delivery modes and provides a system to classify them as illustrated in *Figure 5*.

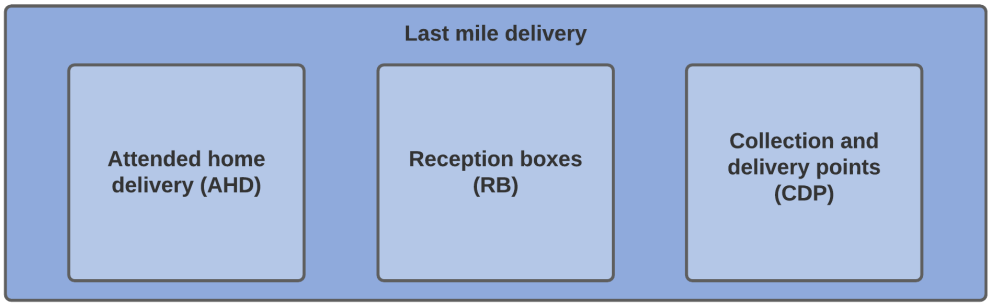

Figure 5: Illustration of different LM delivery modes (Wang et al., 2014)

Attended home delivery

Attended home delivery (AHD) is the last mile delivery mode where couriers deliver the goods to the doorstep of the receiver. The benefit with AHD is that the courier can meet the customer face to face, something researchers argue can contribute to higher customer satisfaction (Wang et al., 2014). The disadvantage of AHD is low operational efficiency, which makes it expensive and time-consuming to handle massive orders. Narrow delivery windows are also increasingly popular with B2C receivers, combined with high average waiting times, greatly reducing the routing efficiency (Agatz et al., 2010). The potential for unattended home delivery has been discussed frequently in the literature, however, due to security and social acceptance, it has not been preferred favorably by consumers (McKinnon & Tallam, 2003; Punakivi et al., 2001; Xu et al., 2008). According to Wang et al., (2014) AHD is suitable for scenarios with sparse population and small order quantities.

Reception boxes

Reception boxes (RB) can be divided into three types; independent reception box, delivery box, and shared reception box. An independent reception box is installed at the garage or in the yard of the customer. A delivery box with a docking mechanism, preferably owned by the LSP, and retrieved after the goods have been collected by the customer. Shared reception boxes work in the same manner as individual reception boxes, but are shared with multiple receivers (Wang et al., 2014). The purpose of RB's is to remove the limitations for a courier when serving a home delivery order, for instance, the limitation of waiting time and delivery slots (Punakivi et al., 2001). Reception boxes allow couriers to aggregate the deliveries and to leave the goods in the boxes for the customer to pick them up at their

convenience using a password, barcode, or some other type of identification. According to Punakivi et al., (2001) reception boxes can also be refrigerated to store groceries such as vegetables and fruits. Their study further indicates that it is a large investment cost in terms of RB's, but that it is still feasible compared to AHD's. Punakivi et al., (2001) found up to 60 percent last-mile cost reduction by using RB's instead of AHD's. Wang et al., (2014) emphasize that RB's is desirable with unattended home delivery, especially with goods such as groceries, vegetables, and fruits. The literature on last mile delivery is highly concentrated around self-service technology and solutions such as parcel lockers (Olsson et al., 2019). Parcel lockers are shared reception boxes owned and operated by the LSP, and are currently being rolled out in Norway (Posten Norge, 2020b; PostNord AS, 2020b). There is still a gap in the research on the concept of refrigerated reception boxes and groceries, especially regarding practical considerations such as climate, electricity, and maintenance.

Collection and delivery points

Collection and delivery points (CDP's) are typically post offices, grocery stores, convenience stores, and other institutions. These institutions either belong to the LSP's or cooperate with them by offering customers a serviced location to collect their goods (Wang et al., 2014). Customers can typically track their delivery progress through tracking services provided by the LSP, something which has a positive effect on customer satisfaction (Vakulenko et al., 2019). When receiving a notification of an awaiting package ready for pick-up, customers can identify themselves and collect their goods at the CDP. These points can aggregate orders and serve a large number of recipients, thereby greatly improving operational efficiency (Wang et al., 2014). An empirical study conducted by Weltevreden (2008) on CDP's showed that online shoppers are more willing to use CDP's in the vicinity of their homes. The study also revealed that the travel distance did not affect the customer satisfaction because little travel was required by the consumer and that they often had to be there in conjunction with other errands - e.g., grocery shopping or refueling their car. A study of CDP's in the Netherlands showed that this solution also is beneficial to the cooperating parties because one out of four customers would make a purchase when collecting or returning their parcels (Weltevreden, 2008). The study also indicated that a driving distance of a maximum of five minutes was critical for the success of these points. CDP's have for a long time been a common

practice in Norway, presumably due to the high cost of home deliveries. Several LSP's have therefore built a solid network of CDP's relatively quite early in the e-commerce era (Dagligvarehandelen, 2021; PostNord AS, 2016). The same trend has been identified in Sweden by Liu et al., (2019), reinforcing the assumption that this is due to the high cost of home deliveries and last mile in general. Wang et al., (2014) suggested that CDP's along with shared reception boxes are more appropriate in scenarios with high population density and large order quantities, as well as cost-dependent scenarios.

In addition to goods reception solutions, the literature on last mile delivery also encompasses social studies regarding new technology and solutions (Olsson et al., 2019). A study with the aim of investigating the factors that affected the consumer's intention to use self-service parcel delivery was conducted by Chen et al., (2018). The study found that factors such as location, convenience, optimism, innovation, and human interaction positively influenced the consumers' intention to adopt new solutions. In addition, cultural and social factors greatly influenced the adoption of new solutions.

Environmental impact has also to some degree been discussed in the literature on last mile delivery. A study by Song et al., (2013) found that greenhouse gas emissions increased significantly when home deliveries failed, and a new delivery attempt was required. The use of CDP's to handle these failed first-time home deliveries was found to significantly reduce the environmental impact of failed deliveries. The study however does not take into account the environmental impact of the travel required by consumers to collect their goods from the CDP. The Norwegian Centre for Transport Research did a case study with Porterbuddy - an LSP in Norway specializing in express home deliveries (Andersen, 2020). The study found that with sufficiently high volumes, Porterbuddy's distribution solution would have a lower traffic and emission impact than an average journey to and from a CDP. However, a study like this is hard to generalize due to its unique components. What kind of transport mode the consumer adopts to get to the CDP largely influences the outcome of such studies. A sensitivity study by Liu et al., (2019) found that the relocation of only 5 percent of the CDP's from urban to rural areas in Stockholm could decrease the probability for a consumer choosing a car as a travel mode to get to the CDP.

2.1.2 Current situation

The last decade has shown that there has been an increasing focus on logistical operations towards last mile delivery. Businesses have focused on increased specialization in core activities, often outsourcing the logistical operations to an external logistics service provider. This has given rise to the big industry of third-party logistics service providers. The implications of this shift were first manifested in the B2B segment, as this segment accounted for most of the senders and receivers. E-commerce has gained and is continuing to gain increasing importance in many countries, in both mature and emerging markets (Mangiaracina et al., 2019). Online initiatives are proliferating across different industries, further accelerated by the recent COVID-19 pandemic.

2.1.2.1 Increased focus on the end customer in last mile logistics

The rise in e-commerce has increased the focus on the B2C segment in last mile logistics. Giannikas et al., (2017) identify product range, order size, and recipient as key differences between B2B and B2C last mile logistics. The product range available for end customers is often smaller than the range available for business customers. Although a wide range of products can be ordered by end customers today, there are certain items mostly ordered by business customers only. Giannikas et al., (2017) give the example of landing gear for an aircraft, which is bought by business customers only. The orders placed by end customers are also expected to be smaller in quantity and value compared to the orders placed by business customers. This is explained by the fact that end consumers buy goods to satisfy their personal demand, while business customers buy goods to satisfy the demand of their business, as well as the demand of their customers (Giannikas et al., 2017). The recipient in a B2C transaction is an individual end customer. The end customer expects his or her delivery to be by a last mile delivery mode of their convenience. This can for instance be home delivery, parcel locker, or a CDP. The recipient in a B2B transaction is typically a company requesting delivery to their premises (Giannikas et al., 2017). The delivery point can be a small 7-Eleven store in the city center or a large distribution center.

The difference in product range and order size has major implications on last mile logistics design. For instance, the size, weight, and quantity of goods determine the

resources required in different links of the last mile logistics supply chain. Whether the recipient is a business or end customer largely decides when the delivery has to take place. For instance, within office hours if it is a business and, in the evening, if it is a home delivery to an end customer.

2.1.2.2 Market demand for last mile delivery modes

A shift towards multi-channel and pure e-commerce operations has led to an increase in the demand for home deliveries, as they are primarily aimed at end-users. Today's consumers have higher expectations than ever towards cost, service level, and sustainability. The consumers want their order to be delivered to their requirements, as well as a place and time of their choosing. Whereas a bricks and mortar retailer has the "last 50 meters challenge", i.e. how to manage the significant cost of getting the product from the delivery vehicle onto the shelf in the most cost-effective way, the online retailer is concerned with the "last mile challenge" (Martin, 2016).

E-commerce in Norway increased by 37% from 2019 to 2020. Norwegians traded for NOK 35 billion in Norwegian online stores. Shopping from foreign online stores accounted for around 50% of their total spending, totaling approximately NOK 70 billion. This means that online shopping accounts for 13-15% of Norwegians' store shopping (PostNord AS, 2020b). There is a legitimate concern for the fact that the recent COVID-19 pandemic is largely attributed to the spike in e-commerce growth last year. PostNord AS believes that the growth will continue at a faster pace than before. This is attributed to the fact that many new customer groups have overcome the e-commerce threshold due to the pandemic. The LSP's are therefore expanding their services and setting goals for the future. The company estimates that by 2025, their capacity will be tripled at their terminals. In addition, 750 parcel lockers are planned to be installed, and 1600 CDP's are planned to be optimized for smoother processes in 2021 (PostNord AS, 2020b).

Posten Norge is also investing heavily in innovative solutions. The LSP has entered into a partnership with OBOS - Norway's biggest housing construction and development association, intending to test out parcel lockers at one thousand locations (Posten Norge, 2020b). Going forward, Posten Norge expects that

innovation and digitalization will continue to affect the current practices and business models (2018a). Recently the company launched a new service where the end customer can return goods bought online by leaving them in their mailbox (Posten Norge, 2021a). The LSP is extremely focused on efficiency and sustainability and has a goal of only using renewable energy sources on vehicles and in buildings by 2025 (Bring Norge, 2020). By doing so the company aims to reduce its operational expenses along with reducing its carbon footprint (Posten Norge, 2020a).

Porterbuddy started in 2017 as a technology based LSP, specializing in express home deliveries for customers in geographically constrained areas in Norway (Andersen, 2020). Their retail partners are omni-channel stores, often with physical stores. Porterbuddy has been able to offer end customers free and bundled delivery on additional items bought from any of their retail partners (Porterbuddy, 2021). By aggregating and delivering the goods in one delivery operation, the LSP can cut costs and reduce its carbon footprint.

DHL has specialized in global express deliveries, and the company believes that agility, innovation, and flexibility will be crucial drivers for success in a dynamic marketplace (DHL, 2021a). The LSP believes that technology will play a crucial part in ensuring these drivers. For instance, a drone delivery pilot named “Skyport” has been running a while in Germany, enabling easy shipping to areas blocked by natural barriers, such as water and mountains (DHL, 2021b). The LSP is observing four key e-commerce trends affecting last mile logistics. The first trend is flexible delivery solutions since customers increasingly are expecting to select when, where, and how goods will be delivered. The challenge DHL is recognizing in this trend is that there are capacity constraints, making it hard to satisfy the demand. Another trend is short-term volume surges due to the growth of seasonal logistics. Big shopping days during holidays and promotional days such as Black Friday, Cyber Monday, Valentine’s Day, and Christmas put immense strain on LSP’s as they have to build up additional capacity and resources to handle the demand. The third trend is increased local presence in the form of localized delivery networks and hubs. Since the customers are expecting fast delivery, LSP’s are aiming at shortening the last mile by increasing the number of regional delivery networks. However, a major

challenge with this trend is inventory management in terms of knowing how much to stock and where to stock certain items. The last trend identified is innovative solutions and flexible models due to emerging technologies like AI, and big data. The biggest challenge is identifying and targeting the right technological investments for long-term solutions (DHL, 2018).

2.1.2.3 The rise of home deliveries

PostNord conducted a consumer survey in mid-October 2020 (PostNord AS, 2020a). The survey revealed some interesting statistics on consumer trends. Almost everyone is shopping online, and only 6% of consumers stated that they did not shop online. Half of those under 30 want the package delivered home and the desire for home delivery increases with the number of people in a household. Further, 61% of consumers in households with 5 people or more want to get the package at their doorstep.

Delivery method	Total	Male	Female
CDP	50 %	55 %	45 %
Home delivery	39 %	34 %	44 %
Delivery to workplace	0 %	0 %	0 %
Parcel locker	4 %	6 %	3 %
Do not shop online	6 %	5 %	7 %

Table 1: PostNord AS consumer survey mid-October 2020 (PostNord AS, 2020a)

CDP's are still the most popular delivery mode among norwegian consumers. 50% state that CDP's are their preferred delivery mode. In 2018, the share was 62%. The largest proportion of men want to pick up the package at a CDP with a share of 55% against 45 % of women.

Parcel lockers are still a relatively new concept in the norwegian market and only 4% of consumers state this as their preferred way to receive their package. Still LSP's like Posten and PostNord are investing heavily in parcel locker solutions (Posten Norge, 2020b; PostNord AS, 2020b).

There is an increase in people who want packages delivered home, 39% of the respondents stated this as their preferred delivery mode. 44% of women want their

order to be delivered to their home, against 34% of men. The consumer survey also reveals that the desire to have the package delivered at home systematically increases with the size of the household. 60% of households with five or more people answered that they want home delivery. This delivery mode is especially popular among the younger generation. Young people want their packages to be delivered at their door to a greater extent than older people. 59% of young people between the ages of 15-17 and 47% aged 18-29 responded that this is a delivery service they want. On the other hand, only 26% in the age group 60+ years want home delivery. According to PostNord (2020a), the demand for home delivery among the younger consumer groups indicates that home delivery will grow significantly in the years ahead. They believe that it is unlikely that this consumer group will change its preferences once they have become accustomed to home deliveries.

2.2 Emerging technologies

According to researchers and professionals, we are currently in the 4th industrial revolution (Deloitte, 2019). This revolution is named industry 4.0 where digitalization and integration of the supply chain are key concepts (Liao et al., 2017). Through the digitization of products and services, as well as technology integration both horizontally and vertically in the value chain, it is possible to bring out the next level of cost-efficiency and increased productivity, as well as create new business models and customer platforms (Koh Lenny et al., 2019; Liao et al., 2017; S. K. Rao & Prasad, 2018).

2.2.1 The world is changing

The Norwegian Ministry of Transport (2021) highlights connectivity, automation, and zero-emission technology as the three most important technologies and the drivers that are expected to affect future transport. Digitization and a whole range of key technologies are expected to drive new processes, new business models, and services (Vaska et al., 2021). These changes are expected to affect all levels of society, leading to significant changes in transportation needs and the transport system (The Norwegian Ministry of Transport, 2019). To get a better grasp of the role of emerging technologies in the future, it is important to understand the societal trends and driving forces. Selected development features from literature are

therefore presented in this subchapter. The features discuss the role of digitization from a national and international perspective, changes in work life, value networks, and business models.

2.2.1.1 Continued globalization

Continued globalization is increasing the demand for transport through increased division of labor in production (Cusmano et al., 2010). Outsourcing the division of labor to more efficient markets points directly in the direction of more freight transport, both with raw materials and finished goods. Norway being a small and open economy is completely dependent on the developments in the global economy for its economic development (Norwegian Ministry of Transport, 2021). In Norway's National Transport Plan for 2022-2033, new regulations, new technology, international competition, and domestic adaptation are identified as crucial elements for its success (Norwegian Ministry of Transport, 2021).

2.2.1.2 Increased urbanization

Increased population in urban areas provides a basis for both more cost-effective and qualitatively better public transport services (The Norwegian Ministry of Climate and Environment, 2017). The rise of e-commerce in urban areas is driving changes in last mile distribution and flexible transport services (Norwegian Ministry of Transport, 2021). Greater concentration of population also provides a basis for streamlining freight transport with bigger and fewer nodes (e.g., transition between sea transport in large ports to/from rail/road) for distribution to factory/warehouse (Norwegian Ministry of Transport, 2021).

2.2.1.3 Emerging technologies

According to the literature, emerging technologies will lead to more efficient and comprehensive transport systems (Dong et al., 2019; Schroten et al., 2020). Electrification, which has come a long way for the railway and the car fleet in Norway, is expected to spread to buses, vans, trucks, ships, and planes, in response to our international climate commitments (KPMG, 2018). At the same time, new zero-emission technologies such as hydrogen are evolving rapidly (Fragiacomo et al., 2020). Increased information exchange and connectivity made possible by digitization and access to big data allow transport systems to always be connected.

By doing so they will be better able to communicate with each other, the infrastructure, back systems, and users (Norwegian Ministry of Transport, 2021). Autonomous land-, sea- and air-based transport systems will make the future transport systems more cost-effective, more available, and secure, which in turn points in the direction of increased transport demand (The Norwegian Ministry of Transport, 2019).

2.2.1.4 A change in work-life

A change in the work-life leads to increased work mobility where many routine work tasks are performed by the use of AI and robots (Webb, 2019). Tasks will be able to be solved regardless of time and place, and the productivity growth is expected to be taken out in increased leisure time. These changes mean, however, also that the boundary between work and leisure is partially blurred (McCloskey, 2016). Business-related travel is expected to decrease, also reducing rush hour peaks, while leisure travel is expected to increase. The effect on freight transport is not unequivocal. The demand for goods might be reduced due to the prioritization of experiences, which in turn results in lower transport demand. Decoupling the time and place for production combined with autonomous transport systems could contribute to more efficient utilization of the transport infrastructure around the clock (Norwegian Ministry of Transport, 2021). However, this can also mean that the B2C last mile delivery is broken down into a smaller number of units, which in turn points in the direction of lower efficiency and increased transport work (Norwegian Ministry of Transport, 2021).

2.2.2 Selected emerging technologies

In the transport sector, the biggest future changes will come as a result of increased connectivity, information flow, software systems, automation, and electrification (Dong et al., 2019; Norwegian Ministry of Transport, 2021). Together with trends such as urbanization, shared economies and a change in work-life, balance opens up for new opportunities, business models, products, and services. Automation and digitization are leading to major changes in the way we produce goods and services, what and how we consume them, and the design and level of the services which are delivered (KPMG, 2018; S. K. Rao & Prasad, 2018). To provide a better

understanding, relevant emerging technologies are briefly presented in this subchapter.

2.2.2.1 Robots and automation

The next generation of robots will be able to interact with people to perform more complex tasks (Ribeiro et al., 2021; West, 2018). The idea is that people should do what they do best, while the work is done in collaboration with robots that have slightly different properties regarding repetitive and dangerous tasks (Sander & Wolfgang, 2021). This will affect both industrial production and transport systems. Posten Norge was in 2018 the first in the world to pilot an autonomous letter and parcel delivery robot, and has since been running numerous tests in controlled environments (Posten Norge, 2018b, 2020c).

2.2.2.2 Autonomy

Autonomy can be seen as a more advanced form of automation. Where an automated system is programmed in advance, an autonomous system can make its own decisions (Visser et al., 2018). Autonomy can in some contexts deal with analyzing information extracted from basic data. This can for example be used to identify and predict possible future events, which in turn gives decision support to humans (Norwegian Ministry of Transport, 2021). In other contexts, autonomy deals with larger systems such as a fleet of autonomous vessels or vehicles. Each autonomous vessel will make decisions based on changes in the environment in which they move, and shall in principle do this without a human driver onboard (Bruce & Otter, 2016; Norwegian Ministry of Transport, 2021).

2.2.2.3 The internet of things

The Internet of Things (IoT) means that objects, means of transport, and infrastructure elements are connected, thereby being able to exchange information and services (Lee & Lee, 2015). An example of this is that if a car equipped with a friction sensor detects slippery roads, the car itself can send information to other cars in the immediate area and alert them about the danger (Madakam et al., 2015; Taha, 2018). With IoT, it is conceivable that both infrastructure, components, and means of transport themselves signal their condition, their load, and their maintenance needs (Manoj Kumar & Dash, 2017; Norwegian Ministry of

Transport, 2021). Connected for predictive analysis, this enables more cost-effective maintenance of all parts of the transport systems. The Internet of Things is made possible as a result of advanced sensor technology with a multiplication of bandwidth and processing power that provides lower cost, increased reliability, higher precision, lower power consumption, and miniaturization of electronic circuits (Collela, 2019).

2.2.2.4 Big data

Big data is about the utilization of large amounts of data, often across organizations, data sources, and formats (Günther et al., 2017; IBM, 2021). Among other things, this can include real-time data streams where IoT is expected to be the primary source (KPMG, 2018). Hence, big data is a new technology that encompasses the entire value chain; data collection, storage, processing, analysis, and visualization of results (Ministry of Local Government and Modernisation, 2016). The Organisation for Economic Co-operation and Development (OECD, 2013) cited in The Ministry of Local Government and Modernisation (2016) argues that big data represents a paradigm shift towards a more data-driven economy, where smart compilation and analysis of large amounts of data can improve economic competitiveness, drive innovation, and contribute to equitable distribution and sustainable development. The OECD report from 2013 estimates that the use of big data in transport and logistics represents the opportunity to save 380 megatons of CO2 emissions worldwide. The use of big data is expected to increase exponentially in line with the development of advanced analytical methods (Ministry of Local Government and Modernisation, 2016).

2.2.2.5 Software

Software is the core of artificial intelligence and is a prerequisite for realizing all digital products and services (KPMG, 2018). Software is the basis for many of the biggest technological innovations such as mobile phones, the Internet of Things, and most high-tech products and services (KPMG, 2018). The software is produced for all modes of transport, both for products included in means of transport and infrastructure, for fleet management, transport management, and for optimization of freight and passenger transport (Norwegian Ministry of Transport, 2021).

Autonomous systems depend on the software that enables the use of artificial intelligence, map systems, and sensor data for such systems (Visser et al., 2018).

2.2.2.6 Artificial intelligence and machine learning

Artificial intelligence (AI) is about developing computer systems that can learn from their own experiences and solve complex problems in different situations and environments. The literature categorizes AI as weak and strong, also referred to as narrow and general AI (Goertzel, 2014; Harwood et al., 2019; Ministry of Local Government and Modernisation, 2016). Narrow or weak AI are solutions geared towards a specific narrow area or developed with one specific task in mind. Narrow AI often performs one task very well, such as image processing or pattern recognition for specific purposes (IBM, 2020). These machines may seem very intelligent, but often have far greater limitations than even simple human intelligence. General or strong AI is similar to human intelligence known as artificial general intelligence (AGI), which we are still far from achieving today.

A general AI, like humans, can use its intellect to solve all kinds of problems, generalize learning and experiences from one problem to another, and think holistically about complex problems (IBM, 2020). Machine learning (ML) being a sub-area of AI, describes the ability of computers to draw experience from large amounts of data and make choices based on this knowledge (Wenzel et al., 2019). Pomerleau (1991) demonstrated in the early 90s that an AI neural network could drive a vehicle reliably and safely on various types of roads, ranging from paved paths to interstate highways. Bruce & Otter (2016) found AI neural networks good for recognizing patterns to control autonomous vehicles.

2.2.2.7 Battery and hydrogen technology

Batteries often have high efficiency but are also heavy and large. The technology is evolving fast and provides constant improvements in the form of increased battery capacity, battery size (i.e. weight and volume), and fast charging solutions (Klumpp, 2014; Norwegian Ministry of Transport, 2021). This technology is believed to be central in achieving the goal of zero emissions in the transport sector (Norwegian Ministry of Transport, 2021). While batteries store energy and deliver power directly, the hydrogen fuel cell system delivers power by reversing hydrogen to electricity (Steilen & Jörissen, 2015). The hydrogen is stored in a tank, and the

fuel cells deliver the effect in the form of electrical energy. Pilots for hydrogen applications are underway in several modes of transport (The Fuel Cells and Hydrogen Joint Undertaking, 2019). The market for hydrogen in transport is immature, and there is currently a lack of legislation and regulations, which is a prerequisite for a well-established market (Norwegian Ministry of Transport, 2021).

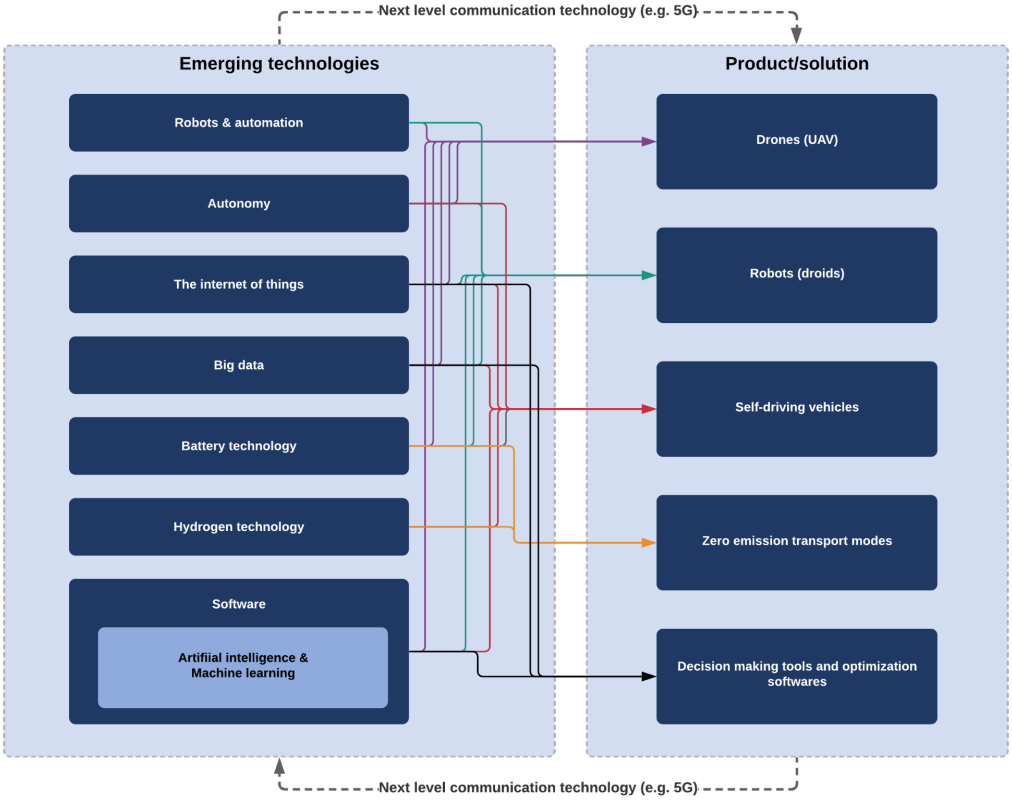

Figure 6: Explanatory illustration of the connection between emerging technologies and their respective end-solutions, made by the authors.

2.3 Efficiency in last mile logistics

Good and efficient last mile logistics is crucial to obtain a competitive advantage as the cost of last mile logistics accounts for around 50 percent of the total delivery cost (Joerss et al., 2016). According to Martin Christopher (2016), logistics and supply chain management can provide a multitude of ways to increase efficiency and productivity. A brief introduction to efficiency in supply chain management and last mile logistics is presented in this subchapter. How efficiency is measured in last mile logistics is also presented in this subchapter.

2.3.1 Defining efficiency

Several definitions of efficiency exist in the literature. Stevenson (2015) defines efficiency as getting the most out of a fixed set of resources. Another definition is an effective operation as measured by a comparison of production with cost (as in energy, time, and money), or as, the ratio of the useful energy delivered by a dynamic system to the energy supplied to it (Merriam-Webster, 2021). A logistics-related definition is that efficiency is the internal functioning of logistics and generally being considered best represented through some ratio of a normal level of input to real levels of output (Fugate et al., 2010). In other words, efficiency can mathematically be expressed as output/input or financially as (NOK) value-added / (NOK) costs. This definition and equation fits perfectly with Mentzer and Konrad's (1991) work, as their work considers efficiency to be "the ratio of resources utilized against the results derived".

Based on various literature and definitions on efficiency in last mile logistics the authors have chosen to use the following definition concerning the research question. Efficiency in this thesis is used to describe the ratio of resources utilized against the results derived, where the firm's success is composed of two different dimensions; service level and cost-efficiency. According to Collin (2003) service level and cost-efficiency are opposite poles, which a firm has to balance to achieve the optimal result. Leaning too much on the cost-efficiency side can result in a longer delivery time as the LSP is using the slack time to optimize its fill grade. The delivery time can be improved by increasing the number of dispatches, but this will lead to lower efficiency and additional cost. Collin (2003) argues that it is very important for a company to find the balance between cost-efficiency and service level. Christopher (1998) argues that efficiency improvements must consider the whole supply chain and that companies should not make a profit at the expense of another supply chain member. He reasons that this is short-term profit and will for sure result in an increase of price in the long term. Hence, a firm has to consider both how it best utilizes its internal resources and how it best benefits from collaborative efforts in the supply chain (Christopher, 1998).

According to Christopher (1998), the future market leaders will be the ones that have sought and achieved the twin peaks of excellence. They should have gained

leadership in cost-efficiency and service level. According to Collin (2003) there is no “one size fits all” approach when it comes to balancing the two dimensions. Each company, based on its strategic fit, has to find its balance to maximize the profits for the company. Christopher (1998) argues that a business has to master both internal and external performance. In the context of last mile logistics, some customers require very high customer service and are willing to pay for that (i.e. express courier and high-value goods transport). For other customers, the cost is the most important factor and these companies tolerate reduced customer service (i.e. longer delivery time and no tracking option)

2.3.1.1 Cost efficiency

Macioszek (2018) argues that the last mile delivery process is the least efficient and most expensive part of the delivery process. The researcher reason that this is due to challenging target service levels, the small dimension of orders, and a high level of geographically spread delivery locations. Hence, the cost can amount to half of the total logistic cost (Joerss et al., 2016; Vanelslander et al., 2013). Mangiarancina et al., (2019) argue that to be successful, B2C e-commerce players need to both be effective and reduce costs. The paper expresses that actors in the e-commerce supply chain usually consider service level targets as constraints, and optimize their cost factors to stay competitive.

2.3.1.2 Service level

According to Bowersox & Closs (1996) the consumer is crucial and should be included for a successful supply chain management. The service level encompasses all activities and processes that add value for the customer (Pettersson, 2008). Hence, the consumer has to be willing to pay for the additional activities, so the value-added is a net positive (Fugate et al., 2010). According to Bowersox & Closs (1996), price, short delivery time, and punctuality are three important service-level factors in the context of last mile logistics. This is consistent with the findings of Lu et al., (2015), that e-commerce customers are very demanding in terms of service level, especially considering punctuality and short delivery times. The literature is mostly unanimous considering the importance of service level, however, Borsenberger et al., (2015) found that even though consumers demand a higher service level, they are not willing to pay for the additional cost.

2.3.2 Measuring efficiency in last mile deliveries

Measuring efficiency in last mile logistics can be viewed from various aspects. For a successful measurement of the efficiency in last mile logistics, it is necessary to consider a large number of factors different in nature (Andrejić & Kilibarda, 2013). When measuring efficiency, it is important to delicately balance factors related to service level and cost-efficiency. According to Christopher (1998), factors related to service level and cost-efficiency need to be balanced when setting up a supply strategy. Christopher (1998) argues that research on the efficiency of supply chains often has found that activities related to increasing the service level have often added more cost than efficiency.

The financial formula for defining efficiency, (NOK) value-added / (NOK) costs is, therefore, a good indicator for measuring if the activity in question is making a positive impact (Fugate et al., 2010). The formula indicated that the value added by a measure should be higher than the related cost. Efficiency can be monitored and measured and expressed in various units (Andrejić & Kilibarda, 2013). These can for instance be financial, technical, or social factors. According to Andrejić & Kilibarda (2013), measuring efficiency in the domain of last mile logistics is a complex process that requires consideration of all subsystems, processes, and activities as well as the impact of various financial, operational, environmental, quality, and other factors.

The literature points out various measurements that can be used to evaluate the efficiency of the last mile logistics supply chain. Domingues et al., (2015) provide a comprehensive and innovative performance measurement framework for a third-party logistics service provider (3PL). The performance indicators from their framework are listed below and are highly relevant as they are supported by a thorough revision of the existing literature regarding performance indicator systems within logistics.

Performance Indicators	Expanded description:	References
Distance traveled per day	Total number of km traveled during a certain period of time over the period number of days	Krauth et al. (2004; 2005)
Turnover per km	Turnover of a certain journey divided by the total number of km of the designated journey	Krauth et al. (2004; 2005)
Delivery Frequency	Total number of deliveries that took place in a certain period of time	Krauth et al. (2004; 2005)
Completeness	Percentage of full/ complete orders dispatched by the total number of orders	Garcia et al. (2012)
On-time delivery performance	Percentage of orders received on time (date and hour) defined by the customer	Schönsleben (2011)
Vehicle loading capacity utilized per journey/vehicle	Utilized loading capacity per journey (or vehicle) over the total available loading capacity	Krauth et al. (2004; 2005)
Claims due to out of time deliveries	Percentage of claims due to deliveries executed after the agreed date	Garcia et al. (2012)
Order to delivery cycle time	The average elapsed time from the moment the order is ready to the reception by the customer (includes loading/unloading)	Gunasekaran et al. (2001)
Vehicle loading/unloading time	The average freight loading/unloading time	Garcia et al. (2012)
Loss and Damage frequency	Number of loss and damaged during transportation, in relation to the total number of products transported	Bowersox et al. (2013)
Transportation accidents	Number of accidents occurred during the transportation journey of products during a certain period of time	Kravokics et al. (2008)
Cargo theft	Number of theft events during transportation of products, during a certain period of time	Kravokics et al. (2008)
Cycle time improvement	Percentage of cycle time improvement relative to the previous year	Bagchi (1996)

Table 2: Performance Measurement Framework for the transportation activity of a 3PL firm (Domingues et al., 2015).

2.4 Supply chain sustainability

This subchapter addresses the issues of sustainability and its connection to last mile delivery and emerging technologies. A key part of this subchapter is concerned with how to measure sustainability, which works as a base to analyze how sustainability is affected by the implementation of emerging technologies in last mile logistics. The literature puts a lot of emphasis on the fact that environmental matters are important to the survival of companies (Hahn & Scheermesser, 2006). Businesses in general, tend to degrade the environment by exploiting natural resources,

generating waste, and polluting (Devkumar S et al., 2019). Yi-Chan & Tsai (2007) argues that companies in addition to seeking financial returns have a responsibility to operate sustainably.

Sustainability as a term was first acknowledged in a report by the Brundtland Commission of the UN in 1987 (Secretary-General & Development, 1987). The report laid the foundation for The United Nations' work on sustainability by addressing global concerns such as environmental development. The report recognized the goal of sustainability to ensure that we meet the needs of the present without compromising the ability of future generations to meet their own needs. Ever since the report was published, the interest and the importance of sustainability has grown, this has led to increased interest and research on green innovations, policies, and studies on environmental effects (Y. Chen et al., 2018; Devashish et al., 2003; Martin, 2016; Yi-Chan & Tsai, 2007).

Multiple dimensions of sustainability concerns have been introduced as the term has been expanded over time. The most common set of concerns are economic-, social- and environmental considerations (Basiago, 1998; Helming et al., 2008; Robert et al., 2005). These concerns are often referred to as the triple bottom line (TBL) or the three "P's"; people, planet, and profit, a term introduced by Elkington (1994) who stressed that organizations should start managing environmental, social, and economic aspects of their business equally. In theory and practice, these three dimensions are not mutually exclusive, but they are rather linked to each other (Braccini & Margherita, 2019; Martin, 2016).

2.4.1 Sustainability in last mile logistics

The "green last mile" is a fairly young topic of making the last stretch of transport and logistics more environmentally friendly and sustainable, it has been widely discussed in recent literature (Doi & Murakami, 2021; Elhedhli & Merrick, 2012; Figliozzi, 2020; Pharand, 2021; P. Rao, 2007). However, to our knowledge, there exists little literature directly concerning the impact of emerging technologies on sustainability in the norwegian market. This study will therefore make a great contribution to the literature on this subject in this specific setting, as there exists

no “one-size-fits-all” solution regarding emerging technologies and last mile logistics (Klumpp, 2014).

In recent years sustainable transportation has gained popularity and increased attention from norwegian and EU transport policymakers (European Commision, 2021; Norwegian Ministry of Transport, 2021). With the new shift towards sustainability in the transport sector, the Norwegian government has developed a goal to reduce emissions from domestic transport by half within the ten years between 2020 and 2030 (Norwegian Government Security and Service Organisation, 2020). The key tools proposed by the Norwegian government for cutting emissions in the transport sector include increased CO2 tax, measures to increase the use of biofuel, as well as various requirements and subsidies for the use of zero and low emission vehicles (Norwegian Ministry of Transport, 2021). The National Transport Plan for 2022-2033 emphasizes that emerging technologies will be able to solve some of the challenges we have previously faced with traditional solutions for accessibility, capacity, and transport safety. The plan also emphasizes that automation, electrification and zero-emission mobility, new business models, and the development of interacting intelligent transport systems are some of the drivers of the green shift (Norwegian Ministry of Transport, 2021).

The literature refers to several ways for an LSP to focus on creating a green last mile. For instance, by implementing programs such as carbon-neutral transport, zero- or low emission delivery fleets, reducing noise or carbon from the air (Khare & Pandey, 2017). In the business world, we see that Posten Norge has developed an ambitious goal of only using renewable energy sources in their vehicles and buildings by 2025 (Posten Norge, 2021c). PostNord AS, another big LSP in Norway is highly focused on reducing its CO2 emissions. They plan to achieve this by optimizing routes and fill grades, investing in more fuel-efficient vehicles, increasing the proportion of EV’s, and increasing the use of biofuels (PostNord AS, 2020a). DHL (2021c) has recognized that consumers increasingly consider sustainability during their purchasing decisions. Based on this the LSP is very transparent regarding its carbon footprint, publishing detailed reports and initiatives, and thereby using its environmental policies as a competitive advantage.

In addition to the LSP's focusing on sustainability, the norwegian organization CHOOOSE is allowing retailers and consumers to offset their carbon footprint by paying a monthly subscription fee (CHOOOSE, 2020a). The fee is used in projects aligned with the UNs sustainable development goals, such as community projects, carbon removal, and renewable energy (CHOOOSE, 2020b). Their retail partners can through CHOOOSE's technological solution give their customers the option to carbon balance their shopping cart while they are checking out. Furthermore, CHOOOSE differentiates itself from the LSP's as they are not physically involved in the last mile delivery, but positively impacting the environment through their business model.

2.4.2 Measuring sustainability

According to Joerss et al., (2016) the cost of last mile logistics accounts for around 50 percent of the total delivery cost, making it extremely expensive and important to manage. To manage a business process, it must be measurable, hence the famous saying that "what gets measured, gets managed" (Klaus, 2015). When measuring sustainability in last mile logistics, the triple bottom line is a practical framework that allows for a distinction between economic, environmental, and social sustainability (Mangiaracina et al., 2015).

The triple bottom line framework defines three bottom lines that companies must satisfy to promote sustainable development (Elkington, 1994). The figure below briefly explains what, according to Elkington, is included in the triple bottom line.

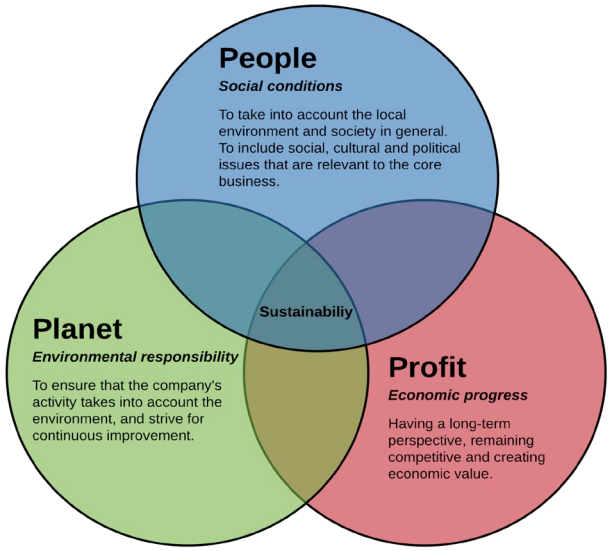

Figure 7: Dimensions of the triple bottom line (Elkington, 1994).

According to Comi & Russo (2012) economic sustainability includes measures such as delivery time, utilization, trip length, time in transit, loading and unloading time. Social sustainability is more challenging to measure, as it can be understood as the reduction of conflict between the business and stakeholders affected by their operations (Comi & Russo, 2012). Environmental sustainability can be understood as the reduction of air and noise pollution, habitat loss, etc, and is often an outcome of how the economic and social sustainability measures are managed (Comi & Russo, 2012).

The triple bottom line can be difficult to measure because while profitability is easily quantifiable, social and environmental responsibility are somewhat subjective measures (Ahi & Searcy, 2015; Goh et al., 2020). In terms of the economic dimension, there are many ways of measuring financial and economic data, for instance by the use of standardized operational or accounting-related measures (Govindan et al., 2020; Henriques & Richardson, 2004).

According to Miller et al., (2007) there is a lack of valid, comparable, and quantifiable measurements for the social and environmental dimensions. A restaurant might measure and report on how much it reduces waste by switching to environmentally friendly packaging or by serving food to a homeless shelter. A car manufacturer might measure progress in terms of producing less polluting vehicles. A government project to expand public transport can measure how much it reduces the highway congestion on the road. Other important factors to report on, depending on the organization, may include employment, employee turnover, fossil fuel consumption, hazardous waste management, percentage of women and minorities employed in general and in senior positions, contributions to charity, how earnings and benefits are compared to a living wage, and the number of employees utilizing workplace benefits to pursue higher education.

2.4.2.1 Economic sustainability

Milton Friedman famously argued that the only social responsibility of business was to maximize profits (Fox, 2012). These profits, if only returned to the firm's owners, could be put to charitable purposes as the shareholders saw fit (Nilsson &

Robinson, 2017). Sustainable companies aim to make a profit, by increasing their revenues and reducing their costs. The economic dimension of the TBL framework is not only about pure economic gain, but also about how this profit affects society as a whole.

Economics sustainability is first and foremost about the social and environmental benefits that can be achieved through profits (Carson, 2015). For a nation, sustainable economic growth means that their gross domestic product (GDP) per capita increases over time, and that the increase is not threatened by biophysical consequences such as pollution and/or diminishing resources or social consequences (Rogers et al., 2008). Within economic sustainability, one is dependent on a focus on cost-efficiency, earning capacity, productivity and income levels (The Norwegian Ministry of Agriculture and Food, 2018). Such sustainability presupposes that there must be a sufficient relationship between the number of people the company is to employ, the industry's resource base and market opportunities.

In the context of last mile logistics, economic sustainability can be improved by a more efficient use of resources, for instance by better route optimization and truck utilization. A better flow of vehicles contributes to reducing working hours and fuel consumption, leading to less congestion and air pollution, especially in urban areas (Comi & Russo, 2012). Increasing the utilization of trucks and delivery vehicles contributes to a better traffic flow by decreasing the number of delivery vehicles on the road and reducing the cost per trip (Comi & Russo, 2012).

2.4.2.2 Social sustainability

The social dimension of the TBL can be defined as a combination of social, ethical and political issues that are relevant to consider for a company’s workforce, customers and community development (Ahi & Searcy, 2015; Chopra, 2019). The focus of sustainable practices has primarily been on the economic and the environmental dimensions, while there has been less focus on the social implications of the business in and around the company. A company operating within the TBL will give greater importance towards human rights, and labor standards, for instance by paying competitive wages, taking care of the safety of its

employees and ensuring that they do not exploit the society or the labor force through child and slave labor (Carson, 2015). Such a company will also step in to help the local community by contributing in a positive way towards, for example, education and health (Martin, 2016).

When it comes to employees, the social bottom line is about labor rights, health, safety and discrimination (Carson, 2015). Labor rights deal with laws and regulations, including that child workers must not be used and that safety in the workplace must be safeguarded. The social bottom line also considers external factors involving business connections and the local community. According to Carson (2015) the company is responsible for safeguarding human rights, combating corruption and they must contribute to the local community.

In the context of last mile logistics, human capital is an important resource and their performance is positively related to the performance of a company (Myers et al., 2004). However, having possession of a strategic resource such as human capital will not give any advantages unless they are facilitated well. Amazon has recently been in a news flare concerning some of their drivers, who due to time constraints were not able to have lunch breaks, while others had to urinate in bottles to make the delivery windows (Klippenstein, 2021; Taylor & Hartmans, 2021). A socially responsible business aims at taking care of its customers as well as its employees. Couriers spend a considerable amount of time in traffic, and driver fatigue is positively correlated with accidents and crashes (C. Chen & Xie, 2014).

Digitalization and emerging technologies are being implemented in logistics and the supply chain as a whole. According to Bechtsis et al., (2017), digitalization is positively correlated with social sustainability, as technical developments can improve safety and reduce process time, which is essential to the end-user (Barth et al., 2015; Olsson et al., 2019). A popular concern regarding digitalization and automation is the fear of machines taking over human capital (Hanifan & Timmermans, 2018). Merlino & Sproge (2017) argues that humans and machines can provide a superior service to the end-user by interacting with each other. Consequently, an interaction between humans and machines will create new value for a business, its stakeholders, and its customers.

2.4.2.3 Environmental sustainability

The environmental dimension of the TBL seeks to focus on the sustainability of our planet and environment by conditions such as the use of resources, the amount of waste and its handling, emissions to air, soil and water (Elkington, 1994). According to Acquaye et al., (2017) environmental sustainability can be defined as the integration of environmental thinking into the entire lifecycle process of supply chain activities.

The idea behind this dimension is that companies who operate within environmental sustainability will be more profitable in the long run and in some cases be able to reduce costs by acting in an environmentally friendly manner. Carson (2015) argues that most businesses are at some level dependent on natural resources and the climate, and thus benefit by taking care of the environment. Environmental sustainability is of significant importance for logistics service providers (Evangelista et al., 2017). Usually, the more efficient a logistics process is, the more sustainable it is. Businesses have an attractive economic gain by reducing their fuel consumption, and thereby they also contribute to reducing greenhouse gasses such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) (Fan et al., 2018; Shaheen & Lipman, 2007).

A research paper by Gevaers et al., (2009) considers the last mile of the supply chain to be one of the most polluting parts of the supply chain for several reasons. The first reason is the chance of failed home deliveries due to the consumer not being at home, which in turn implies extra costs, kilometers, and emissions. The second reason is that door-to-door deliveries could create scenarios of vans running empty while the couriers get the packages delivered. While the third reason listed is that regions with a high degree of rural areas make it challenging to generate profitable and efficient routing plans.

Noise is considered to be pollution according to the Norwegian Pollution Control Act and is the pollution problem that affects most people in Norway (The Norwegian Ministry of Climate and Environment, 2020). Noise pollution also poses a threat to human health and welfare, and the largest contribution of noise pollution comes from road traffic. While emissions of air pollutants from the transport sector

have been reduced, exposure to noise levels above the accepted limit values has remained constant in European urban areas in recent years (European Environment Agency, 2021). Noise also has significant health consequences. Nighttime noise can cause sleep disturbances. Long-term 24-hour exposure can result in, among other things, high blood pressure and cardiovascular disease (The Norwegian Institute of Public Health, 2019). Urbanization among the European population is expected to increase, and a significant proportion of the urban population will live near transport infrastructure and high-traffic hubs, such as airports and highways (European Environment Agency, 2021).

The EU standards include specifications for vehicle testing, but there are significant discrepancies between the official figures (i.e. the emissions recorded under test conditions) and the emissions that take place in the real world. According to The European Environment Agency (2021) measures to solve this problem are on the way. These measures include the development of new test specifications and the roll-out of portable emissions measurement systems (PEMS), which can be mounted on cars to measure emissions while driving on the road.

2.4.3 Critique of the triple bottom line model

Several arguments have been made against the TBL as a framework. This usually happens when new regulations and concepts occur, and we can draw this to ethnocentrism and fear of the unknown (Atu, 2013). This may occur because businesses are not willing to change, and believe that it works well as it is. A number of the resistance arguments of the TBL are based on the fact that there is no standard method for measuring development. While many draws this as an advantage of the concept, that you can shape it to suit the company you are going to use it within (Sridhar & Jones, 2013). This means that TBL is used as a general framework that is adapted to the organization. In this way, the concept can be used within both traditional organizations, but also within non-profit organizations (Wyszomirski, 2013). One can also use the concept in a geographically spread context, as well as within a wider range of organizational forms.

There has also been some criticism towards the disadvantages of the TBL. These address the fact that it will be very time-consuming to define expectations and risks

associated with implementing TBL. One concern that is expressed is the possibility that an organization's actions do not support its intentions (Atu, 2013). The organizations can then claim that they intend to take greater social and environmental responsibility, while their real intention is to appear more responsible by greenwashing their brand (Mitchell et al., 2008; Roberts & Koeplin, 2011).

According to Atu (2013) the weakness of TBL is its limited ability to be implemented in a purely profit-oriented financial system. It is not as easy to measure the benefits for society and the environment, as it is to measure profits. It is not possible to sum up across the three bottom lines, and it is therefore assumed that companies have difficulty in seeing the benefits of using TBL. In 2018, Elkington recalled the framework on the basis that the TBL is not being used as he hoped it should be. He also believes that the TBL is used for pure reporting, and not as a tool for change (Elkington, 2018). Thus, Elkington believes we can no longer focus on profit and that the three P's of the TBL should be defined as people, planet, and prosperity rather than profit.

2.5 Theoretical framework

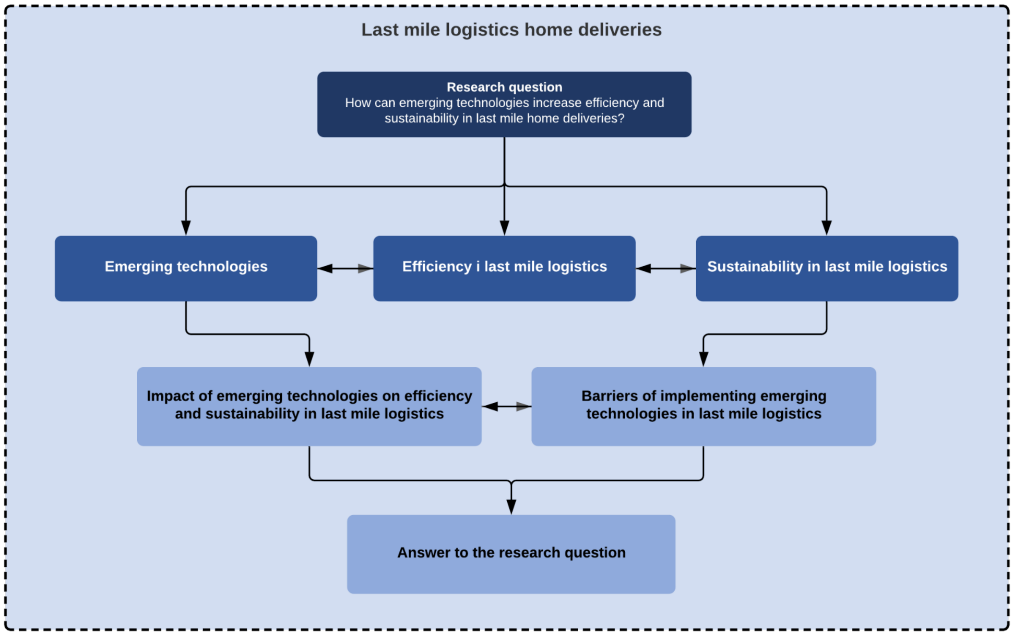

Figure 8: Illustration of the theoretical framework made by the authors

The framework serves as a basis for our empirical findings and discussion. Theories from different researchers have been combined to create a solid

background for investigating the different aspects academia presents on LM logistics (2.1), emerging technologies (2.2), efficiency in LM logistics (2.3) and supply chain sustainability related to LM operations (2.4). Further, the study examines different LM delivery concepts (2.1.1.5), the change in market demand (2.1.2.2), different emerging technologies that exist in the market (2.2.2), and how efficiency (2.3.2) and sustainability (2.4.2) is being measured in LM deliveries. The reviewed theory provides the base for discussing the sub-question and research question for the thesis and assists the authors to connect the dots between this huge research area.

3 RESEARCH METHODOLOGY

This section describes what methodological choices we have made to answer our research question; "*How can emerging technologies increase efficiency and sustainability in last mile home deliveries*?". We will elaborate on the methods used, the reasoning behind why they were used, and how the methods were conducted. We will start by describing the research strategy and research design applied. Planning, structuring, and having sufficient data to work with is an important part of a thesis. Therefore, we will explain how and why the primary and secondary data was collected and analyzed to answer the research question. Furthermore, a discussion on the quality assessment is provided, addressing the trustworthiness and authenticity of the thesis.

3.1 Research strategy

A research strategy can be described as *"...a general orientation to the conduct of business research"* (Bryman & Bell, 2011, p. 26). Within research strategies, there are two different directions; qualitative and quantitative research. A qualitative research strategy emphasizes words and can explain the phenomenon which is not possible to quantify (Bryman & Bell, 2011, p. 386). Rotolo et.al (2015) describes emerging technologies as a multifaceted phenomenon, which implies that the technologies have several aspects and abilities. The objective of our research is to understand how and which emerging technologies impact last mile home deliveries in Norway positively. Meanwhile, the aim of the study makes a qualitative approach appropriate by providing an understanding of the non-quantifiable factors impacting the implementation of emerging technologies in the last mile process of home deliveries. Hence, another argument for using qualitative methods for this subject is that there is not broad usage of emerging technologies in last mile deliveries yet, and it would be difficult to quantify the implications of using these technologies. This research paper will thereby investigate through a qualitative research strategy.

However, some common criticism of qualitative research methods is that they are too subjective, making the outcome difficult to replicate in other settings, time-consuming to collect, and problematic to generalize (Bryman & Bell, 2011, p. 193). The analysis of our collected data was all of the qualitative character as we sought

to get viewpoints from different actors and researchers regarding the industry situation, technological opportunities and barriers, and how emerging technology can contribute to sustainability in home deliveries. A qualitative research approach is characterized to be a more open-ended research strategy, linking key concepts in literature with the collected research (Bryman & Bell, 2011, p. 67). Thus, a qualitative research strategy will help us to better understand the dynamics associated with using emerging technologies in last mile processes and discover patterns rather than forcing ideas from theory on the data collected.

According to Bryman and Bell (2011), there are mainly two theoretical approaches to a research strategy; deductive and abductive. The deductive approach is applied when researchers are testing the existing theory (Bryman & Bell, 2011, p. 723), while an inductive approach is better suited when researchers aim to develop a theory by moving from specific observations to broad generalizations (Bryman & Bell, 2011, p. 724). The combination of an inductive and deductive approach is referred to as an abductive approach. Mantere and Ketokiv (2013) explain that an abductive reasoning approach is a method to turn surprising facts into matter of course and identify conditions that make the phenomenon less puzzling. The latter approach is also referred to as systematic combining, by Dubois and Gadde (2002). Systematic combining is well suited for qualitative case studies and concerns the simultaneous evolution of the theoretical and empirical framework. This approach is specifically appropriate for the development of new theories and the process is well explained in *Figure 9* below.

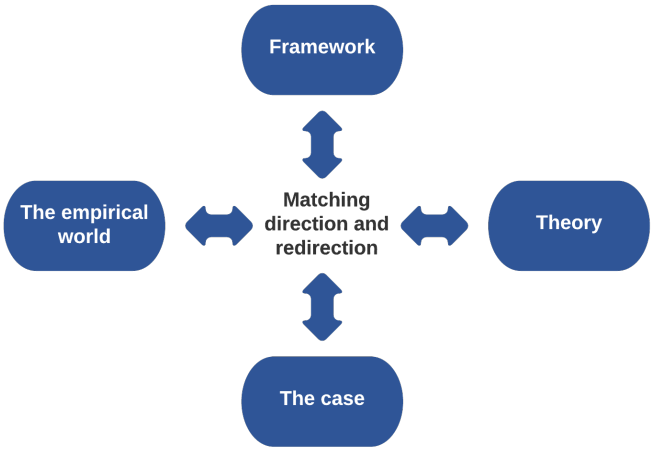

Figure 9: Illustration of systematic combining (Dubois & Gadde, 2002, p. 555)

The systematic combining process consists of going back and forth between theory, the framework, the case study, and the empirical world. By using abductive reasoning, we initiated the research project by collecting data, information and observing issues as well as moving back and forth between framework, data sources, and analysis. Thus, the abductive approach has been acknowledged as the most suitable approach in the interpretation of our findings.

3.2 Research design

Bryman and Bell (2011) describe research design as a framework for collecting and analyzing data used to answer the stated research question. In other words, a research design is used to provide a framework for the collection and analysis of the data, and the chosen design helps to prioritize the different dimensions within the research process. Thus, the research design can be explained as the overall plan for relating the conceptual research problem to relevant and practicable empirical research (Ghauri & Grønhaug, 2010). In this research, it was necessary to conduct information and understand the relationship between emerging technology and factors affecting the last mile processes, which is consistent with the characteristics of a case study. We further limited our area of research to home deliveries in Norway. According to Bryman and Bell (2011), a case study differs from other studies as it focuses on a bounded system or situation. The description fits well with our focus on the digitalization of last mile home deliveries. Other designs were considered, including comparative and longitudinal design. However, given the nature of our research question, time constraints, and the scope of the project, a case study design was chosen. It enabled us to investigate a complex topic and besides, a case study is a preferred design when a study addresses a “how” or “which” question (Yin, 2003). A case study design was further appropriate as we did a qualitative case study of how emerging technologies can contribute to last mile home deliveries in Norway.

The nature of the research was exploratory since we were exploring how emerging technologies could increase efficiency and sustainability in last mile home deliveries. Available academic literature on the usage of emerging technologies in last mile home deliveries in Norway is lacking. According to Dubois & Salmi (2016) an exploratory case study is an excellent choice when seeking a foundation

for several contextual aspects. The design can be used to gain a deeper understanding of data and the dynamics around the phenomenon of interest and for further theory refinement or development. Therefore, an exploratory case study was found to be the best fit for this research project. We chose a single case study due to limited time and also because in-depth study of multiple cases such as last mile B2B versus last mile B2C supply chains would have extended the study and increased the complexity. Instead, we decided to concentrate on emerging technologies in the last mile home delivery market only. This approach provided the opportunity to include multiple perspectives from different actors in the same home delivery market, as there were no limitations to a specific home delivery company. This approach in turn helped us to gain insight and create a complete picture of the norwegian last mile home delivery market, and to make the results valuable to all actors.

3.3 Data collection

The data collection has been divided into two parts, containing primary and secondary data. The project has been approved by the Norwegian Centre for Research Data (NSD) and the data has been collected, processed, and stored accordingly.

3.3.1 Primary data

Primary data has been collected by the authors themselves with the purpose to explore and obtain more context to the research topic (Appannaiah et al., 2010, p. 108). The authors reached out early to several relevant companies and as a starting point, a meeting was arranged with two researchers from Telenor Group. Through their contacts in Telenor, the authors received an invitation to a seminar hosted by Mobility Lab, including several relevant LSP actors discussing topics in line with the research study. Through that seminar, the authors got in touch with several relevant actors and both their network and reach expanded significantly.

Since it has been taken a qualitative position for the case study, the main source of primary data has been collected through interviews. To be able to conduct a detailed examination of the case, Bryman & Bell (2011) recommend the use of semi-structured interviews and observations. The authors chose a semi-structured

interview approach to allow the participants to speak freely around the topics and to create room for the interviewer to improvise follow-up questions based on the participants' responses. The interview guide was always provided beforehand to prepare the participants for the meeting and to avoid any misunderstandings. Using semi-structured interviews was of great help to add more depth to the exploratory study as new viewpoints and questions emerged from the primary questions.

However, due to the recent pandemic, it has not been possible to travel or conduct any physical observations. The restrictions following the COVID-19 pandemic led us to use online communication tools such as e-mail, Zoom, Teams, and Skype to communicate and collect data from companies and participants. This method made the process less time-consuming and efficient as we managed to perform several interviews within a short time frame. Although Bryman & Bell (2011, pp. 495–496) argues that there are some limitations of conducting interviews through online video calls, such as the dependability of having a good internet connection for all parties, fluctuations in the sound quality, and that it might be difficult for the interviewer to read the body language of the participants properly. Luckily, nor did we or the participants experience any hardships by using online communication tools.

3.3.1.1 Sampling

Sampling is about identifying and selecting a representative subset of the population or of specific people that need to be contacted to obtain relevant information and data. According to Yin (2003) non-probability sampling is often associated with case study research design and qualitative research. Purposive or judgmental sampling is a non-probability sampling method proposed by Bryman & Bell (2011) for qualitative research. This sampling method facilitates the researchers to deliberately select strategic research participants to provide important information (Maxwell, 2012). The authors have chosen this sampling method for the data collection as it is ideal for exploratory research design, even though it does not allow for generalization and subjectivism (Malhotra, 2012).

For the first round of data collection participants with sufficient knowledge and insight in logistics and emerging technologies were contacted, to be the main targets

for the semi-structured interviews. The sample consisted of six interviews, where five of the objects were researchers within logistics and emerging technologies. One of the interview objects was a provider of technological solutions to logistics service providers. For the second round of data collection, the authors found participants with key managerial positions in leading logistics service companies to be the targets for our semi-structured interviews. The second sample consisted of three interview objects working for LSP's. In addition, an interview was conducted with the Ministry of Local Government and Regional Development (KMD). This was done since only they were best suited to address one of the hypotheses.

The meetings were held online through a video conference as the COVID-19 pandemic restricted physical meetings. Video conferencing was preferred rather than telephone interviews as face-to-face contact between the researchers and respondents provided more information than the verbal response through the usage of facial expressions, body language, and a deeper understanding of the feelings and attitude towards the subjects being discussed (Brønn & Arnulf, 2019). The time spent on each meeting varied from 30 to 90 minutes. A tape recorder was used during the interviews to enable the interviewers to focus on the conversation rather than taking notes (Bryman & Bell, 2011). The audio recording was used later for the transcript after the meetings.

According to Collins & Onwuegbuzie (2007) the sample size should not be so limited that it is difficult for data and theoretical saturation. In addition, it should not be so large that it is difficult to undertake an in-depth analysis due to information overload. The sample size of ten participants has by the authors been considered to be adequate to get saturation and generate enough data through conducting interviews with competent profiles in the domain of logistics and emerging technology. This is supported by the suggestion of Eisenhardt (1989) that four to ten cases are optimal when gaining in-depth knowledge and understanding.

Interview object(s)	Organization	Technological expertise	Logistical expertise	Interview type and length
Object 1	Telenor Research - Telenor Group	High	Medium	Video conference - 60 minutes
Object 2	Telenor Research - Telenor Group	High	Medium	Video conference - 60 minutes
Object 3	ITS Norway	High	High	Video conference - 90 minutes
Object 4	Zendera AS	High	High	Video conference - 60 minutes
Object 5	The Institute of Transport Economics (TØI)	Medium	High	Video conference - 45 minutes
Object 6	The Institute of Transport Economics (TØI)	Medium	High	Video conference - 45 minutes
Object 7 Object 8	Ministry of Local Government and Regional Development (KMD)	Medium	Medium	Video conference - 45 minutes
Object 9 Object 10	Posten Norge AS	NA	High	Video conference - 30 minutes
Object 11	Dhl Express (Norway) AS	NA	High	Video conference - 30 minutes
Object 12 Object 13	LSP provider	NA	High	Video conference - 30 minutes

Table 3: Overview of the participants in the qualitative data collection.

3.3.2 Secondary data

Whereas primary data is collected by the authors themselves, the secondary data is originally collected by other researchers or companies (Bryman & Bell, 2011, p. 312). There are both advantages and disadvantages to using secondary data sources (Bryman & Bell, 2011, pp. 317–322) and some of the advantages include gaining broad access to high-quality data and information as well as it is much less time consuming than gathering the data ourselves. Making data available for secondary analysis may enhance fuller use of the data or new interpretations. In our case, we used secondary data such as official statistics, annual reports, market research reports, and news articles to gain a deeper understanding of the case study and the market it operates in. We also used secondary data to some extent to support our

findings and analysis. However, there are some limitations with secondary data that one should be aware of, Bryman and Bell (2011, pp. 320–322) argues that due to the lack of familiarity and control of the secondary data, it may be of inadequate quality or at risk to be wrongly interpreted.

We also gathered secondary data by participating in several webinars, including the City Logistics webinar hosted by Mobility Lab, the C-ITS (Cooperative Intelligent Transport Systems) webinar, and the REGSMART (Regulating Smart Mobility) webinar hosted by ITS Norway. The City Logistics webinar discussed topics regarding how to build a sustainable future and about finding ways to balance congestion impact with the growing demand for same-day/next-day home deliveries. While the C-ITS and REGSMART webinar focused on automated mobility solutions and how businesses can get a smooth digital transition. The webinars were very useful as we got introduced to actors working with emerging technologies and innovative home delivery solutions. Through the participation, we got valuable insight into the LSP and home delivery market as the webinars touched several topics related to our master thesis. Overall, the webinars provided us a better understanding of the current challenges facing the industry today, of the solutions that exist in the market, and of where the industry aims to be in the future.

3.3.2.1 Literature study

The purpose of our literature study is to provide a solid theoretical foundation to our thesis framework and interview guides. Munn et. al., (2018) suggests using existing literature to help indicate which research methods have previously been used and to gain a holistic overview of a certain topic while identifying knowledge gaps. We used this approach and began our research by investigating existing theories on technologies used in last mile distribution processes. There are several aspects to our research question, we have the technology aspect, the last mile aspect, and the sustainability aspect. The literature study required extensive research in all three aspects to find interdependencies, links, and nodes that tied it all together. There has been done a thorough literature analysis with relevance to our research question based on existing research articles, white papers, news articles, reports, and books.

Moreover, the academic literature has been gathered from different journals such as the *Business Process Management Journal, European Journal of Operational Research, European Journal of Transport and Infrastructure Research, European Journal on Transportation and Logistics, The International Journal of Advanced Manufacturing Technology, The International Journal of Logistics Management, International Journal of Urban Sciences, Journal of Cleaner Production, Journal of Artificial General Intelligence, Journal of Manufacturing and Technology Management, Journal of Environmental Management* and *Journal of Business Logistics*.

The main reason for doing such an extensive search for the literature review was the need to gain a holistic view of the existing literature and to create a basis for our expert interview questions. During our literature study, we noticed that there seems to be a lack of local Scandinavian research regarding our thesis topic, we have therefore mostly used international papers to gain more insight and deeper knowledge. We have also seen it as necessary for the thesis to be updated on the newest progress in technology used in last mile processes by continuously searching for news articles related to our research topic.

A summary of all the data sources and collection methods used is provided in the table below:

Type of data	Data collection method
Primary data	Semi-structured interviews with experts and practitioners
	Webinars: City Logistics C-ITS REGSMART
Secondary data	Official documents: Official statistics, annual reports, white papers, market research reports, news articles
	Academic literature from Journals: Research papers, literature reviews

Table 4: Source of data and collection methods

3.4 Data analysis

Qualitative data derived from interviews typically gives a large corpus of unstructured textual material which is not straightforward to analyze (Bryman & Bell, 2011, p. 571). The authors experienced this scenario after transcribing each interview resulting in having 10 documents and 103 pages of transcribed material. Bryman and Bell (2011) present a strategy for analyzing qualitative data, called grounded theory. The strategy has been defined as "a theory that was derived from data, systematically gathered and analyzed through the research process" (Bryman & Bell, 2011; Strauss & Corbin, 1998). In this method, data collection, analysis, and eventual theory stand in close relationship to one another. The grounded theory strategy fits well with our abductive approach as it helps discover new relationships and variables (Dubois & Gadde, 2002), which in our case has been to explore the relationship between different emerging technologies and the home delivery market and how it affects the variables of supply chain efficiency and sustainability.

After each interview, the conversations were transcribed, relevant quotes were highlighted followed by coding. A stepwise illustration of the data analysis process is given in *Figure 10.* Coding is an analysis technique within the grounded theory and this method helps the researchers to capture primary content and discover repeated codes that indicate the emergence of patterns and in turn helps categorize the data further (Theron, 2015). The data was coded in two rounds as two sessions of semi-structured interviews were held. Using this technique made it easier for the authors to find repetitive statements on certain topics. Additionally, the authors used this technique to narrow down the main content of the statements into four specific hypotheses, which are presented below in section 4.3.

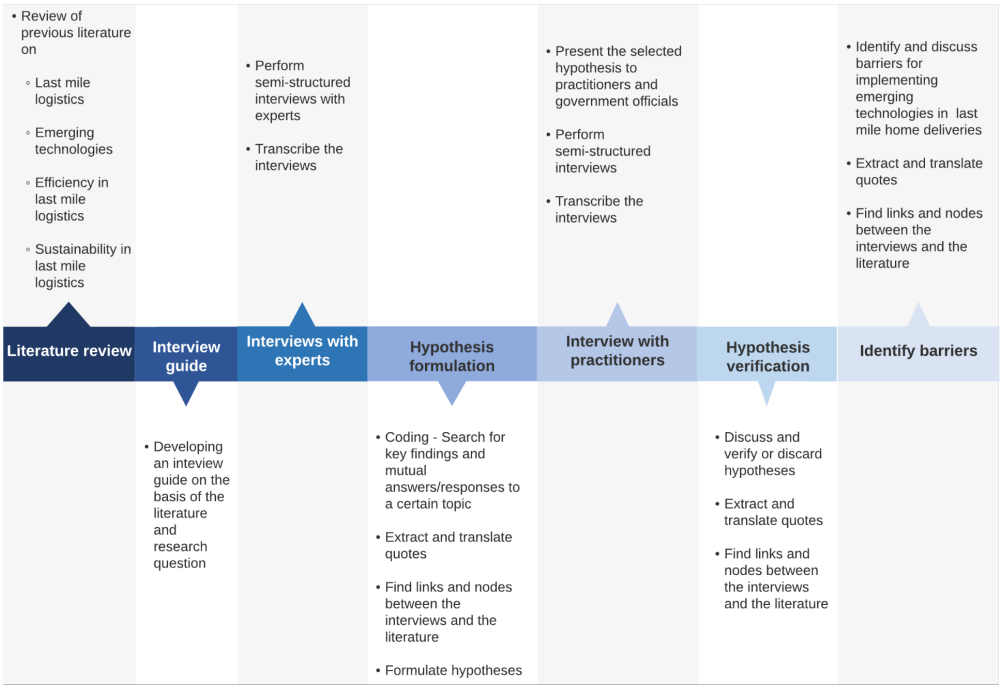

Figure 10: Stepwise illustration of the data analysis process made by the authors

1.1 Quality assessment

A major challenge for researchers is to achieve the highest possible quality when conducting qualitative data, and to ensure scientific quality, two prominent criteria; trustworthiness and authenticity must be fulfilled (Bryman & Bell, 2011, p. 395; Lincoln & Guba, 1985). Another concern regarding qualitative research is that qualitative research tends to be too subjective, difficult to replicate and generalize (Bryman & Bell, 2011, p. 408). Thus, there are four criteria's for assessing the trustworthiness of a study, that is; credibility, transferability, confirmability, and dependability. These criteria's, as well as the authenticity of the data collected for this research paper, will be discussed in this part.

1.1.1 Trustworthiness

Credibility entails how accurate and true the findings are. To obtain a high degree of credibility, the researchers should seek several sources of data to study the chosen phenomena (Bryman & Bell, 2011, p. 396). An abductive approach was therefore seen as appropriate to secure credibility as several sources of data were conducted in this study. The authors used a combination of literature, semi-

structured interviews and attended several seminars with emerging technologies and last mile context to gain knowledge and variety in viewpoints.

Transferability refers to whether the findings of the study can be adapted to other contexts or time (Bryman & Bell, 2011, p. 398). Qualitative studies are mostly of contextual uniqueness, and great concern is that the research tends to be too subjective or difficult to replicate and generalize (Bryman & Bell, 2011, p. 408). Our study addresses the barriers that exist in implementing emerging technology in last mile home deliveries. Several technologies are being discussed by both experts and practitioners, and how these technologies can contribute to increased efficiency and sustainability in the LSP sector in Norway. The authors acknowledge that some viewpoints or aspects may be missing due to the time constraint of the study as the dataset does not contain interviews from every existing expert or practitioner in the field. However, the findings should be generalizable to other complex supply chains than e-commerce.

Emerging technology is a constantly evolving topic, and breakthroughs occur continuously. Hence, even though the challenges discovered through this study might be relevant to discuss in the near future, the technologies mentioned probably won't be. Besides, every challenge is an opportunity, and our research lays the groundwork for further research upon this specific topic or related areas.

Dependability parallel's reliability and involves ensuring that complete records of the research are kept and managed in a discrete manner (Bryman & Bell, 2011, p. 398). While reliability refers to the repeatability of a study and concerns whether another researcher can achieve similar findings when reviewing the same raw data material (Riege, 2003). The conducted interviews have been audio-taped and transcribed precisely to what was said by the interviewees. However, the interviews were held in norwegian and the researchers acknowledge the risk of missing quality or context in translation. Google translate has been used to some extent, in addition, the authors have quality proofed each sentence and there has been a great focus on translating as accurately as possible. Furthermore, the data collected has been managed accordingly with the NSD guidelines, and the authors can assure that the

findings are consistent with the raw data material and repeatable, hence, dependability is secured.

Confirmability is concerned to what extent the researchers acted in good faith (Bryman & Bell, 2011, p. 398), more specifically, how well the researchers have avoided affecting their findings with their values. Bryman and Bell (2011) state that it is merely impossible to stay completely objective in business research and that the researchers' meanings and interests will somehow influence the study even if it is without intention. To avoid the risk of being biased, the authors have used audio recording and both authors have been present while conducting the interviews. These precautions limit the possibility of the author's beliefs and values influencing the data collection. In addition to being as objective as possible, the authors have interviewed both experts and practitioners to get a nuanced view of the research topic.

1.1.2 Authenticity

In addition to the four trustworthiness criteria's, Guba and Lincoln (1985) emphasize the criteria of authenticity. Authenticity contains a broader set of issues concerning the political impact of the research, these issues are; fairness, ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity (Bryman & Bell, 2011; Lincoln & Guba, 1985). The data collection of this study represents participants from different actors in the supply chain of home delivery as well as government actors and tech/last mile experts. Therefore, the authors are confident that the criterion of fairness is fulfilled. However, collecting viewpoints from every single actor in the home delivery industry would have made the research even more authentic. Anyhow, by interviewing some of the main big actors in the industry, the authors find the results to be representative of the whole industry. The authors will to some extent provide ontological and educative authenticity, as the aim of the study is to find ways of how emerging technologies can improve the efficiency of last mile logistics and hence make businesses more competitive and sustainable. Furthermore, the research contributes to catalytic and tactical authenticity as the findings provide an overview of the changes that need to be made and urges businesses and the government to take action.

4 FINDINGS

In this section, the findings from our research are presented. The structure of our findings is in line with the two interview guides (*Appendix 1 and 2*). The section has been divided into three parts; results from expert interviews, presentation of hypotheses, and results from interviews with industry actors.

4.1 Expert interviews

4.1.1 Current situation

The semi structured interviews with industry experts revealed and elaborated upon the biggest challenges within the last mile (home delivery). Several challenges were mentioned by the experts, and in this paper these challenges have been categorized in four categories. The categories are high labor costs, transport mode complexity, consumer preferences, and balancing the socio-economic perspective.

Most of the respondents mentioned that last mile home deliveries are human resource intensive, which contributes to high labor costs. This makes last mile home deliveries a very expensive business model due to the complexity of home deliveries. On the flipside this brings forth a wide range of opportunities for automation as computers are becoming faster and more intelligent, however the cost factor is still very important.

> *Much of the cost of transportation is in driver cost, if you are going to have a professional home delivery based on people who are going to carry it out then it can be a pretty expensive business model (...) The introduction of automation of that function will be an ever-increasing need.* (Object 3)

> *It is very complex, there are many factors that affect efficiency. Typically, if you are delivering to someone who lives in an apartment building, then it is difficult to find parking, doorbell etc.* (Object 4)

The expert interviews revealed that transport mode complexity is a major challenge as businesses have to consider efficiency, sustainability, and regulations from the government. This causes increased costs, uncertainty and operational inefficiencies.

> *Another challenge is the climate part, which vehicles do you use? How can home delivery be carried out in a financially sustainable way?* (Object 3)

> *Companies focus on using the right vehicle in the right vehicle park, so the EV does not have to charge during the day. It is important to have EV's with different ranges in the fleet.* (Object 4)

Another major challenge is that B2C customers are very demanding and expect a very high level of service compared to B2B customers. Short delivery windows and lack of flexibility makes consolidation of goods challenging. Consumers have a busy life, and they expect the transport service to be flexible. Consumer demand towards fast deliveries rather than sustainable deliveries makes it increasingly challenging for LSP's to balance the aspects of sustainability and efficiency.

> *Consolidating the goods is a very important part of getting a good business model and making optimal use of the vehicles. So, the big question is, how do you do it while meeting consumers' needs for flexibility?* (Object 3)

> *It is not sustainable to not be able to make a home delivery and have to drive the item back to the warehouse. It is much easier to create sustainable flexible solutions to avoid such issues when it comes to B2B rather than B2C.* (Object 3)

> *Many people have a very busy everyday life, and when you have a delivery home, it should fit into the busy everyday life. Therefore, it is very important to have good communication between the users and the couriers. New technology has helped a lot to improve communication.* (Object 4)

> *It is important for online stores to make the process as smooth and easy as possible for the customer (...) When customers get the choice, they often choose the greener/cheaper option according to their preferences.*
> (Object 6)

Finding an optimal balance between sustainability and efficiency is identified as a key challenge. Increased home deliveries generate increased traffic in neighborhoods, and some experts argue that this will increase the total overall transport, making the socio-economic balance unsustainable. The findings show that it is possible to make last mile home deliveries more sustainable, but the focus is rather on making it faster. In addition, there is a lack of visibility for the consumers, making their choice of transport service a tradeoff between price and delivery time, rather than including the environmental impact.

> *A lot of home deliveries generate a lot of transport than only shopping at the store. Usually when you are at the store, you do other errands at the same time. Must make an assessment of what is the most sustainable.* (Object 3)

> *No measures are being taken that provide an incentive for a smarter, more sustainable ordering of transport services (...) the biggest challenge is to make the customer aware of the transport they generate when they shop online.* (Object 5)

> *When something becomes more efficient, that efficiency is usually taken out in different ways. You can either charge the consumer more money, deliver faster, or do it in a more green and sustainable way. Right now, there are few intensives to make it more sustainable, instead we are getting faster home deliveries.* (Object 6)

> *I believe that if you make the customer aware of the transport he or she generates when ordering online, you can increase consolidation, get more environmentally friendly delivery services, reduce the amount of traffic and increase sustainability. (Object 5)*

4.1.2 Emerging technologies

In the literature review section of this paper, the authors elaborated upon how big the phenomenon of emerging technologies is. Hence, in the semi structured interviews, the experts were specifically asked about emerging technological

solutions within autonomy such as autonomous vehicles, drones and robots. In addition, the experts were asked about software's such as AI and big data.

4.1.2.1 Self-driving vehicles

The expert interviews revealed that self-driving vehicles have great potential as they eliminate the cost of labor related to a driver. However, it will take a long time before we get self-driving cars on the open streets. The reason for this is that the technology is too immature. In addition, these machines require an effective support system around them.

> *It is a very long time before we get self-driving cars on normal, busy roads and streets/open areas. Admittedly, pilot projects are running with buses that cruise at 20km/h, but the technology is far too immature to let self-driving cars into traffic.* (Object 2)

> *One of the advantages of small autonomous vehicles is that they can replace several couriers, but if they get stuck on a curb, or (...) are damaged or stopped. Then someone has to fix or bring them in. It becomes important to have an effective support system around them.* (Object 6)

It is crucial that the sensor technology and AI works perfectly as there are many factors in the environment to consider. Equally important is the considerations towards regulations and enabling infrastructure. However, numerous pilots with autonomous vehicles are running in controlled areas (e.g., factories, warehouses and ports).

> *We expect that the fifth generation of autonomous vehicle technology will be mature enough for this, and as of today we are at level 2-3* (...) *It comes into use much faster in closed and controlled areas.* (Object 2)

> *There are many things that need to be in place. One thing is to develop sensors (...) and the artificial intelligence that is needed to be able to read the traffic picture correctly and make the right movements and such. The second is the regulation of the sector and the type of traffic, it is a huge topic*

> *that is very easy to underestimate (...) You must also have a suitable infrastructure (...) you must have a charging infrastructure that is adapted to the type of vehicle and the type of traffic* (Object 3)

4.1.2.2 Drones (UAVs)

The expert interviews revealed that drones in the form of unmanned aerial vehicles (UAVs) have great potential both in urban and rural areas. Even though they can carry less weight, they do not have the same infrastructure constraints as self-driving vehicles.

> *Drones are probably coming so it's buzzing. You do not have the same requirements for infrastructure, you have infinitely more space in the air than on the ground, but there are obstacles and regulations in the aviation space as well.* (Object 3)

Several pilot projects are taking place in controlled areas. According to the expert interviews the progress is relatively slow, even though the technology is mature. A major concern which is slowing down the implementation of UAVs is the lack of regulations from the government.

> *Airspace must be regulated in completely different ways than it is done today. This is only in the start-up phase and pilot projects take place in highly controlled areas.* (Object 1)

> *When it comes to drones, it will be necessary to implement a signaling system for low-flying drones as it is for aircraft, so that all drones know where the others are. Everyone must be connected to the same central control system so that accidents can be avoided* (Object 2)

> *The authorities predicted that drone delivery would become common in 2018-2019. There is absolute potential, but I think it is quite a long way before it becomes a practice with drones in the public space. There are several security challenges.* (Object 5)

> *New regulations must be in place where airspace is regulated in terms of the altitude and the direction of the drones. Until it is in place, no one will allow drones to deliver anything. This is probably a long way off.* (Object 2)

In addition to the lack of regulations, there are major concerns regarding safety. There is also a lack of research on the effects of drones on public health, especially in the form of noise.

> *We do not have enough research on how many drones it is okay to have in the air, and how much noise is acceptable by the people (...) In Switzerland, there was a case where UAVs moved goods across a lake, but then a drone fell down (...) the project had to be stopped for 3 months because people were scared.* (Object 6)

> *Before drones can enter the market, we need to get more research in place (...) Must find out what the acceptance levels are, are we for instance disturbing the health of Oslo`s citizens by introducing 5 drones that fly regularly? We lack research on that.* (Object 6)

4.1.2.3 Robots

The experts agree that replacing human labor will be a key driver for a more efficient transport system. Like autonomous vehicles, robots that are able to replace the tasks of a courier in a home delivery setting are also considered too far away. The technology is considered to be immature, making the investments too large and inflexible.

> *Replacing human labor will probably be the main key for the transport sector. You already have industrial robots for packaging and loading.* (Object 3)

> *The cost of a human is around NOK 150 an hour while a robot most likely costs you many hundreds of thousands (...) By setting a robot up against a human, the deviation is so extreme that it is not feasible to use a robot*

> *instead of a human. The incentives to make such a large investment, when you can rather use people for a small sum, is very very low. In addition, you get much less flexibility with a robot, everything must be pre-programmed.* (Object 4)

One of the experts argued that there is still great value in having a human driver due to their intelligence. This coincides with our literature review, that we are far away from artificial general intelligence (AGI), which is just as intelligent as a human.

> *I do not think the robots will replace all the tasks in transport, for example a courier driver who is familiar with the residential area, familiar with customers, and routes. If there is a change notification, there is a great value in having a physical driver. I believe that it will take a long time before robots and autonomous vehicles can replace such human intelligence. (*Object 5)

To be able to utilize the capabilities of these solutions at a grand level, it is important to have access to good and reliable data for the supply chain partners. Big data is a key technology in making this a success, hence making the level of information exchange crucial.

> *By using big data together with new technology, we are able to arrive at more real objective data to improve the route optimization quite a lot.* (Object 4)

4.1.3 Information exchange

In the literature review section of this paper, the authors elaborated upon that a good flow of information among supply chain partners is crucial for their success. Then relevant emerging technologies depend upon good information to make predictions and decisions. Hence, in the semi structured interviews, the experts were specifically asked about the need for a higher level of information exchange. In addition, the experts were asked about challenges or barriers in today's transport system to ensure a good flow of information.

The expert interviews revealed that LSP's are hesitant towards sharing information to make their own, other actors and their stakeholders processes more efficient. A reason for this is the lack of incentives and that information is viewed upon as a strong competitive advantage.

> *Each carrier holds information about their transports close to the chest. It is difficult to cooperate, and a lot of information about the deliveries in the area is not available to everyone who may be able to use it to make it more efficient. (...) Information is seen as a strong competitive advantage.* (Object 6)

However, there are some initiatives in place to encourage collaboration. ITS Norway is a membership association for everyone in the transport industry. They are working towards developing, promoting and coordinating the implementation of intelligent transportation systems in Norway.

> *We work with the authorities to create competition-neutral meeting places between the authorities and the business community so that they can have an arena to talk to each other without coming into conflict with procurement rules, etc.* (Object 3)

A major challenge regarding information exchange is that data streams are expensive. To create meaningful insights from the data, which leads to new business models and software solutions often require a combination of various data streams. Some of the data streams or data sets are open source, while others are licensed. The challenge that actors working towards solving some of the issues in the transport sector face is that the combined price of all the data streams needed is far greater than the price they are able to charge their customers.

> *There is a challenge with Google, all the historical traffic data they own is expensive to procure. Buying it all the time is challenging. Our challenge is that we need to have information from 5-6 different sources into one product, so everyone sells their information as their only product, and then*

> *often charges as if it is the only product you should buy. They do not have to deal with the fact that you need to buy 5, 6 other products. The price is often very high, which means that even though there are some weaknesses with open-source data, both technological and data quality, it is not financially possible to buy all the data you need because there is no margin left for us. Thus, open source becomes the option.* (Object 4)

Technological infrastructure is crucial for effective information exchange. A challenge facing the transport sector and various other industries, is that they rely on proprietary technological infrastructure, which makes the sharing of information outside of their organization complicated and challenging.

> *What we register from the telecom industry's point of view is that there is great interest in being able to use shared infrastructure as mobile networks and 5G represent. Many people are interested in this opportunity, precisely because it is very expensive to build and operate proprietary infrastructures. If you can share infrastructure, then it is very attractive from a cost perspective. In addition, standardized solutions can hopefully make it possible to connect different systems in new ways and thus provide added value.* (Object 2)

Moreover, there is a relationship of mutual dependency between the government and the industry in order to make progress for the society. The expert interviews revealed governmental investments to be another challenge to efficient information flow, as building solutions for the future requires continuous updating of the foundation.

> *The current establishment represents a great slowness, an institution that takes a very long time to change. Major investments have been made in technology and in building institutions. To write it off and replace it with something completely new, takes a very long time. This is one of the challenges now when the telecom industry wants to offer network solutions to other industries such as the road transport sector and others, because within telecom there is a new mobile network generation every decade. 2G, 3G, 4G and now 5G.* (Object 2)

4.1.4 Sustainability

In the literature review section of this paper, the authors elaborated upon that the transport sector is a sector where efficiency and sustainability have a positive correlation. In the semi structured interviews, the experts were specifically asked about how sustainability is related to emerging technologies, how sustainability is measured, and how the EU Green Deal affects the transport sector.

There is a general consensus among the experts that emerging technologies will lead to more sustainable and efficient solutions. However, implementing and operating these technologies come with their own challenges regarding sustainability.

> *The future-oriented technology we have been talking about is extremely energy-intensive, so we have to work very hard to ensure that the technology we develop is sustainable. This is a huge challenge in itself.* (Object 1)

Another challenge is that the development of infrastructure required to make the green shift is not being built fast enough. A major concern is the growing need for charging stations for EV's as well as the comprehensive infrastructure (technological and physical) required for operating with robots, drones and self-driving vehicles.

> *You have to expand the infrastructure again to be able to charge vehicles, and the power grid in Norway is not designed for everyone to charge their cars at the same time. Then you will not be able to charge all drones or robots either, for those who will carry out last mail delivery with such vehicles.* (Object 2)

As mentioned in the section above, there is a need for collaboration in the form of information exchange. When asked about how sustainability is measured in the transport industry, no specific standards were mentioned. A reason recognized for this is the lack of information exchange among supply chain actors.

> *In addition, we struggle to benchmark the effects of using dynamic route optimization because we do not have any data to counteract it.* (Object 4)

> *We have not set up a way to measure sustainability, it is an area where we are unsure of where the effect lies. We see for every new customer we get that we find effects we have not thought of before.* (Object 4)

When asked about how the EU Green deal is affecting the transport sector in Norway the experts considered it to be a good initiative to help local municipalities make more sustainable plans.

> *An efficient and sustainable transport sector has not always been on the agenda, but now that the EU Green deal has laid down guidelines, the municipalities can say that they must work with it because it is required by law and has a reason to prioritize those matters.* (Object 6)

When asked about the ethical dilemmas and issues related to the introduction of solutions based upon emerging technology, the experts were concerned with challenges related to liability, and ill intentions. In addition, the dilemma of balancing the benefit to society with increased pollution.

> *In Asia, diesel generators are used to operate base stations in some cases. Just the idea is completely cruel, but on the other hand, you bring your mobile phone out to people in the outermost villages of Bangladesh, they get access to mobile networks and get the opportunity to develop their business base. This is a dilemma, you are doing something that is good but not necessarily environmentally friendly.* (Object 1)

> *The big question is liability, if a self-driving car injures someone in traffic, who should be held responsible? Is it the one who owns the car or the one who has ordered the car for himself?* (Object 2)

4.2 Hypothesis

The expert interviews left the researchers with questions that the experts could not elaborate upon. It was also interesting for the researchers to explore some of the statements collected during expert interviews with real life practitioners in the field. The following hypothesis was therefore formed:

1. Human labor is the biggest cost when it comes to home delivery. Hence, automation in the form of self-driving cars, robots and drones will have great potential to reduce the costs associated with home delivery in the near future of 20-30 years.

The reasoning behind this hypothesis is that the expert interviews emphasized the important role of solutions such as self-driving cars, vehicles and drones towards efficiency. However, the researchers argued that the technology is still immature. Hence, the hypothesis was formed with a timeframe of 20-30 years given the maturity level, infrastructure development, regulations and acceptance.

2. Optimization of logistics processes made possible by the use of AI and big data has a great potential for providing environmental benefits, as well as increasing the efficiency of home deliveries in the near future 5-10 years.

Data sets and data streams have been available for a long time, however the competence and the computational power of getting meaningful insights from the data has been challenging. With the availability of IoT, AI and big data in addition to increased collaboration among supply chain actors, it is expected that the data will bring forth more meaningful insights and decision-making processes. Given the barriers related to information exchange, a timeframe of 5-10 years is presented.

3. There is weak cooperation between actors in the business community. Increased collaboration in the form of sharing information, infrastructure and resources will contribute to increased efficiency and environmental benefits.

The reasoning behind this hypothesis is that the experts' interviews revealed that there are socio-economic benefits as well as benefits related to increased efficiency by both horizontal and vertical collaboration in the supply chain.

4. The government lacks in providing good solutions and incentives in the form of regulations and infrastructure, so that the business community can invest, test and use new technology on a large scale with the goal of increasing efficiency and sustainability.

The expert interviews stressed that the government needs to facilitate the green shift, and the implementation of emerging technologies. The industry is having concerns regarding technological and infrastructure due to long term investments, unsuitable electrical systems, slow development of charging stations and slow processes regarding new regulations and permits.

4.2.1 Hypothesis model

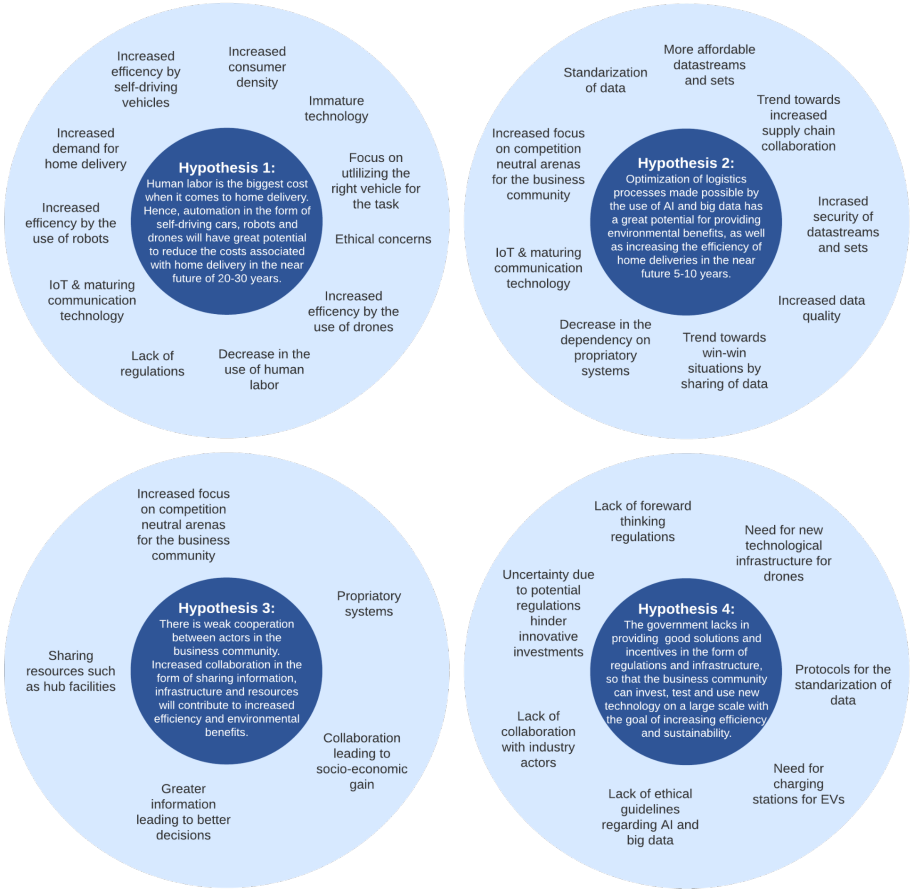

Figure 10: Summary of the main findings establishing the four hypotheses from the expert interview, made by the authors.

4.3 Interview with practitioners

Based on the hypothesis, interviews were held with KMD (Kommunal-og moderniseringsdepartementet) and three major logistics service providers**.**

4.3.1 First hypothesis

The first hypothesis is the following:

Human labor is the biggest cost when it comes to home delivery. Hence, automation in the form of self-driving cars, robots and drones will have great potential to reduce the costs associated with home delivery in the near future of 20-30 years.

All of the interviews agreed and confirmed that labor cost and the costs associated with the transport mode were the largest cost factors in last mile home deliveries. They also agreed with the timeframe in the hypothesis and mentioned that the technology is evolving and that it is not justifiable in terms of costs right now.

> *The drivers and of course the vehicles are the cost drivers.* (Object 11)

> *Given what it costs for that type of technology today and what it will cost in 20 years, it would most likely be correct to think that automation almost eliminates the need for physical labor.* (Object 10)

> *There is still a lot to learn about autonomy and related technologies, but of course if you think in a 20-year perspective, anything is possible. But in the next 4-5 years, we do not see that the cost level of using such technology is sustainable.* (Object 9)

The interviewees partly agreed that the technological solutions we proposed will have great potential to reduce costs and improve efficiency. Pilots have been running on self-driving reception boxes, but even though the last mile can be shortened greatly, making the last meters to the customers doorstep is very complex and costly.

> *We have tested the concept around self-driving reception boxes, it is a technology that in the long run can be cheap enough to be rolled out on a large scale.* (Object 9)

> *I'm unsure to what extent automation can solve the last mile challenge, seen in a dependent relationship that the recipient must be home to meet the autonomous vehicle.* (Object 9)

The participants viewed reception boxes near to the receiver's residence as a form of home delivery. They also argued that attended home deliveries are very difficult as the receivers have busy schedules. Hence, to make automated home deliveries viable, there is a need for smart homes.

> *We look at a vending machine as a mailbox rack, or an extension of the customer's mailbox. A reception box machine I would say is a form of home delivery.* (Object 12)

> *What makes home delivery more complex is that you have to meet the customer with the technology we are looking at now. To use smart technology, we must first have smart homes, right?* (Object 10)

One of the participants mentioned that consumer preferences might differ greatly in 20 years. Therefore, it is challenging to predict if these solutions will have the greatest impact.

> *So, the question is whether there are better ways to offer good home delivery services, which makes me unsure if I want to deny or confirm. Because we may see completely different changes or changes in demand over the next 20 years that we must take into account.* (Object 10)

When asked about the potential of smart robots the participants were more reluctant towards the feasibility and potential of robots. As the robot would need to have all the properties of a human courier, the technology might be adapted in a longer time perspective.

> *I have a hard time imagining that a robot can deliver home (...) But of course there are variants here, if we stick to home delivery. In an area that is densely populated (e.g., Oslo), then you can have a system where a self-driving vehicle arrives, transfers packages and deliveries to a vending machine (...) It is also possible to have some of these spread out over a separate city or in a residential area. But somehow from there, until this robot arrives right at the door, rings at the door and delivers, then I would say a much longer time perspective, if it is at all possible to do.* (Object 11)

The participants argued that we will most likely see a shift towards home deliveries to reception boxes nearby residential areas and self-driving reception boxes. Hence, the receiver will have to walk outside their residence to receive their goods.

> *There are many benefits to picking up at a drop-off point, as opposed to sitting at home and waiting.* (Object 11)

> *There will be more of an ice cream truck approach, that when the self-driving delivery van arrives, you have to physically go out and pick up the package.* (Object 12)

Asked about the potential of drones (UAVs), the participants meant that there is potential in certain settings but not in the way the media has been portraying it.

> *When it comes to drones, it is something the media has been very fond of and talking about for many years, while we in the industry have not really been that enthusiastic there.* (Object 12)

> *On drones, it is more about what type of transport it is best to use them for. We do not see it as optimal to fly drones in the middle of Oslo city center to deliver packages to homes.* (Object 9)

The reservations towards drones were mainly driven by the limited use today, the complexity and the lack of regulations.

> *Our barrier for drones will probably be that there is limited use for them today. Otherwise, the economic scalability of it, and the rules of society by applying that technology.* (Object 9)

> *I have also received inquiries from companies that have contacted me and asked if we are interested in drone deliveries to the vending machines, but who will then place the packages in the vending machines? There is also zero regulation on this. Are you going to have lots of drones flying around the cities then? Imagine that there are 100,000 packages a day to be delivered around Oslo. Drone capacity is usually one package at a time.* (Object 12)

4.3.2 Second hypothesis

The second hypothesis is the following:

Optimization of logistics processes made possible by the use of AI and big data has a great potential for providing environmental benefits, as well as increasing the efficiency of home deliveries in the near future 5-10 years.

The semi-structured interviews revealed that everyone uses AI and Big Data to some degree in the industry. It is expected that AI and big data will have the biggest potential within the area of optimization, and specifically route planning. The technology is to some extent in use today, but mostly static route planning. There is still a lot of potential and room for improvement as dynamic route planning is complex to implement.

> *We use AI and Big Data primarily to fine-tune the routes before they leave the terminal, but not while the route is running.* (Object 11)

> *We use Big Data and AI to a certain extent to automatically make changes to other routes in order to still have the optimal route structure so that it enables all deliveries to be made within a certain time period.* (Object 11)

When it comes to sustainability, it is believed that a fossil-free car fleet will have a greater effect than dynamic route planning.

> *I do not agree with the hypothesis that AI and Big Data have the greatest potential. The greatest potential for achieving environmental benefits in the industry in general is by changing car fleets, i.e., switching completely to fossil-free.* (Object 12)

The participants also supported the findings from the expert interviews, regarding the positive correlation between sustainability and efficiency.

> *If we do things more efficiently, then we will profit from it both economically and environmentally.* (Object 9)

> *An optimized route structure is good for the environment because any LSP will always seek to optimize so that the distribution route is as efficient as possible and that we drive as short as possible. What is good in terms of efficiency and cost, it is also good in terms of the environment.* (Object 11)

One of the areas these technologies are expected to make a huge impact is dynamic route planning. However, there are numerous challenges related to data quality. In addition, tech companies are entering the transport sector to challenge the established LSP's.

> *Route planning is not difficult, but getting it loaded with that combination you want of products, sizes and possibly grouping, it is difficult.* (Object 12)

> *You can use traffic data and weather data, but the information is still not fine-tuned enough. If you are delivering a package on the fourth floor in Oslo, there is no data on how long it will take for you to deliver to the specific block. There are enormous opportunities here, but it is also very complex.* (Object 12)

> *When it comes to route planning, you look back 10 years, there were hardly any things. Now there is a forest of companies, tech companies, you have pure tech companies that now do home delivery.* (Object 12)

4.3.3 Third hypothesis

The third hypothesis is the following:

There is weak cooperation between actors in the business community. Increased collaboration in the form of sharing information, infrastructure and resources will contribute to increased efficiency and environmental benefits.

The interviewees partially agreed with this hypothesis. Several argued that they are most effective as independent actors, and that collaboration can be beneficial for small actors. In addition, there were many risks associated with collaboration between LSP's. For instance, risks related to liability, competition, innovation, and strategic advantages.

> *We have an efficiency on our deliveries that is so high that a third party distributing for us and for others, will never in the world be able to be as efficient.* (Object 11)

> *From a socio-economic perspective, there should only be one logistics actor. But then we would have been in a monopoly situation, I would say that it is healthy with competition to drive new and better solutions and a market price that makes things move forward*. (Object 12)

> *If we were to share everything with everyone, what separates us from our competitors?* (Object 13)

One of the objects pointed out that there was a lower threshold for looking for collaboration opportunities across industries. Posten has, among other things, a collaboration with KLP and Ragn-Sells which is called the *"Beloved city project"*, the collaboration has led to less traffic and increased sustainability. Through an

interdisciplinary collaboration, one can complement each other's value chain without having to worry about the competition perspective.

> *Cooperation with competitors is limited as it should be according to competition law, but I think there is great potential in different types of concentrations and cooperation across business industries.* (Object 9)

> *When you go across the business industries, you will find opportunities for collaboration across different industries that together can create new systems. By complementing each other's value chains.* (Object 9)

The government is working towards being as transparent as possible by sharing public data.

> *Data from the public sector is being made available to a much greater extent for the private business sector, so that they can take advantage of this. That is something we have been working on, to be as transparent as possible.* (Object 7)

One of the participants pointed towards market research and argued that speed is more important than the environment for the customer. In addition, the customer does not have any willingness to pay for the speed or specifically the environment.

> *If you look at market research, they (the customers) often answer that they care very much about the environment, but then the willingness to pay is not there in reality. (...) If we look at what a consumer expects from lead time, we have noticed that the consumer is not so concerned about the environment when it comes to willingness to pay, there is a very low willingness to pay for transport in general.* (Object 12)

4.3.4 Fourth hypothesis

The fourth hypothesis is the following:

The government lacks in providing good solutions and incentives in the form of regulations and infrastructure, so that the business community can invest, test and use new technology on a large scale with the goal of increasing efficiency and sustainability.

The semi-structured interviews revealed that the LSP's agree with the hypothesis. They understand why the regulations are set by the authorities but argue that the regulations are time consuming processes, complicated and often hinder and slow down new initiatives and developments.

> *The hypothesis sounds correct, but then there is a balance to it, for us as a business actor, we naturally want to have freer regulations because we want to drive development. At the same time, we are dependent on having these regulations in order for the society to function, so it is certainly a friction that always will be there. (...) Framework conditions for public procurement, or whether there are regulatory framework conditions for tests of new vehicles or completely new concepts, that can certainly slow down or complicate the development.* (Object 9)

KMD believes that it is easy to point out that the public sector must facilitate the business community. They argue that the business community must also be able to find the right models that are able to function in line with the regulations that have been set.

> *If one is to automate the transport for the last mile then self-driving robots that walk or drive on sidewalks, and self-driving cars and possibly drones are presumably the solution. But this is technology that has already been developed, however it must be safe to control these technologies in the public space. This is where our area of responsibility comes in, there will be radio frequencies to control drones, and mobile networks that help to monitor and control remotely, i.e. autonomous vehicles and other forms of*

> *robots that move on the sidewalk and so on. So, we are an infrastructure player in that connection, but there are a number of regulatory challenges here as well.* (Object 7)

The LSP's express uncertainty about who will bear the costs of the development. Another uncertainty factor is the regulations that are set and could be set in the future, and how they might impact their business. One of the LSP`s expressed that the closing down of streets in Oslo has led to huge challenges, and that they have not been involved in the processes or received any support from the government afterwards.

> *Oslo is very ambitious with its environmental goals. It is one thing to switch to fossil-free vehicle solutions. But now there is also the question of whether biogas is allowed to be used within these zones. Then there are questions about infrastructure. Who will bear the cost of infrastructure when you have a large enough network for biogas / biodiesel / electricity solutions? These are big investments that need to be made, but by whom?* (Object 13)

> *We get time windows we are allowed to deliver in and then we have to deal with it (...), they close down, but there is little help or guidelines to get for how we should deliver everything that is needed to be delivered. At least that's my impression of the government.* (Object 12)

On the topic of sustainability KMD encourages last mile actors to see synergies across markets to find new smart solutions. KMD does not want the regulations to be an obstacle to development, changes in the regulations take time and this also applies at the international level. KMD explains that they are working to facilitate the development of a national 5G network so that they have the basic structure needed for optimization of the data, but they also state that they are not working to create end solutions, that role is given to the businesses.

> *We want to facilitate innovation, but then there are obstacles we must overcome. Therefore, we have facilitated "regulatory playgrounds" where businesses can test new things outside the current regulations.* (Object 8)

> *The public authorities are not working to create the final solution, the ball has been given to the players in the business world. Last mile actors must be able to see synergies across markets to find smart solutions (...) They must discover the right business models that manage to work in line with the regulations because we work with global standards that have focused on security and the solutions must be generalizable.* (Object 8)

In addition, the government has stakeholders from both state and municipalities.

> *There is a slight difference between the state and the municipalities. There are both state and local rules, and yes it gets more complicated.* (Object 7)

On the question of how the government worked towards or in line with the EU Green Deal, KMD pointed out that the state's goals are more ambitious than the EU Green Deal. This was also the case for two of the LSP's.

> *Our goals are more ambitious than the EU Green deal, we are working hard to turn our climate goals into zero emissions by 2045. We also aim to only use fossil-free cars and buildings by 2025. This is an area we are working hard on, so if Norway is to halve their emissions from the transport sector, it means that we must contribute even more.* (Object 9)

> *We are much more ambitious than the EU Green deal goal, in 2030 we will be 100% fossil-free. In 2025 we will already be there.* (Object 12)

Regulations and the introduction of standardization in the field is time consuming and demanding because the government has to deal with national and international stakeholders. As the technology is still evolving, regulations have to be well crafted.

> *Your research area is frequently being discussed in EU forums, about whether one should have common European rules which then Norway may*

eventually have to comply with. It's challenging because we must know how to handle some liability issues around this topic first. (Object 7)

4.4 Barriers for implementing emerging technologies

In order to fully answer the research question, the sub-question concerns barriers for a successful implementation of the selected emerging technologies. The barriers need to be addressed and broken down, and the authors have therefore consequently added questions regarding implementation challenges in the interview guide (See Appendix 1 and 2). Through the interviews, several barriers were identified, and these will be presented using the PESTEL framework. PESTEL is an acronym for Political, Economic, Socio-cultural, Technological, Environmental and Legal factors (Alvarez, 2014). The framework is used by the authors to structure and categorize barriers identified from the interviews, and to understand the bigger picture of adopting the selected emerging technologies into businesses. Further, the analysis assists the authors to discover hidden opportunities from the barriers which will be discussed in the next section.

4.4.1 Political barriers

Political factors refer to what degree a government intervenes in the economy or a certain industry as well as laws and regulations that businesses must adhere to in their respective operative countries (Issa et al., 2010). In terms of the sub question, four main political barriers for implementing emerging technologies in LM context were identified during the interviews. The first barrier concerned the need for new, more suitable regulations to keep up with the digital pace as some industry actors expressed their concerns about the inadequate infrastructure in Norway. The second barrier addressed the complexity in regulations as there are both state and local laws and regulations to adhere to. While the third barrier referred to the uncertainty business actors face around the use of emerging technologies due to immature regulations, which is also the fourth barrier.

When it comes to drones, it will be necessary to implement a signaling system for low-flying drones as it is for aircraft, so that all drones know where the others are. Everyone must be connected to the same central control system so that accidents can be avoided. In addition, I believe that

new regulations must be in place to regulate the height and direction of the drones. Until it is in place, no one will allow drones to deliver anything. This is probably a long way off. (Object 2)

You have to expand the infrastructure again to be able to charge vehicles, and the power grid in Norway is not designed for everyone to charge their cars at the same time. (Object 2)

There is a slight difference between the state and a municipality. Both state and local rules apply and yes it gets more complicated. (Object 7)

4.4.2 Economical barriers

Every factor that weakens a country's economic performance or hinders profit for an organization could be considered an economic barrier (Issa et al., 2010). The findings revealed several barriers that need to be solved before companies profit from using the selected emerging technologies. One of the barriers mentioned was that the end product often tends to become too expensive. Another barrier mentioned was the lack of incentives to invest in emerging technologies since human labor is more cost efficient today than using robots for the same task.

A human costs maybe 150 NOK per hour while a robot most likely costs you many 100,000 NOK. The incentives to make such a large investment are very very low. In addition, you get much less flexibility with a robot, everything must be pre-programmed. (Object 4)

Looking at these tech companies, there are none of them that are close to making money or even going break even. (Object 12)

In the next 4-5 years, we do not see that the cost level of using such technology is sustainable. (Object 9)

A prominent economic barrier discovered from the findings was the challenge of dealing with several proprietary systems. They are difficult to coordinate and expensive to replace with standardized solutions, however standardization is

necessary to achieve a digitally connected society. Moreover, there were mentioned issues regarding conflict of digital infrastructure investments.

> *There are a number of business agreements that need to fall into place, because you have someone who will invest in the road infrastructure, someone will invest in quality assurance of the infrastructure, someone in the applications and everyone sees autonomous vehicles as an opportunity and will extract profit from it (…) You also have the county roads, and the national roads, which are also invested differently, they must also cooperate. Then we have to think about the different car brands that are used, do they have the same type of applications? This is not only technological, but also economical, several players must work together to put in place agreements for autonomous vehicles to become a reality on Norwegian roads.* (Object 1)

4.4.3 Socio-cultural barriers

Socio-cultural barriers are related to consumer awareness, citizens attitudes, organizational culture and individual practices (Issa et al., 2010). In this case, all factors that resist using emerging technologies for its optimal purpose. Interviews with several LSP actors revealed that businesses find it challenging to operate in the B2C home delivery market due to its unpredictable nature. This in turn made it more complex to use emerging technologies. Another challenge was the lack of acceptance to emerging technologies and the trust issues with self-driving vehicles in public spaces.

> *To create enough trust in the machine to sit in a driverless vehicle and make consumers have confidence in the system is challenging. Automatic transmission vehicles have existed for almost 40-50 years, but it has taken an extremely long time to get most cars to automatic transmission. In Norway, there are still many who still drive manuals. When we know people's resistance to new ways of driving cars, then we have to think, why should people choose to get into autonomous vehicles when they do not even let go of manual transmission?* (Object 1)

The B2C market is very sporadic, it is hard to collect data on it. (Object 4)

Other resistance factors identified for using emerging technologies such as robots or drones, are the lack of flexibility for the consumer and the diverse housing conditions of the citizens in Norway.

> *How do you maintain flexibility? Without being dependent on the recipient actually being at home and in such a way that you are secured against both theft and unintentional damage due to the temperature being wrong?* (Object 3)

> *There are too many variables; depending on whether you live in a separate house or apartment, or whether there are one or several entrances, how will these technologies manage to deliver to all varieties?* (Object 3)

4.4.4 Technological barriers

Although there are many advantages of using the aforementioned technologies, there are some concerns. Several interviewees highlighted that there is a huge difference from testing emerging technologies in small pilots than launching an actual service using these technologies. A repeated barrier was that the technology is still not mature enough to be used in public and that it is challenging to even get a pilot project in place due to the complexity and uncertainty surrounding the emerging technologies. The findings also revealed that businesses are in need of increased tech competence to manage the technology and to discover business opportunities. External factors were also mentioned to be challenging to handle, because there are so many variables such as weather conditions and traffic that must be aligned. In addition, the need for effective backup solutions or a comprehensive support system around the technologies were brought up as a resistance factor.

> *The weaknesses are perhaps more that it is difficult to realize, things do not go as expected in practice (...) It takes time for all parties to absorb that complexity and learn to deal with it. (...) It is continuous learning.*
> (Object 1)

> *The transport systems must be up and running all the time, they cannot be down for a week due to installation of a new system. So, then it is much more convenient for us to put new layers upon outdated systems. But in the end, it creates enormous inefficiency. But this problem creates opportunities for other new players who can start with blank sheets.* (Object 4)

> *A courier has to make a number of decisions in one day, if a change notification comes, there is a great value in having a physical courier. I believe that it will take a long time before robots and autonomous vehicles can replace such human knowledge.* (Object 5)

4.4.5 Environmental barriers

There is a growing focus towards environmental issues due to the scarcity of raw material, carbon footprint and pollution targets set by governments (Issa et al., 2010). Environmental barriers refer to every factor negatively impacting the climate, and in this setting, aspects that make operating with emerging technologies less environment friendly. Although every interviewee agreed that sustainable principles must be integrated into the technological solutions, they did not provide any answers on how to make that a reality. One comment was that there has not been enough research done on the environmental impact of emerging technologies in public spaces, and that the businesses lack proper measurement systems to measure all aspects of their environmental impact. Other concerns were regarding space and the energy consumption of having connectivity. However, there were some contradictory opinions among the interviewees on how technologies could contribute to increased sustainability. Some had a lot of faith in the opportunities while some meant that using emerging technologies for sustainable matters were just a way for businesses to show off given the premature stage of emerging technology solutions.

> *It requires an enormous amount of energy to fire up base stations and networks, and so do servers that will carry all this processing of the applications needed for autonomous vehicles to run.* (Object 1)

> *When we measure the number of stops per hour, then if half an hour is lost to charge an electrical vehicle, that is a loss of very expensive time.* (Object 11)

4.4.6 Legal barriers

Legal factors tend to overlap with political factors, but this category covers more specific laws such as consumer protection laws, health and safety laws and ethical issues (Issa et al., 2010). A majority of the interviewees shared their frustration over slow bureaucracy decisions and that the increase in restrictions to operate in urban areas are becoming challenging. While the government actors explained in their interview that the regulatory environment in Norway is heavily influenced by the EU regulations and that regulatory challenges take time to solve both at international and national level. Moreover, the authorities are obliged to make decisions for the greater good of the socio-economic situation in Norway, while business actors have the freedom to act more opportunistically. Thereby, there will be a constant friction between business actors and the authorities as both parties are mutually dependent but do not always share the same investment incentives.

> *Changes happen so fast in the market, and we have to bear the costs and be insecure for so long, it is a big institutional barrier.* (Object 12)

> *If we look at self-driving reception boxes, it is required by law that we have a person walking next to it, so there is a bit of immature regulations around that.* (Object 9)

> *There is a balance, for us as a business actor, we want to have freer regulations because we want to drive development. At the same time, we are dependent on having regulation of structure for the whole to work, so it is certainly a friction that will always be there.* (Object 9)

One frequently mentioned challenge during the interviews were the privacy concerns and the risk of data breaches or misuse while using emerging technologies, especially while talking about drones and big data. Norway upholds strict conditions regarding the processing of personal data, and the Data Privacy Act

protects the citizens from breach in privacy and safety (Regjeringen, 2019). There is a general principle based on The Personal Data Act that all individuals should be in control of how data relating to them is being used, and data cannot by law be used for other purposes for which the data were initially collected without the data subject's consent (Datatilsynet, 2021). Although these laws are important for å well-functioning society, they can hinder data exchange and collaboration among actors, as data must be stored in regulations to law and the quality must constantly be ensured.

> *Information is withheld for many reasons, including competition, privacy, and data quality. The moment you start making data available, if that information is of the wrong quality, then it can be a serious security risk. This in itself can be an obstacle to data sharing because you do not have good enough control over your own data.* (Object 3)

> *There is a huge ethical aspect to data sharing, if the data is shared uncritically then it can be quickly misused. (...)Platforms for data sharing and data management is a giant project, because then comes the question; Who owns the data? Who will pay for it? Data has huge value, and you do not want to give away data for free, but those others profit from.* (Object 3)

In addition, the findings revealed traffic security concerns of using self-driving vehicles, drones and robots in public spaces. Norway has many road traffic laws and regulations, and the extensive Road Traffic Act applies to all traffic on the road and must be followed when walking, cycling or driving.

> *In Norway we have a road traffic law that triumphs everything, and then we have an exception law to test that type of self-driving vehicles, but before they can ordinarily operate, we must have a regulatory framework that takes care of e.g., guilt distribution. Because who is to blame if accidents happen?* (Object 3)

> *Having a pilot here and there does not change much, unless you get it up on a large scale. We have a high focus on safety in Norway, safety is so*

> *important in traffic, and it should be quite difficult to get a permit exemption that could affect safety.* (Object 5)

Another challenge identified among the interviewees was the risk of biased decision-making by artificial intelligence with machine learning. There were also concerns regarding the ethical mindset of algorithms, and how to manage that properly to avoid severe consequences.

> *If a self-driving car is about to collide in a crowd, should it drive on the kid or on the grandmother or drive in the ditch? It becomes the kind of dilemma, the ethics of the algorithms.* (Object 3)

> *Machine learning is difficult to test because it finds rules that it thinks are good and the behavior is influenced by many factors. There have been some examples of machine learning on the legal system in the United States where machine learning was used to make good decisions. It turned out that it was incredibly racist because the system is like that from before. So that is a risk with machine learning and it's challenging to prevent.* (Object 6)

5 ANALYSIS AND DISCUSSION

In this section, the analysis and discussion of the findings in relation to the theoretical background will be presented. Combining the most relevant findings and results from these chapters will help the authors to answer the research question, *"How can emerging technologies increase efficiency and sustainability in last mile home deliveries?"*. To evaluate how emerging technologies can contribute to increased efficiency, the performance indicators presented by Domingues et al., (2015) will be applied. Likewise, the triple bottom line framework from Elkington (1994) will be used in relation to sustainability. Moreover, the last section will be in relation to the sub question: *"What are the barriers for a successful implementation of emerging technologies?"*. Barriers will be discussed and the PESTEL framework has been used to structure the barriers identified from the findings.

5.1 How emerging technologies make home deliveries more efficient

The findings show that emerging technologies have a great potential for leading to a more efficient and comprehensive transport system. This is in line with the current literature on this topic. Namely that, through digitization of products and services, as well as technology integration both horizontally and vertically in the value chain, it is possible to bring out the next level of cost-efficiency and increased productivity (Koh Lenny et al., 2019; Liao et al., 2017; S. K. Rao & Prasad, 2018).

The authors and the interviewees believe that these technologies will shape the future of last mile home delivery transportation in the coming years. Table 5 shows the relationship of emerging technologies and the performance indicators presented by Domingues et al., (2015). The emerging technologies assessed are drones (UAVs), self-driving vehicles, robots, artificial intelligence and machine learning, big data and electric vehicles. The plus and minus sign indicates if the performance indicator increases or decreases due to the related technology. The interviews highlight a number of challenges and barriers that the actors, the industry, the facilitators and other stakeholders have to overcome before these solutions are possible and feasible to implement. This is discussed thoroughly later in this section.

Performance Indicators	Expanded description:	Formula	Drones (UAV)	Self-driving vehicles	Robots	AI (ML)	Big data	EV
Distance travelled per day	Total number of km travelled during a certain period of time over the period number of days	Σ km travelled in a certain period of time / No. of days of the given period of time	+	+		+	+	-
Turnover per km	Turnover of a certain journey divided by the total number of km of the designated journey	Σ Turnover per journey / No. of km of the given journey	+	+	+	+	+	+
Delivery Frequency	Total number of deliveries that took place in a certain period of time	Σ No. of deliveries (in a certain period of time)	-	+		+	+	
Completeness	Percentage of full/ complete orders dispatched by the total number of orders	(Σ No. of complete deliveries / Total No. of deliveries) x 100				+	+	
On-time delivery performance	Percentage of orders received on time (date and hour) defined by the customer	(Σ No. of punctual deliveries / Total No. of deliveries) x 100	+			+	+	
Vehicle loading capacity utilized per journey/vehicle	Utilized loading capacity per journey (or vehicle) over the total available loading capacity	(Σ Utilized capacity per journey/vehicle / Total loading capacity per journey/vehicle) x 100				+	+	
Claims due to out of time deliveries	Percentage of claims due to deliveries executed after the agreed date	(Σ No. of out-of-date claims / Total No. of deliveries) x 100				-	-	
Order to delivery cycle time	The average elapsed time from the moment the order is ready to the reception by the customer (includes loading/unloading)	Σ (Reception date by customer – Order ready date in the Warehouse) / Total No. of deliveries	-		-	-	-	+
Vehicle loading/unloading time	The average freight loading/unloading time	Σ(Order reception – End time of the journey) / Total No. of deliveries	+		-	-		
Loss and Damage frequency	Number of loss and damaged during transportation, in relation to the total number of products transported	(Σ No. of damaged items delivered + Σ No. of lost items / Total No. of deliveries) x 100	-	-	-	-	-	
Transportation accidents	Number of accidents occurred during the transportation journey of products during a certain period of time	Σ No. of transportation accidents	+	-		-		
Cargo theft	Number of theft events during transportation of products, during a certain period of time	Σ No. of theft during transportation	+	+	+			
Cycle time improvement	Percentage of cycle time improvement relatively to the previous year	[(Average cycle time on the present year – Average cycle time on the previous year) / Average cycle time on the previous year] x 100				+	+	

Table 5: Relationship of the selected emerging technologies and performance indicators on efficiency from Domingues et al., (2015)

The findings showed that most of the emerging technologies made it possible to cover a wider range of distances due to automation. As there are no human drivers the autonomous transportation system can operate continuously. This is also supported in theory by Bruce & Otter (2016). However, the distance travelled might also be shortened due to the range constraints for EV's. The findings showed that this constraint would be solved in a relatively short amount of time as both electric

and hydrogen technology is evolving rapidly. As the distance is travelled more efficiently, labor cost decreases, and electric or hydrogen vehicles are implemented at a larger scale, the turnover is expected to increase. However, the findings show that the technologies are very expensive to implement, and they are expected to reach a break-even point over time, before they start generating huge profits.

As the transportation system is able to operate at all times of the day, the delivery frequency will potentially increase, as well as the percentage of on-time deliveries, something which directly improves the service level. By leveraging the data and letting AI make sound decisions, the LSP's will be able to better balance the delicate relationship between cost and service level. Drones (UAVs) will be able to cover huge distances in a relatively short amount of time, increasing the delivery frequency and on-time deliveries. Similarly, the number of claims on out-of-time deliveries is expected to be reduced. The findings revealed that drones are less constrained by traffic and physical infrastructure. However, they are dependent upon technological infrastructure, feasibility, and the number of drones.

Artificial intelligence in the form of machine learning and big data is capable of leveraging data to better utilize vehicle capacity and decrease the order to delivery cycle time. By having the dimensions and the weight of all the goods to be transported, as well as having other delivery information, AI is able to better plan and execute delivery sequences and transportation mode selection. This is expected to become more difficult with time as the slack time decreases, resulting in a decrease in delivery cycle time, making it harder for LSP's to consolidate goods. However, fast deliveries are something that the consumers appreciate, and it directly increases the service level.

The risk of accidents and the risk of loss or damage to the goods has several dimensions it. By relying on computers, the risk of human errors is mostly eliminated, but the risk of computational error increases. Machine learning technology is maturing but the literature reveals that we are a long way from seeing advanced artificial intelligence (IBM, 2020). Machines such as autonomous vehicles and drones are prone to hacking and malfunction. Hence, the risk of accidents due to these factors is expected to increase, the social implications due to

an accident are also very high as people are skeptical towards new technology. Damaged goods are expected to decrease by better handling and information flow. Digital twins are virtual representations that serve as the real-time digital counterparts of physical objects. By leveraging this technology computers will be able to track, monitor, detect and prevent damage to goods (DHL, 2019).

5.1.1 Emerging technologies cost breakdown model

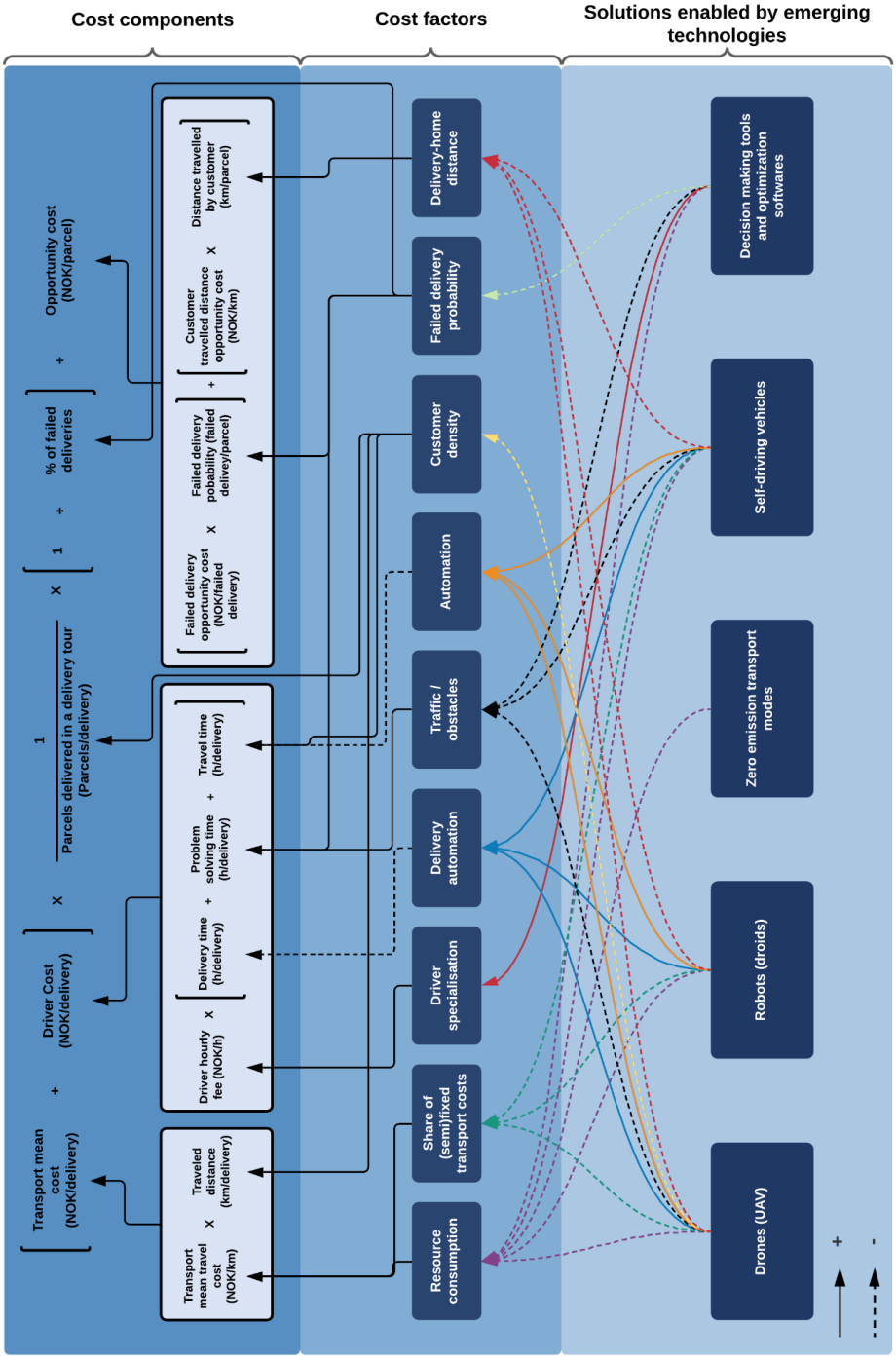

Figure 11: Cost-breakdown model of emerging technologies made by the authors

5.2 How emerging technologies make home deliveries more sustainable

The findings show that emerging technologies have a great potential for leading to a more sustainable transportation system without compromising the behavioral shifts mentioned in the literature review. The findings revealed that every firm is unique with different business models, operations, and contexts. Therefore, there is no universal approach to increase sustainability in last mile home deliveries. This aligns well with previous literature (Klumpp, 2014). The findings revealed that there is a positive correlation between efficiency and sustainability in logistics. This positive correlation creates incentives for LSP's to invest in new solutions to increase their efficiency, while also increasing sustainability.

Table 6 shows the relationship between emerging technologies and the sustainability performance indicators presented in the literature (Orsic et al., 2019; Trung et al., 2020; Wichaisri & Sopadang, 2014). The indicators are further categorized under the TBL framework by Elkington (1994). The emerging technologies assessed are drones (UAVs), self-driving vehicles, robots, artificial intelligence and machine learning, big data, and electric vehicles. The plus and minus sign indicates if the performance indicator increases or decreases due to the related technology.

Performance Indicators	Expanded description:	TBL dimension	Drones (UAV)	Self-driving vehicles	Robots	AI (ML)	Big data	EV
Traffic congestion	No. of units in operation / km	Economic	-	-	NA	-	-	NA
Speed	min/ no. of parcels	Economic	-	-	+/-	-	-	+/-
Utilization	No. of parcels /delivery run	Economic	NA	NA	NA	+	+	NA
Cost of delivery	Costs / No. of parcels	Economic	-	NA	+/-	-	-	-
Lead time	Time between task creation and work completed	Economic	-	NA	-	-	-	+/-
Emission	CO2 /km	Environmental	+/-	+/-	NA	-	-	-
Resource consumption	Natural resource consumption/No. of parcels	Environmental	+	-	NA	-	-	-
Pollution	Air pollution + water pollution)/ No. of parcels	Environmental	+	-	NA	-	-	-
Noise	Decibels	Social	+	-	NA	NA	NA	-
Health and safety	Improved health and safety standards	Social	+	+	+	NA	NA	NA
Accidents	Number of accidents	Social	+	-	NA	-	-	NA

Table 6: Relationship of emerging technologies and sustainability performance indicators made by the authors

5.2.1 Economic dimension

The findings revealed that emerging technologies have the potential to reduce traffic congestion. The findings seem to be in line with the literature on this topic by Comi and Russo (2012), that a better flow of vehicles contributes to reducing working hours and fuel consumption, leading to less congestion and air pollution. While humans are often distracted, leading to congestion and dangerous traffic situations, machines in the form of self-driving vehicles are always alert and in sync with other machines. The combination of new communication technology such as 5G with the power of AI to crunch vast amounts of big data in real-time has the potential to ease clogged roads. Additionally, a lot of the traffic is expected to move into the air by the use of drones.

The innovations and shifts in transport patterns will naturally increase the delivery speed. By leveraging real-time data, AI will be able to optimize routes and the autonomous transportation system will be able to execute deliveries in the expected time windows. By doing so the lead time is expected to shrink, leading to increased customer satisfaction and service level. According to Archetti (2021) e-commerce customers increasingly expect extremely short delivery times. The literature review addresses that the profits earned can be used to benefit the owners, the customers, or other stakeholders (Nilsson & Robinson, 2017). The findings reveal that even though the customers want and expect fast shipping, they are not willing to pay for it. Hence, it is reasonable to consider that a big part of the cost savings due to drones, AI, and big data will benefit the consumers.

5.2.2 Environmental dimension

The findings indicate that less traffic congestion and increased capacity utilization are expected to reduce the overall emission and pollution caused by the last mile home delivery supply chain. Additionally, the consumption of natural resources is expected to decrease as well. It is expected that drones will be able to reduce CO2 emissions by their capability of flying straight across the terrain instead of maneuvering the roads. However, the trend towards increased home deliveries indicates that the need for drones to fulfill the demand will keep increasing. The interviewees showed concerns regarding this trend, based on lack of regulation and the increased cost of maintaining a drone fleet as well as an autonomous van fleet.

According to Townsend et al., (2020) there are many different power sources available for drones. For the application of drones in the last mile home delivery context, lithium-ion batteries are expected to be most suitable. These drones might also have the capability of recharging through integrated solar panels. Hence, based on the type of power source and the scale of application, drones can contribute to decreasing as well as increasing CO2 emissions. The same is true for self-driving vehicles.

The findings reveal that all future autonomous vehicles are expected to be EV's or zero-emission. The findings also revealed that EV's have the biggest potential of reducing CO2 emissions. However, there are still concerns around the sustainable practices of producing new transportation systems, especially concerning lithium-ion extraction (European Commision, 2019). Additionally, when moving towards electrification, the cost of developing new infrastructure and the origin of the electricity becomes even more important. AI and big data are expected to be the technology driving these solutions forward, contributing greatly towards lower emissions, air pollution, and resource consumption.

5.2.3 Social dimension

Noise is considered pollution, and it is the pollution problem that affects most people, where road traffic makes the most noise (The Norwegian Ministry of Climate and Environment, 2020). Although drones do not emit any considerable amount of CO2 emissions, they are very loud. This might become an issue, especially in the last mile home delivery context, where noise pollution is noticed where people live. As self-driving cars are expected to be battery or hydrogen-powered, the noise of a combustion engine will disappear, leading to overall less noise pollution. However, increased home deliveries will cause more noise in neighborhoods, outside people's homes.

A huge benefit of industrial robots is that they are able to perform dangerous tasks with accuracy, limiting the risk of error and accidents. Drones and autonomous vehicles are expected to raise the level of health and safety as they can be programmed and monitored. Various tasks usually performed by the courier, such as loading and unloading can be performed by a robot in the future. As machines

do heavy lifting and other repetitive tasks, the risk of strain injuries is expected to decrease (Matthews, 2019).

The findings revealed that the emerging technology is expected to have multiple implications on the number of accidents. First and foremost drones are expected to move the traffic from the streets to the sky, reducing the risk of accidents on the ground. However, as the number of drones in the sky increases, so does the risk of malfunction, hacking, and accidents. Self-driving vehicles on the other hand rely on machine learning, live streams of data, and instant communication technology. Current literature points toward a fully autonomous transport system where everything is safe and effortless. The findings suggest that there are a lot of factors to consider, for instance, obstructions, snow, rain, malfunctions, and human factors. However, the findings suggest that the number of fatal accidents will be reduced by the use of emerging technologies.

5.2.4 The TBL model in relation to the selected emerging technologies

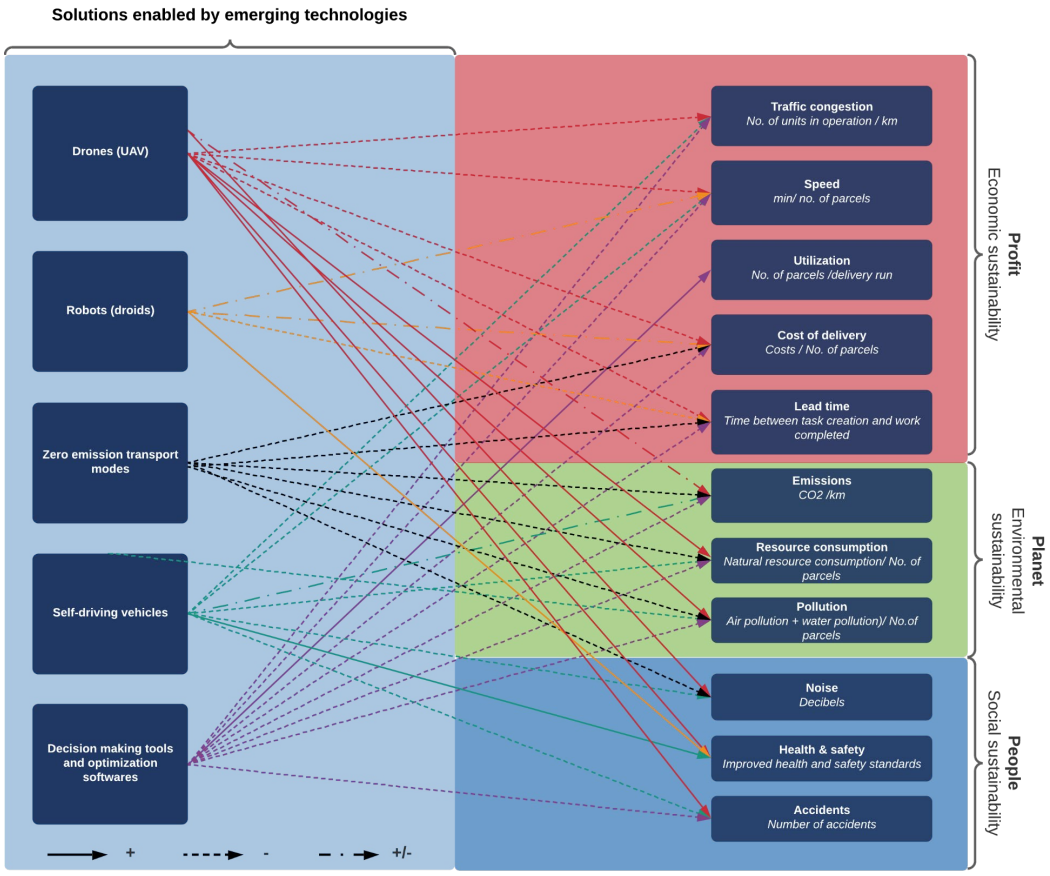

Figure 12: Explanatory illustration of how emerging technology solutions contribute to the triple bottom line, made by the authors.

53 Trade-offs

The findings suggest that there is not a one size fits all approach to balance the various dimensions of efficiency and sustainability. Each actor must develop a strategy representative of their business model. The findings reveal that emerging technologies have huge potential to increase efficiency as well as increase the sustainability in last mile home deliveries. The figure below demonstrates the various dimensions an LSP has to balance in order to keep all of its stakeholders satisfied.

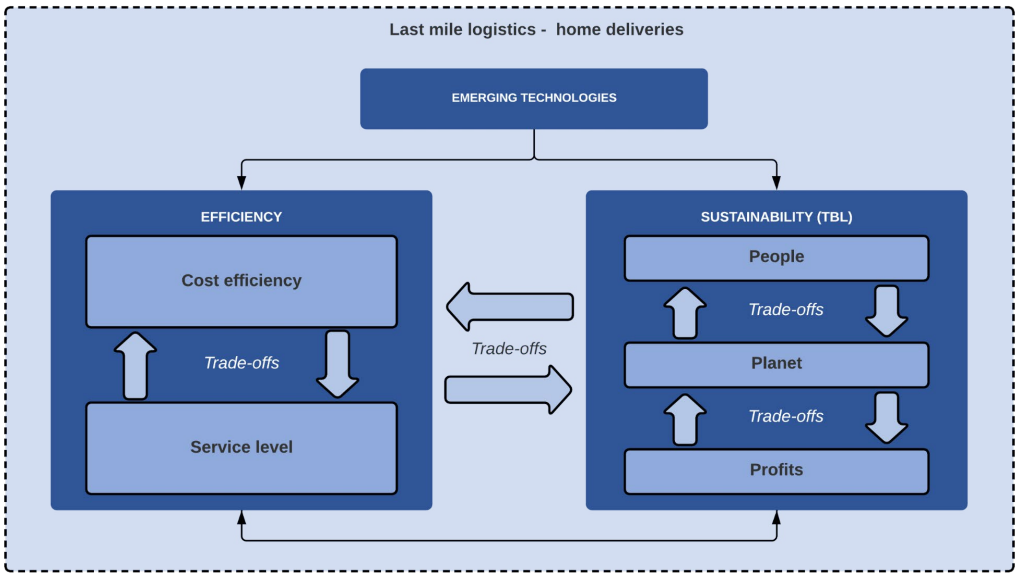

Figure 13: Illustration of the dimensions and trade-offs in LM home deliveries made by the authors

The marketplace is becoming more competitive, and consumers are becoming more demanding. They expect fast home deliveries but are not willing to pay for the increased cost. An e-commerce store or an LSP has to balance the delicate relationship of cost and service level in order to generate a healthy profit and keep its customers satisfied. Increasing their service level, for instance by providing faster shipping makes it harder to consolidate goods to decrease the per delivery cost. The government, consumers, and other stakeholders are simultaneously putting pressure on logistic service providers to apply more sustainable practices. Increased pressure, incentives, and regulations force LSP's to balance the dimensions of economic-, environmental-, and social sustainability.

The findings suggest that even though emerging technology seems to have some negative implications in some circumstances, the implications are overall positive. The literature argues that each company has a unique sustainability potential, depending upon current adverse impacts and the feasibility of operational improvements (SCB, 2013). Trade-offs have to be made by future LSP's and other last mile home delivery actors, and their strategy might impact their operations greatly in the future, as more regulations will be introduced and expectations from consumers will continue to increase.

5.4 Barriers

The findings revealed several barriers for adopting emerging technologies and interviewing different types of actors; LSP`s, authorities, researchers, and experts, gave the discussion a nuanced touch. In order to structure the identified barriers from the conversations with different actors, a PESTEL framework was used. This framework was preferred by the authors to structure the barriers as it can be applied in several contexts and settings (Issa et al., 2010).

Category	Barriers for implementing emerging technologies
Political	● Lack of regulations concerning emerging technologies ● Inadequate physical infrastructure ● Complex regulations - Tensions between state and municipal regulations ● High uncertainty regarding new regulations
Economical	● Services required for making the final solutions are costly, making the final product too expensive ● Conflict of profit sharing and investment interest ● Proprietary systems are challenging to integrate ● Expensive to replace proprietary systems with standardized solutions ● Human labor is more cost-efficient today than using robots ● Lack of collaborative competition-neutral business models
Socio-cultural	● Lack of social acceptance towards new technological solutions ● Lack of flexible collection methods for the consumer ● Consumer's shopping behavior is unpredictable
Technological	● Immature technology ● Lack of competent employees due to technological complexity ● Emerging technologies require new technology infrastructure ● Lack of machines adaptability ● Acceptance towards adding modules instead of re-designing complete systems ● Needs effective backup solutions/support systems ● Low battery capacity ● Efficiency concerns with charging EV's ● Infrastructure capacity constraints
Environmental	● Increased connectivity requires more infrastructure and power consumption ● Greenwashing ● Lack of proper measurement systems and indicators ● Not enough research on the environmental impact of emerging technologies in public spaces
Legal	● Immature regulations concerning the effects of emerging technologies on current laws and regulations ● Risk of biased decisions ● Lack of organizational resources and external funding ● Risk of quality breach ● Risk of data misuse ● Traffic safety concerns ● Slow changes

Table 7: The PESTEL framework for barriers identified through findings

Identifying and categorizing barriers for such a comprehensive topic was challenging, and although the barriers have been structured in six categories, the authors identified several overlaps. A significant barrier for implementing emerging technologies in public spaces was the lack of adequate infrastructure. This barrier mainly referred to the requirement of increased connectivity for the optimal use of robots, drones, and self-driving vehicles in LM operations. Concerns for the infrastructure touches upon all six categories in PESTEL. On one hand, our findings revealed the eagerness of business actors to explore and integrate new LM tech solutions, while on the other hand, the findings revealed that these solutions require an extensive upgrade of the current infrastructure in Norway. Public roads in Norway are divided in four different ownership categories, municipal roads are owned by the municipality, county roads by the county municipality, highways are owned by the State and there are also private roads owned by individuals (Vegdirektoratet, 2014). A total renovation of the current road infrastructure would require collaboration and willingness to invest from all parties involved.

In addition, the legal issue for this barrier is the traffic safety concerns of having multiple self-driving vehicles, robots, and drones in action. A report from SINTEF explains the current road traffic legislation to be the main barrier for the development of autonomous vehicle usage on public roads (SINTEF, 2017). Moreover, the report emphasizes that the transport sector is in a period of historic changes. This is in line with our findings where several LSP actors urged the need for political action towards making new regulations for LM tech innovations to drive the change. Meanwhile, the authorities explained that there have to be both political and economic motives behind making legislative changes. Another recent report from the Department of Transport Economics has conducted a review of international research on this topic. The report claims that if technology is to surpass the human driver, there will be a need for road standards, and regulations that prepare both roads and autonomous vehicles for better communication (Transportøkonomisk institutt, 2019). This requires autonomous vehicles to be able to exchange information with other traffic units, with the road, and with an additional road traffic control center to be able to operate safely, and that requires increased connectivity (SINTEF, 2017). The findings revealed that increased

connectivity requires more infrastructure and energy consumption, which has environmental implications.

The findings further revealed that there is a lack of proper research on the environmental impact of emerging technologies in public spaces. This barrier causes uncertainty among LSP actors as there are no proper regulations or systems in place to measure the environmental effects on integrating the selected technology solutions in their LM operations. Currently, as a result of lack of research on this area, there is a probability of negative environmental impact which in turn can make it less attractive for actors to invest in these solutions. There is evidence both from findings and literature that policies drive change, and history shows several examples of that. One recent example is when the norwegian government came to an agreement that all new cars sold by 2025 have to be zero-emission, which drove consumer behavior towards choosing environmentally friendly options (RECHARGE, 2019). Another example is the recent legislation of zero-emission transportation of goods in cities by 2030 adopted by the Government of Norway (Oslo kommune, 2020). Although there are no current state instruments to achieve that goal, the legislation is still stimulating the businesses to prepare for zero-emission last mile operations.

6 CONCLUSION

The objective of this research was to investigate the impact of emerging technologies on efficiency and sustainability in last mile home deliveries. The research question of this study is: *"How can emerging technologies increase efficiency and sustainability in last mile home deliveries?"*. To fully understand the implications, the authors found the following sub-question to be relevant: *"What are the barriers hindering a successful implementation of emerging technologies?"*.

The study found emerging technologies to have the ability to overall increase efficiency in last mile home deliveries. The increase in efficiency is made possible by the reduction of human labor, better decision-making processes, and new zero-emission transportation modes. The emerging technologies discussed in this study seem to have huge potential to increase efficiency in terms of cost and service level. However, even though the technologies are evolving rapidly, the timeframe is long for advanced AI and full autonomy. Hence, the future outlook regarding these specific technologies might change, as many new technological solutions can develop in the meantime. Additionally, last mile home delivery is demand driven, and societal trends can shift the direction of how consumers want to buy and receive their goods. It might very well be the case that a 3D printer in a consumer's home can decrease the demand for transportation.

The study found emerging technologies to overall positively affect the three dimensions of sustainability; people, planet and profits. This is made possible by the adoption of zero-emission technology, and better decision-making processes. However, drones were found to increase noise pollution and possibly be more in-efficient in certain contexts. Our exploratory study found that efficiency and sustainability often had a positive correlation with logistics. However, the long-term implications on the various dimensions of sustainability might still not be clear. Technological solutions such as autonomous transport systems need to communicate without interference or delay. Building the required infrastructure to support these technological developments, come with their own implications on sustainability.

This study has found that emerging technologies can increase efficiency and sustainability in last mile home deliveries. Technology has simplified our lives, but it has also made us more vulnerable. Hence, security and ethical consideration are important to address and agree upon. By sustainable development, we will be able to meet the needs of present generations, without degrading the prospect for future generations.

6.1 Practical and social implications

From the literature and the interviews, the authors identified how emerging technologies can contribute to increased efficiency as well as sustainability in last mile home deliveries. This research paper aims to answer the research question by providing the reader with a systematic overview of how certain relevant emerging technologies affect relevant performance indicators. The performance indicators have been identified during the literature review, concerning cost and service level under the domain of efficiency, and economic-, environmental-, and social sustainability under the domain of sustainability.

Additionally, important work has been done towards identifying, discussing and categorizing barriers for implementing emerging technologies. The authors believe that the lack of information exchange in this specific industry contributes to making the barriers less visible for stakeholders. The barriers are complex, and by providing an overview the authors aim to stimulate discussions, collaborations and entrepreneurship in order to overcome these barriers.

An aim of this paper was to provide actors within e-commerce and the logistics industry, as well as stakeholders in key positions, with insight into this research topic. The interviewees showed great interest in the research question and stressed that this topic is highly relevant.

> *I think that your research area is very relevant. Fifty percent of the younger population prefers home delivery as a delivery method. If you look towards Denmark, The United States or Europe in general, home delivery is the dominant delivery method, so Norway is a little behind. But this change means that you have to deliver all the way home instead of pallets to a post*

office. Then there is talk of a completely different cost level and it has consequences, especially environmentally. So this research topic is really in the center of the challenges we face. (Object 12)

6.2 Theoretical implications

The authors believe that this thesis offers a unique perspective on how emerging technologies can contribute towards increasing efficiency and sustainability in last mile home deliveries in Norway. Our thesis also differs in several ways from all the other cases and literature we are familiar with. Firstly, previous literature in this specific context has been concentrated around the last mile for B2B, something that is very different from B2C. Secondly, there is a lack of research on this topic in this context, focusing on both efficiency and multiple dimensions of sustainability.

The findings regarding efficiency were in line with the performance indicators presented in the literature review. Hence, the findings confirm previous literature regarding relevant performance indicators by Domingues et al., (2015). The findings also revealed that there was a lack of standardization in the way sustainability was measured, a challenge also presented in the literature review (Ahi & Searcy, 2015; Goh et al., 2020). Additionally, some LSP's were concerned that the increased focus on sustainability is leading to more *greenwashing*, as there is a lack of quantification. However, the expert interviews also revealed that with data sharing and emerging technologies, measuring social and environmental dimensions of the triple bottom line will become easier.

The research is also unique in the way that it involves industry experts working in the technology sector, the logistics sector, as well as experts working in the crossing point of these two. The expert interviews confirmed many of the benefits highlighted in previous literature, while they addressed the benefits as well as the barriers in the norwegian context. Interviews with people in key positions in dominating LSP's revealed the current situation as well as challenges and barriers. Hence, the thesis contributes to the scientific literature by addressing this important topic in the norwegian context as well as the B2C context.

During the data collection, we became familiar with very interesting information that is not found described in the same context in previous literature; for example,

the re-designing of complete systems for LSP's without compromising short term operations. We may not be able to confirm all of the findings due to lack of implementation and measurement. However, we can point to areas that will be of interest for further research.

6.3 Limitations

Before starting the work on this master thesis, the authors knew that the paper would have some limitations. There is a lack of research on B2C last mile home deliveries in Norway. Further, there was no comprehensive literature on emerging technologies in last mile home deliveries in Norway. However, the previous international research on emerging technologies is considered sufficient. Another limitation is the lack of opportunities to quantify the financial impact of adopting these technologies in the last mile home delivery domain. The challenge in quantifying the potential impact is the various factors of uncertainty such as technological maturity, breakthroughs, consumer behavior and regulations. Additionally, there are limited pilot projects running, and the few that are running, are doing so with unsustainably high costs. Furthermore, the author's research on the technological implementation of emerging technologies is not fully comprehensive as the authors have limited knowledge on the technical part of it.

The research is a qualitative study and is to a large extent based on answers from individuals in key positions in major LSP's as well as technology and logistics experts. The different answers from the participants will, to some extent, be affected by their own subjective opinions. However, some of the answers from certain individuals could be biased to a certain degree. The authors have not been able to interview individuals from all of the LSP's, and therefore, may have missed out on essential findings. However, the actors have interviewed six industry experts, five individuals in key positions in the major LSP's operating in Norway, as well as two representatives from the Ministry of Local Government and Regional Development. Based on the extensive research the authors believe that the findings can be generalized for all the actors in this specific industry.

6.4 Further research

In light of the research and its limitations, we recommend researchers to conduct further studies on the impact of emerging technologies in other areas of the logistics field. Future research could consider the potential impacts of specific emerging technologies more carefully, where especially quantification of the benefits and costs would be interesting in line with the TBL framework.

Comprehensive research on drones (UAVs) with respect to noise pollution would also be interesting. Literature suggests that people find noise from drones to be more irritating than noise from cars (Norsk forening mot støy, 2018). It would be beneficial for the decision makers in the government and the industry to understand how UAVs are perceived and their effects on people's health.

Additionally, future research should be focused towards exploring new business models and *blue oceans* caused by emerging technologies.

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APPENDICES

Appendix 1:

The interview guide towards experts and researchers within technology and the transportation sector in Norway

Generelle spørsmål

1. Samtykke til å ta lydopptak av intervjuet? JA/NEI
2. Først ønsker vi i å bli bedre kjent med deg. Hva er din rolle hos (Navn på bedrift)?
3. Har du noen formeninger om relevansen av vårt forskningsområde?
4. Hvordan samarbeider (Navn på bedrift) med logistikkbransjen generelt og med offentlig sektor?
    a. Hvordan samarbeider dere for å løse last mile utfordringer?

Hjemlevering - Last mile

1. Hva anser du til å være de største utfordringene innenfor last mile (hjemlevering)?
2. I tråd med markedsrapporter vi har lest ser vi at flere foretrekker å handle på nett, det er mer utvalg, mulighet til å sammenligne priser og mer tidsbesparende for forbrukeren. Fra vår forskning har vi sett at markedet for hjemlevering er i sterk vekst, og at flere store aktører som bl.a Amazon og små norske aktører som Helthjem.no, Porter Buddy, har begynt å levere varer hjem på døren mye raskere og til en rimelig pris. I tillegg ønsker forbrukerne mer fleksibilitet, smalere tidsvinduer og god service.
    a. Hvordan jobber dere med å løse utfordringene relatert effektivisering av hjemleveringer?
    b. Jobber dere med å implementere fremtidsrettet teknologi for å løse disse utfordringene?
        i. Hvis ja; hvilke?
        ii. Hvis nei; hvorfor ikke?

Fremtidsrettet teknologi

1. *Autonome kjøretøy*
   Autonome kjøretøy er under stor utvikling, og næringslivet uttrykker at det er et spørsmål om tid før selvkjørende biler innføres i flere storbyer i Norge.
    a. Hva tenker du om dette?
    b. Hva mener du må være på plass av teknologisk infrastruktur for en vellykket overgang?
    c. Hva mener du må være på plass av fysisk infrastruktur for en vellykket overgang?
    d. Ser du noen umiddelbare hindringer/barrierer for å sikre en smidig overgang?
        i. Økonomiske, miljømessige, sosiale?
        ii. Teknologiske, organisatoriske?

2. *Dronelevering*
   Det har vært mye diskusjoner rundt dronelevering. Amazon har flere pilotprosjekter på gang, og selv Kolonial har uttrykt at de ser potensiale i denne teknologien i de norske markedet.
   a. Hva tenker du om dette?
   b. Hva mener du må være på plass av teknologisk infrastruktur for en vellykket overgang?
   c. Hva mener du må være på plass av fysisk infrastruktur for en vellykket overgang?
   d. Ser du noen umiddelbare hindringer/barrierer for å sikre en smidig overgang?
      i. Økonomiske, miljømessige, sosiale?
      ii. Teknologiske, organisatoriske?
3. *Roboter med machine learning*
   Litteraturen og nyhetsbildet viser at det er en rivende utvikling innenfor roboter med machine learning. Disse robotene erstatter mange menneskelige oppgaver til en budbilsjåfør. Som f.eks å bære pakker frem til dørstokken, selv over trapper og ujevn terreng. Ettersom robotene begynner å bli smartere og mer effektive, vil det kunne være sterkere intensiver for å heller ta i bruk disse fremfor menneskelig arbeidskraft.
   a. Hva tenker du om dette?
   b. Hva mener du må være på plass av teknologisk infrastruktur for en vellykket overgang?
   c. Hva mener du må være på plass av fysisk infrastruktur for en vellykket overgang?
   d. Ser du noen umiddelbare hindringer/barrierer for å sikre en smidig overgang?
      i. Økonomiske, miljømessige, sosiale?
      ii. Teknologiske, organisatoriske?

Samfunnsansvar og bærekraft

1. EU Green deal signaliserer et stort skifte for norsk næringsliv. Som et bidrag, er Norge forpliktet til å halvere sine klimagassutslipp fra transportsektoren innen 2030.
   a. Hvilken rolle tror du fremtidsrettet teknologi vil spille for å nå dette målet?
   b. Hvilken stilling tar (Navn på bedrift) til EU Green Deal? Har dere kommet med noen initiativer for å nå klimautslipp målet?
   c. Hvordan samarbeider næringslivet og Staten med å nå klimamålene?
2. En eksisterende utfordring med økt hjemlevering i byer med stor befolkningstetthet er trafikken som skapes. I Oslo spesielt, er det et

sterkt fokus på å elektrifisere næringslivs flåter. Dette vil til en viss grad minske forurensingen, men det løser ikke trafikk problematikken.

   a. Droner og selvkjørende mindre roboter, er en direkte løsning, ved hjelp av 5G nettverk. Hvilke samfunnsmessige og miljømessige utfordringer ser dere ved å ta i bruk disse?
      i. Har dere gjort noen utredninger på dette området?

3. Det er flere etiske spørsmål og problemstillinger knyttet til innføring av fremtidsrettet løsninger som selvkjørende biler, droner og bruk av roboter i samfunnet. Det er stor debatt rundt støy, sikkerhet og ansvarliggjøring når samfunnet blir digitalisert.
   a. Hvilke tanker har du om denne etiske problematikken?
   b. Dette er utfordringer som må løses før samfunnet kan anvende teknologien i praksis. Hvordan håndteres disse etiske spørsmålene av næringslivet og interessenter?
      i. Hvilke initiativer er på plass og hvilke må til for at dette skal bli en realitet?

      Etiske problemstillinger: hacking, terror, støy (av droner), kollisjoner, virus, stråling, forurensning ved utbygging av infrastruktur.

Oppsummering

Vi har nå stilt en rekke spørsmål angående forskningsområdet vårt. Er det noe vi har glemt å nevne eller spørsmål du mener at vi burde stilt angående dette emnet? Er det noe annet du ønsker å legge til på slutten av dette intervjuet?

Tilleggsspørsmål

- Samfunnet er i stigende grad preget av løsninger som krever kunnskap, kompetanse og omstillingsevne. Fra deres sitt perspektiv, hvilke tanker har du om samfunnets omstillingsevne til å erstatte dagens (fysiske) transportløsninger av varer og tjenester med autonome kjøretøy, droner, og roboter?
- 5G teknologi anses som å være en viktig brikke, og blir ofte beskrevet som ryggraden bak fremtidens teknologiske løsninger. Deres selskap lister opp følgende fordeler med 5G:
   a. Enorme hastigheter
   b. Skivedelte nettverk
   c. Garantert tjenestekvalitet
   d. Internet of Things - Alt er koblet til alt
   e. Full utnyttelse av VR og AR

  Hvordan påvirker dette logistikkbransjen i forbindelse med ny teknologi som droner, autonome kjøretøy og roboter?

Påvirker dette spesifikt hjemlevering, hvor kunden vil ha varen levert så raskt som mulig og til en rimelig pris?

- Hvilke utfordringer har dukket opp i implementering av 5G, da det har blitt kjørt en del pilotprosjekter allerede?
- Vil 5G teknologien være tilstrekkelig for fremtidens logistikkløsninger, eller blir vi nødt til å vente på en ny generasjon av kommunikasjonsteknologi?
    a. Hva er svakhetene i 5G teknologien, spesifikt ifht. logistikk og transport?
    b. Hva er styrkene i 5G teknologien, spesifikt ifht. logistikk og transport?

Appendix 2:

The interview guide towards practitioners with presentation of our four hypotheses

Generelle spørsmål

1. Samtykke til å ta lydopptak av intervjuet? JA/NEI
2. Først ønsker vi i å bli bedre kjent med deg. Hva er din rolle hos (Navn på bedrift)?
3. Har du noen formeninger om relevansen av vårt forskningsområde?

Vi har intervjuet eksperter og forskere innenfor teknologi og logistikk. Med bakgrunn i de svarene vi har fått har vi formulert fire hypoteser. Disse fire hypotesene ønsker vi å presentere for næringslivsaktører som arbeider med siste mil problematikken.

Hypotese 1

Menneskelig arbeidskraft utgjør den største kostnaden når det gjelder hjemlevering på døren. Derav vil automatisering i form av selvkjørende biler og roboter ha det største potensiale for å kunne redusere kostnadene knyttet til hjemlevering på lengre sikt.

1. Hva er dine umiddelbare tanker om denne hypotesen?
2. Kan du gi oss et bilde av deres kostnadsstruktur når det kommer til hjemlevering?
   i. Hva er de største kostnadsdriverne?
3. Er dere delaktige i noen pilotprosjekter og/eller planlegger dere å investere i automasjon/fremtidsrettet teknologi i på lengre sikt?
   i. Hvis ja; vennligst utdyp (når, hvilken type, etc)
   ii. Hvis nei; Hvordan vil dere holde dere konkurransedyktige i hjemlevering markedet?
4. Hvilke barrierer/utfordringer møter dere for å automatisere Last Mile delen av verdikjeden deres?
5. Vil du avkrefte eller bekrefte denne hypotesen? Hvorfor/hvorfor ikke?

Hypotese 2

Optimalisering av logistikkprosesser muliggjort ved bruk av AI og Big Data har det største potensiale for å gi miljøgevinster, samt øke effektitiveten ifbm hjemleveringer på kort sikt.

1. Hva er dine umiddelbare tanker om denne hypotesen?
2. Tar dere i bruk/planlegger dere å ta i bruk AI/ Big Data for å optimalisere logistikkprosessene deres?
   a. Hvis ja; vennligst utdyp (når, hvilken type, hvordan etc)
   b. Hvis nei; Hvordan vil dere holde dere konkurransedyktige i hjemlevering markedet?

3. Hvilke barrierer/utfordringer møter dere for å kunne ta i bruk AI/Big Data i Last Mile delen av verdikjeden deres?
4. Vil du avkrefte eller bekrefte denne hypotesen? Hvorfor/hvorfor ikke?

Hypotese 3
Det er svakt samarbeid mellom aktører i næringslivet. Økt samarbeid i form av deling av informasjon, infrastruktur og ressurser vil bidra til økt effektivitet og miljøgevinster.

1. Hva er dine umiddelbare tanker om denne hypotesen?
2. Hvordan samarbeider dere med aktører i næringslivet/konkurrenter når det gjelder deling av ressurser/markedsinnsikt?
3. Hva er det som hemmer informasjonsdelingen blant aktører i næringslivet? Er det organisatoriske (proteksjonisme, konkurranse, markedsmakt) eller teknologiske barrierer (proprietære systemer)?
4. Vil du avkrefte eller bekrefte denne hypotesen? Hvorfor/hvorfor ikke?

Hypotese 4
Offentlig sektor legger ikke godt nok til rette i form av reguleringer og infrastruktur, slik at næringslivet kan investere, teste og ta i bruk ny teknologi i stor skala med mål om å øke effektivitet og bærekraft.

1. Hva er dine umiddelbare tanker om denne hypotesen?
2. Hvordan samarbeider offentlig sektor med dere for å tilrettelegge reguleringer og infrastruktur for fremtiden?
3. Hvilke institusjonelle barrierer møter dere på i deres Last mile prosess?
4. Vil du avkrefte eller bekrefte denne hypotesen? Hvorfor/hvorfor ikke?

Oppsummering
Vi har nå presentert våre fire hypoteser og fått deres innspill. Er det noe vi har glemt å nevne eller spørsmål du mener at vi burde stilt angående dette emnet? Er det noe annet du ønsker å legge til på slutten av dette intervjuet?

Tilleggsspørsmål (til offentlig sektor)

- Bilfritt sentrum gjør det utfordrende å levere pakker. Hvilke tiltak har Staten satt i gang for å hjelpe LSP aktører med å finne løsninger for å kunne operere effektivt i et bilfritt sentrum?
- Det er per i dag ingen reguleringer for mobile pakkeautomater. Nylig ble det satt reguleringer på bruk av el-sparkesykler. Hvordan håndterer dere slike utfordringer? Hvilke incentiver er staten med på å sette for at næringslivet skal få til innovative last mile løsninger?
- Oslo kjører en ambisiøs klimapolitikk, men næringslivet uttrykker at det er stor usikkerhet rundt infrastrukturen og hvem som skal bære kostnaden for utviklingen. Hva tenker dere om dette?