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LOG950 Logistics

Sustainability Assessment of Inter Urban Crowdshipping- A Case Study Approach

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Abstract

The freight transport sector in Norway is growing annually, with road transportation accounting for more than 80% of the country's inland freight transportation with the transport sector accounting for 58% of the overall emissions in Norway. Given the severity and effects of global warming, countries are undertaking attempts to restrict emissions through research, carbon taxes, and other means and policies. Over the last decade, one promising emerging concept in sharing economy has been crowdshipping. Crowdshipping is currently in its early phases, with little research on its sustainability, particularly while operating in inter-city or inter-urban areas. This study is the first of its kind which focuses on inter-city crowdshipping. The research employs a case study approach with a case company running the only crowdshipping platform in Norway, where users particularly private individuals along with businesses are registered. Quantitative analysis of the case company’s crowdshipping platform explores the different variables, attributes and stakeholders and studies their behavior. Along with that, an environmental and financial assessment and comparison between the case company’s crowdshipping platform and other 3PL service providers is attempted. Data from the platform was extracted over 6 months and was complemented with a survey for analysis. According to the empirical findings, demand was relatively high in comparison to supply with pickups and deliveries requested throughout Norway with a higher concentration near the cities. When compared to alternative scenarios in which 3PL service providers are utilized, crowdshipping was contributing to lower emissions and was found to be more cost-effective for all the users. Further research was recommended to address the limitations of this study, which included acquiring unaccounted relevant information, more strongly supporting certain assumptions, and incorporating in-direct emissions of the trips for a holistic emission assessment.

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List of Abbreviations

- **SCN -** Supply Chain Networks
- **SSCM** - Sustainable supply chain management
- **CSR** - Corporate social responsibility
- **DC** - Distribution centers
- **CL** - Crowd logistics
- **CS** - Crowdshipping
- **B2B** - Business to Business.
- **P2P** - Peer to Peer
- **TPL** - third party logistics
- **3PL** - Third Party logistics
- **LSP** - Logistics service provider
- **UL -** Urban Logistics
- **CEP -** Courier Express Parcel service
- **GHG** - Greenhouse gasses
- **CO2 -** Carbon dioxide
- **NO_x** - Nitrogen oxides
- **EU** - European union
- **FTL** - Full truckload
- **COPERT** - Computer programme to calculate emissions from road transport
- **OEM** - Original Equipment Manufacturer
- **ICEVS -** Internal combustion engine vehicles
- **AED** - Additional Emission distance
- **HC**- Hydrocarbon

Chapter 1 Introduction

1.1 Research Background

Road transport dominates inland freight transportation in Norway, accounting for more than 80% of total inland freight movement (Eurostat, 2020). Similarly, in Norway, passenger transportation through road dominates, and accounted for about 90% of the total passenger transport in 2017 (Statista b, 2021). However, both these majority shareholders have their inefficiencies in terms of capacity utilization and environmental impact (Eurostat, 2020). In Norway, approximately 30% of all transportation is empty running (Eurostat, 2020). Likewise, the passenger transport suffers from low occupancy per vehicle, while only about 9% of the private passenger cars were electric vehicles by the end of 2019 (Farstad, et al., 2020). Reducing the Greenhouse gas emissions (GHG) has been a major concern around the globe. In 2019, Norway's transport sector emissions totalled 14.7 million tons, with road transport accounting for 8.5 million tons, roughly 58% of total transport emissions and 26.7% of total emissions (European Commission 2021). Given the severity and consequences of global warming, governments are conducting substantial research and finding ways to limit GHG alternatives.

Non-urban passenger travel is responsible for 60% of total passenger transport emissions. Inter-city vehicle travel is more difficult to decarbonize than intra-urban traffic because it includes longer distances, fewer passengers and requires low-carbon alternatives that can power long-distance transportation. The falling passenger car occupancy over years has led passenger transport to be less sustainable due to partially empty vehicles on the road. This, however, provides an opportunity for freight transport through Crowd logistics (CL). (Rai, et al., 2017)

Decisive actions in load consolidation, standardization and collaboration can result in CO_2 emissions from freight transport being 72% lower in 2050 than they were in 2015 (Furtado & Martinez, 2021). As a result of digitalization, new transportation systems are being created and deployed, revolutionizing the passenger and freight transportation sectors, enhancing efficiencies and lowering environmental consequences (Punel & Stathopoulos, 2017). One of these new systems works on the concept of sharing economy. In transportation, there are two main types of sharing - freight sharing and passenger sharing. With idle capacity in transportation, freight and passenger sharing allows for more efficient use of social transportation resources, lowering social logistics costs. Crowdshipping is one form of freight sharing (Le & Ukkusuri, 2019), which is still in its early phases, but has enormous development potential (NOU, 2017).

A comprehensive definition of Crowdshipping (CS) is "*information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has the free capacity with regards to time and/or space, participates on a voluntary basis, and is compensated accordingly*" (Rai, et al., 2017). Crowdshipping (or crowdsourcing) is one of the most promising options for circular and repetitive deliveries; it connects social idle capacity with delivery demands. Crowdshipping is managed using application-based systems that connect supply and demand. These platforms help transportation of goods through commuters or travellers, ideally on their already set itineraries/routes (Mehmann, et al., 2015) (Marcucci, 2017) (Carbone, et al., 2017). Crowdshipping has gained increasing attention in both research and industry. There is a growing interest in the use of crowd-sourced drivers and vehicles for freight delivery (Rougès & Montreuil, 2014) (Rai, et al., 2017) (Carbone, et al., 2017) (Mehmann, et al., 2015). Research on non-urban applications of the crowdshipping concept and their environmental impact is suggested to be performed (Rai, et al., 2018). However, due to the novelty of crowdshipping and the lack of standardized operational processes, the study of this emerging field is challenging.

1.2 Purpose of the research and its boundaries

This study is one of the first to focus on inter-city crowdshipping and provides an in-depth examination of how crowdshipping works and affects the transport sector. The goal of this study is to illustrate how crowdshipping complements freight transportation and attempt to check if it is a sustainable solution. Understanding the performance of crowdshipping deliveries is an outstanding scientific question, due to the novelty and the limited publicly available data. The research on crowdshipping has been limited resulting in a lack of adequate understanding on both sides - researchers and policymakers (Ermagun, et al., 2019). This thesis focuses on inter-city crowdshipping, a topic that has received little attention; existing literature focuses primarily on last mile crowdshipping.

1.3 Research Questions

RQ1: How are the current crowdshipping practices complementing freight transport operations?

RQ2: What are the environmental implications of a crowdshipping platform?

RQ3: What are the economic implications of a crowdshipping platform to its users?

The table below demonstrates the connection between the reviewed literature and the research questions.

Scientific Literature	RQ1	RQ2	RQ3
Today's Supply Chain Network	✓	✓	✓
Transportation	✓	✓	✓
Passenger Transportation	✓	✓	✓
Freight Transportation	✓	✓	✓
Third Party Logistics service (3PL)	✓	✓	✓
Technology and Trends	✓	✓	✓
Sustainability	✓	✓	✓
Triple Bottom Line	✓	✓	✓
Carbon Policy		✓	
Emissions/Climate change		✓	
Ways to calculate emissions		✓	
Empty Running		✓	✓
Sharing Economy	✓	✓	✓
Crowdshipping	✓	✓	✓
Economic Impact	✓		✓
Environmental impact	✓	✓	

Table 1 Relating Research Questions with literature

1.4 Research Propositions

Proposition 1: Crowdshipping is a viable mode of freight transportation.

Proposition 2: Long distance crowdshipping generates less emission than other 3PL service providers.

Proposition 3: Crowdshipping is economically beneficial to its users.

1.5 Significance of the study

Crowdshipping is thought to have a promising future in terms of both freight transportation and environmental sustainability. However, this is still a novel concept with limited real-world data. It is vital to analyze real user data from operating crowd logistics platforms in order to draw reliable conclusions about their influence. (Paloheimo, et al., 2015) This paper uses a case study technique to examine the sole crowdshipping platform in Norway and performs an in-depth descriptive analysis using real data to determine its possible environmental and economic impact.

1.6 Scope and Boundaries

This research employs a case study approach, with Norway as the case country. Norway has a total size of 385,207 km^2 and a population of 5,425,270 as of January 2022. Norway is a long and narrow country with a densely populated southern region. The case company is "Nimber" which is the only crowdshipping platform operating in Norway. All the areas covered by the crowdshipping platform are considered. The data is provided by the case company and the boundaries of this research are clearly stated. The research focuses on inter-city crowdshipping and primarily analyses private individuals rather than companies as bringers (drivers) on the platform and includes all types of goods and packages, including parcels. Finally, a brief overview of these companies is presented.

1.7 Structure

This section presents an overview of the thesis, which is organized into seven chapters. The research paper provides an introduction and background to this thesis in Chapter 1. In Chapter 2, it reviews the current scientific literature, which gives an overview of the important concepts, definitions, descriptions, theories, and past research connected to this research. Chapter 3 provides a brief overview of the case country and case company, as well as significant data and figures to illustrate the current state. Chapter 4 describes the research framework and methodology, how the research is carried out, and which methodologies are employed for data collection and analysis. In Chapter 5, the paper presents the research findings, whereas Chapter 6 discusses the findings and gives insights on the case study. Chapter 7 includes the conclusion, limitations and recommendations for future research.

Chapter 2 Literature Review

This chapter examines the scientific literature on inland freight transportation and associated issues, focusing mainly on the economic and environmental aspects. The literature on crowdshipping is carefully studied, particularly in terms of inter-city transportation. The major objective is to gain a complete understanding of the present body of knowledge on this topic by reviewing current scientific research while identifying current gaps as well as opportunities for future research.

2.1 Importance of Literature Review

According to (Byrne, et al., 2012) , A literature review is essential because it has the ability to summarize a huge volume of research in a specific area and provide a way of delivering an argument convincingly based on evidence. The importance of discovering what is already known in the body of knowledge before beginning any research endeavour cannot be overstated (Hart, 1998). According to (Webster & T.Watson, 2002), Some researchers regard a literature review as just a summary collection of research papers but (Webster & T.Watson, 2002) deemed a systematic review of the past literature crucial for any academic research and considered it effective when it provides a solid foundation for improving knowledge, while promoting the development of theory, resolving research gaps and identifying areas of further research.

The literature review was performed using Molde University's online database and other databases such as GoogleScholar, ResearchGate and ScienceDirect. The literature review methodology was led by an outline of the scope, search terms and inclusion criteria first. After determining the scope, keywords and inclusion criteria, the research article selection was performed by reading title and abstracts and disregarding publications that were not directly connected to the goal of this study.

Considering the emergent nature of Crowdshipping, we used keywords "Crowdshipping", "Crowd sourcing", "Crowd Logistics", "Sharing Economy", "Freight Transport" and combined it with other keywords such as "Environmental, Social and Economic Implications", all the available articles were downloaded. After scanning the relevant articles, reports, and information from web pages, relevant ones were sorted, read, and used. The citations of these articles were also reviewed, and relevant articles were downloaded and read.

2.2 Definitions

2.2.1 Supply Chain

Our research focuses on the delivery of goods from one point to another, thus it's vital to review basic supply chain definitions, such as those listed below.

(John T. Mentzer, 2001) defines a supply chain as a "*set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer*".

2.2.2 Supply Chain Management

Supply chain management is defined by (Keely L. Croxton, 2001) as "*the integration of key business processes from end-user through original suppliers that provides products, services, and information that add value for customers and other stakeholders*".

Typically, supply chain management is categorized in terms of managing three flows, which are information, goods and finances as seen in the definitions above. Thus, the flow of goods constitutes an important element of supply chains.

2.2.3 Sustainable Supply Chain Management

SSCM is defined by Seuring & Müller, 2008) as *"the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental, and social, into account which are derived from customer and stakeholder requirements*" Thus, All players in sustainable supply chains must meet environmental, social, and economic criteria while being competitive and meeting customer needs.

2.2.4 Third Party Logistics

According to (Lieb, 1992), Third party logistics involves "*the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions* *performed by the third party can encompass the entire logistics process or selected activities within that process*".

2.2.5 Sharing Economy

"*Sharing economy means economic activity enabled or facilitated via digital platforms that coordinate the provision of a service or the exchange of services, skills, assets, property, resources or capital without transferring ownership and is primarily between private individuals*" (NOU, 2017).

2.2.6 Crowd Shipping

(McKinnon, 2016) conceives crowdshipping as "*an example of people using social networking to behave collaboratively and share services and assets for the greater good of the community as well as their own personal benefit*".

2.3 Today's Supply Chain Network

The supply chain network of an organization has an influence on how soon goods and services reach the customers. (Klibi & Martel, 2012) have mentioned external suppliers, manufacturing centers, distribution centers (DCs), demand zones, and transportation assets as the five basic entity categories that make up Supply Chain Networks (SCNs). Their research suggests that these networks must be reengineered on a regular basis during their business lifespan, which necessitates strategic decisions to match the network's structure with the demands of future business environments. But now, (Bergstrom, et al., 2020) have discussed that the COVID-19 pandemic has exposed many of the supply chain weaknesses and vulnerabilities that have existed for years. It has prompted businesses to rethink their operations and business strategies; while in other cases, it has created fresh prospects for post-pandemic innovation, expansion and competitive advantage.

(KPMG Powered Enterprise Supply Chain, 2022) examines driver shortages, capacity challenges with logistics providers, inflation, shipment delays, increasing freight prices, decreased inventory levels, labor shortages, and coping with demand peaks have all led to serious talks and have demanded action. (KPMG International CEO Outlook, 2021) performed a survey which revealed that when it comes to disruption and innovation, management teams want to be ahead of the game, with 67% indicating they will boost investment in disruption detection and innovation processes. CEOs will be held personally responsible for driving progress in tackling social challenges, as per 71% of respondents. With 30% of CEOs wanting to invest more than 10% of their turnover in becoming more sustainable, success on climate change will almost certainly need action from both businesses and governments. Lastly, (KPMG Powered Enterprise Supply Chain, 2022) report also reveals that government and business leaders are attempting to establish solutions that will strengthen their local capabilities and reduce their reliance on regional and global supply chains possibly increasing domestic freight transportation. Companies will rethink alternative supply chain network flow, inventory storage capacities closer to customers, and ways to improve last-mile delivery and reverse logistics.

2.4 Transportation

The capacity to get materials and finished goods from anywhere on the planet has broadened the scope of transportation to encompass worldwide supply chain networks and global integrative practices (Morash & Clinton, 1997). Transportation may play a significant integrative role in supply chain networks when businesses compete competitively based on cost, service or time. Transportation might be in a better position to integrate and coordinate flows throughout the supply chain. That is because inputs to industrial processes and finished products cannot reach their destinations without transportation (Nagurney, et al., 2007). In today's globalized economy, materials for manufacturing processes may be located on different continents from assembly sites and consumption points, stressing the importance of transportation infrastructure in product supply chains.

However, GHG emissions from the transportation sector accounted for 14% of total emissions in 2010, owing mostly to the use of fossil fuels for road, rail, sea and air transportation. Petroleum-based fuels, mostly diesel and gasoline, are estimated to supply 95% of the world's transportation energy (European Environmental Agency, 2010).

In the United States, the main source of GHG emissions from human activity is the use of fossil fuels for power, heat, and transportation. The EPA tracks the total GHG emissions of the US and estimates them in the annual report on GHG emissions. Transportation accounted for 29% of the US’s GHG emissions in 2019, becoming its primary source. These emissions come from the burning of fossil fuels as over 90% of the fuel used in transportation is petroleum-fuelled, which are mainly, gasoline and diesel. (European Environmental Agency) (European Environmental Agency, 2010)

2.4.1 Passenger Transportation

In 2017, inland passenger travel by cars accounted for 82.9% of all passenger transport in the EU. Since transportation by buses, trolleybuses, passenger trains, and motor coaches accounted for less than a tenth of total traffic, transportation by passenger cars dominated in all EU nations. In 2017, passenger transit by vehicle accounted for more than 85% of all inland passenger travel in Norway (Eurostat, 2020). In 2018, Norway had around 510 automobiles per thousand residents, with approximately 45% being petroleum-fuelled, 47% being diesel-fuelled, and the remainder using alternative energy. The average rate of occupancy in passenger cars was 1.45 including the driver (European Environmental Agency, 2010).

Non-urban passenger travel is responsible for 60% of greenhouse gas emissions. Inter-city vehicle travel is more difficult to decarbonize than intra-urban traffic because it includes longer distances, fewer passengers and requires low-carbon alternatives that can power long-distance transportation, which are currently few Papaioannou & Sohu, 2021). At the current trajectory, carbon emissions resulting from non-urban passenger travel will be 25% higher in 2050 as compared to 2015. Alternatively, it could be 57% lower with ambitious de-carbonization policies leveraging Covid-19 recovery, such as carbon taxes, greening the electrical system to power electric cars with renewable energy, and economic packages that prioritize environmental sustainability. There was a temporary drop in CO_2 emissions resulting from the economic downturn by Covid-19, also causing non-urban transport to be dropped by 40%. However, even with stringent de-carbonization regulations, non-urban transportation requirement will rise by more than 100% by 2050. (Papaioannou & Sohu, 2021)

2.4.2 Freight Transportation

The physical process of moving commodities, commercial products, and cargo is known as freight transport. In 2015, 70% of goods were transported by sea, 18% by road, 9% by rail, 2% by inland waterways, and less than 0.25% by air (The Maritime Executive, 2019). The growth of freight transport is expected to expand by 3.4% each year until 2050. Among the three inland transport modes of rail, road and inland waterways in the EU, road transport continues to account for most of the freight transport, with about 75.3 % of total inland freight transit in 2018 (Based on tonne-kilometers travelled) (Furtado & Martinez, 2021).

Land transport done by rail or vehicles as it is not always possible to locate a production facility near ports due to a country's restricted coastlines, ground transportation is necessary to convey goods from its origin to the airport or seaport and subsequently to its destination air and seaports (Norris, 2019). Ground transportation is often less expensive than air, but more expensive than sea, especially in underdeveloped nations with inefficient inland infrastructure.

Apart from the degree of development of local infrastructure, the form of road transportation of products is determined by the distance travelled by road, the weight and volume of a single cargo, and the type of product transported (Mihlfeld & Associates, 2018). A van or pickup vehicle can be utilized for short trips and light compact cargo. A truck is more ideal for large shipments, even if they are less than a full truckload. .

Although road freight accounts for only 15% of overall freight activity, it accounts for 44% of the sector's CO_2 emissions. Urban delivery trips account for around 20% of overall emissions, nearly comparable with worldwide marine shipping, but only account for 3% of total freight activity. Road freight will play a crucial role in the decarbonization of the transportation industry. (Furtado & Martinez, 2021) Currently, trucks are responsible for 65% of GHG emissions in the freight transportation industry and are expected to remain dominant in the surface transportation mode. Even though freight transport accounts for more than 40% of total CO_2 emissions from the transportation sector (Planet Energies, 2017), policymakers pay less attention to freight transport than to passenger transport due to its commercial character and cross-border complications.

2.4.2.1 Empty running

One of the ways in which freight transportation differs greatly from passenger transportation is that in passenger transport, passengers often return to their starting point whereas freight flows in only one direction, upstream to downstream. As a result, their efficiency is determined by how much of their two-way capacity is used. (McKinnon & Ge, 2006) In the literature, kilometres travelled without a load, or empty runs, are commonly recognized as a primary indicator of capacity utilization. (Figliozzi, 2007) Empty running is not only a waste of resources in economic terms, but it is also an environmental liability. (McKinnon & Ge, 2006) In the EU, one-fifth of freight travel by road was completed by empty vehicles, with between 15-30% of overall transport documented as empty vehicle-kilometers. In the first quarter of 2017, about 30% of total lorry mileage in Norway was empty running. (Statistics Norway, 2017)

2.4.2.2 Future of freight transportation

Freight transport is expected to more than double in size over the next three decades, necessitating immediate and bold decarbonization efforts. Decisive actions towards load consolidation, standardization, and collaboration can result in CO_2 emissions from freight transport being 72% lower in 2050 than they were in 2015. (Furtado & Martinez, 2021). The focus on resilient supply chains in the aftermath of the COVID-19 pandemic presents opportunities for freight decarbonization. Logistics optimization through digitalization and automation can help reduce carbon intensity. (Furtado & Martinez, 2021)

2.5 Third Party Logistics service (3PL)

Third-party logistics providers include freight forwarders, courier companies, and other businesses that integrate and provide subcontracted logistics and transportation services (Hertz & Alfredsson, 2002). (Hertz & Alfredsson, 2002) describes four categories of 3PL service providers: a standard TPL provider, service developer, customer adapter, and customer developer.

- The standard TPL provider may be thought of as a company that provides conventional TPL services such as warehousing, distribution, pick and pack, and so on.
- As a service developer, TPL is thought to provide enhanced value-added services. Differentiated services for various customers, bespoke packaging, cross-docking, tracking and tracing, customized security systems, and so on. Such a breakthrough is made possible by a sophisticated IT system.
- The client adaptor might be defined as a TPL business that takes over customers' existing operations and improves handling efficiency while not actively developing services. This sort of supplier may take over a customer's whole warehousing and logistical operations and rely on a small number of extremely close clients.
- The most complex and challenging form is the customer developer. It entails a high level of integration with the client, which frequently takes the form of taking over the customer's

entire logistical operations. There would be a limited number of clients, and the work on each of their jobs would be considerable. The customer shares the risk and benefit of logistics management with such a company.

Package delivery is the delivery of cargo containers, parcels, or high-value mail as discrete shipments inside the 3PL domain. Most postal systems, express mail, private courier businesses, and less-than-truckload cargo carriers offer this service (Dennis, 2011).

The key global players in parcel/package delivery are FedEx, UPS, DHL or Deutsche Post, Blue Dart, and DTDC. They offer inventory management, warehousing, pick and pack, loading and unloading, real-time order tracking, cold chain transport, and other shipping, fulfillment, and supply chain solutions (Clickpost, 2022). Companies are getting more competitive to exploit the significant opportunity created by the expanding demand for CEP services in these countries (Mordor Intelligence, 2021). International players are making significant investments in regional logistics networks, such as the construction of new distribution facilities and smart warehouses. Local firms face stiff competition from international corporations that have a more developed network.

In Norway, Posten Norge and Postnord as are some of the major players in the CEP and freight transport market. Posten Norge is owned by the Norwegian ministry of transport and communications and is the largest CEP operator in the country. It is the parent organization of Bring, one of the Nordic region's leading mail and logistics company (Bring, 2022). Postnord is the Norwegian arm of the Nordic corporation, Postnord AB which has a revenue of NOK 4.6 billion, roughly 1,500 permanent employees, and around 900 contracted drivers (Postnord, 2022). With 25 divisions and sorting facilities, the corporation has a nationwide distribution network.
The type of items that can be transported via these postal service providers (Bring AS), (Postnord AS) are:

- Letters and Mail

As an individual or a business, their letter and postcard services provide the user with a variety of options for sending their mail both domestically and internationally.

- Parcels

As an individual or a business, their parcel services provide users with a variety of options for sending their parcel packages both domestically and internationally.

- Pallets

The postal service providers can collect pallets weighing up to 1,000 kilograms from business users and deliver them to companies and consumers throughout Norway and Europe.

- Large, heavy bulky items, project specific and offshore logistics

These postal companies have a large capacity for transporting goods throughout the Nordic region and Europe. From individual transportation tasks to more complex logistics solutions, they can assist different types of users and requirements.

2.6 Emissions and Climate change

According to experts, the rising temperatures will endanger the well-being of humans over the next decades since the average temperature of the earth has risen by 0.85^{o}C over the past 130 years. Human activities, which are responsible for increased greenhouse gas emissions, are to blame for climate change which has resulted in a variety of natural disasters and air pollution. (Ghosh and colleagues, 2018)

One such activity is transportation whose rate of emission reductions has slowed. Other industries have reduced emissions since 1990, but transportation emissions are growing as more people become mobile specially in growing economies resulting in increase in vehicle ownership (Sperling & Claussen, 2002).

2.6.1 Sources of emissions

According to studies, when apportioning the sources of air pollution in industrialized and developing countries, the transportation industry comes out on top — both from direct and indirect sources (Government of Australia). Direct emissions are emissions produced and released from the tail pipe of a vehicle. Indirect emissions are produced off-site from energy and fuel production, distribution, and from car manufacturing and its supply chain (Wolfram, et al., 2021). Only recently it has been realized that indirect emissions from the production of fuels are considerable when compared to direct emissions from the tailpipe. Similarly, even though a vehicle that runs entirely on electricity (EV) produces no direct emissions, analyst have expressed concern, that it might result in higher indirect emissions from energy and battery production, which are not typically governed by transportation policies (US Energy Information Administration, 2021). With an increase in the number of vehicles on the road, emissions will rise, air quality will deteriorate, fuel consumption will rise, and instead of moving forward, people will suffer due to traffic congestion, unless a series of actions are taken to not only control traffic but also to improve emission-control technology and find ways to reduce emission.

There are two kinds of emissions as per (Government of Australia) that have an environmental impact:

Greenhouse gas emissions, such as carbon dioxide (CO_2), Nitrous Oxide (NO_x) and Methane create a greenhouse effect and lead to climate change by trapping additional heat from the sun in the earth's atmosphere. However, not all vehicles have the same effect. The amount of fuel consumed, the type of fuel used, and other factors all affect the vehicle's CO_2 emissions.

The second type are **pollutants** emitted by Motor vehicles into the environment such as carbon monoxide, nitrogen oxides, particulate matter, volatile organic compounds, and benzene. These emissions are frequently retained close to the ground, forming a brownish haze that pollutes the air, causing issues to human health.

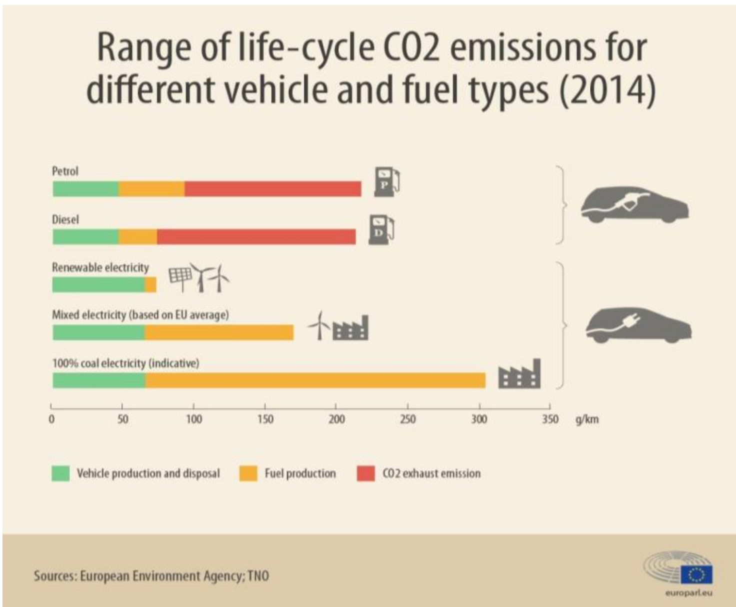


Figure 1 CO2 emissions from the transport sector in EU (2014) (European Parliament News, 2019)

In fuel types, a gallon of gasoline (without ethanol) creates around 19 pounds of carbon dioxide when burned (CO_2) (US Energy Information Administration, 2021). Diesel car emissions have been found to be substantially more hazardous than those from gasoline vehicles (Jacobson, 2002). Although diesel vehicles get 25% to 35% better economy and produce less CO_2, they can generate 25 to 400 times more particulate matter per kilometer than gasoline cars.

GHG emissions from the transport sector in the EU has increased from 725.5 million tonnes in 1990 to 967.5 million tonnes in 2019 (European Commission, 2021).

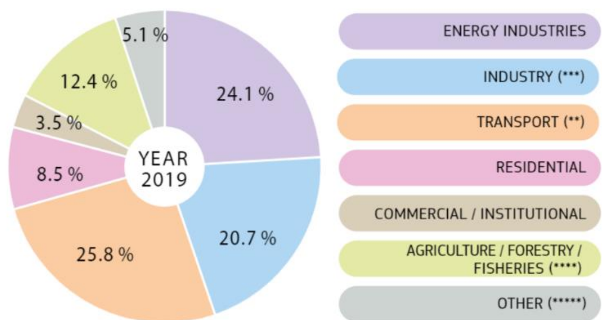


Figure 2 GHG Emissions by sector EU-27 (Shares %) (European Commission, 2021).

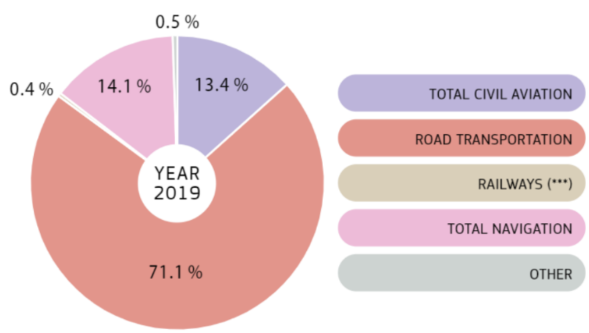


Figure 3 GHG Emissions by Transport modes EU-27 (Shares %) (European Commission, 2021).

GHG emissions from road transport in EU has increased from 620.1 million tonnes in 1990 to 792.8 million tonnes in 2019.

GHG emissions from road transport
EU-27 – BY TRANSPORT MEAN

(MILLION TONNES CO_2 EQUIVALENT)

	ROAD TRANSPORTATION	Cars	Light-duty trucks	Heavy-duty trucks and buses	Motorcycles	Other road transportation	TOTAL TRANSPORT (*)	TOTAL EMISSIONS (**)
2019	792.8	480.4	87.5	214.7	10.0	0.1	1 106.2	3 881.4

Figure 4 GHG Emissions from road transport by transport (Million Tonnes CO2 Equivalent) (European Commission, 2021).

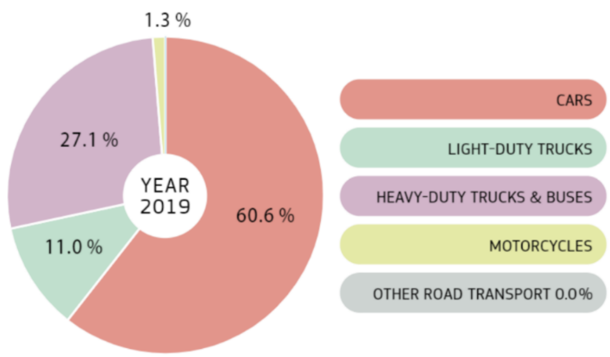


Figure 5 GHG Emissions from road transport by transport means (Shares %) (European Commission, 2021).

2.6.2 Ways to calculate emissions

Carbon dioxide accounts for the largest share of greenhouse gas emissions from transportation (CO_2) (Intergovernmental Panel on Climate Change, 2014). Numerous literature identify categories such as combustion of motor fuels for propulsion, evaporation of motor fuels from vehicle fuel systems, wear of tyres, brake linings, and road surfaces, leakage, and consumption of motor oil as sources of direct emissions of greenhouse gases and air pollutants.

There are several analytical emission models available, each with its own method of estimating fuel consumption or emissions, as well as the characteristics taken into consideration in the calculations. (Ardekani & E. Hauer, 1996) For example, split fuel consumption models into urban (vehicle speed less than 55 km/h) and highway (vehicle speed greater than 55 km/h) models, while

(Esteves-Booth, et al., 2002) analyzed three types of emission models based on emission factors, average speeds, and vehicle types.

(Ntziachristos & Samaras, 2000) created the computer program to calculate emissions from road transportation (COPERT) model, which calculates emissions for all main air pollutants as well as greenhouse gases produced by various vehicle types (e.g., passenger cars, light duty vehicles, heavy duty vehicles, mopeds and motorcycles). It estimates fuel consumption using a variety of functions that are particular to cars of different weights.

(Rødseth, et al., 2019) in their report on "External costs of transport in Norway" utilized emission factors based on the Handbook of emission factors for road transportation (HBEFA). The handbook gives emissions data in grams per kilometer for all major road vehicle types (passenger cars, light commercial vehicles, heavy commercial vehicles, and motorcyclists), as well as subclasses. In 1995, the Umweltbundesamt (Environmental Directorate) in Germany launched HBEFA, a Microsoft Access database program. Germany, Switzerland, Austria, Norway, Sweden, France and the European Commission's European Research Center helped to further build the database. HBEFA provides emission factors for particulates, NO_x, and CO_2 emissions from internal combustion engines which has been used as a basis for calculating emissions per km from different vehicles.

2.7 Sustainability

Sustainability has received a lot of attention resulting from consumer and government demands. These include economic, environmental, and social issues amplified by the global economic crisis, the quest for a higher quality of life, the effects of global warming, and natural resource depletion (Campos, et al., 2019). All industrial and business processes, such as manufacturing, maintenance, marketing, purchasing, sales, and logistics, must be sustainable. (Bretzke, 2011) The integration of sustainability principles into logistics has been accelerated because of the global implications of major product flows, with a focus on transportation activity.

Increasing delivery volumes, along with a desire for quick delivery, puts pressure on logistics service providers (LSPs) to complete the last mile in a cost-effective way while reducing negative environmental and social externalities (Do Trung, et al., 2020).

In today's dynamic delivery environment, LSPs must make more delivery trips in order to meet the increasing demand. More trips will result in more traffic, which will result in more congestion and pollution. This obviously contradicts the municipality's or local administration’s purpose of creating a green, healthy city with little pollution and traffic congestion (Do Trung, et al., 2020). If the LSPs were to function more sustainably by concentrating more and relying only on e-vehicles and cargo bikes, this would have a significant impact on both their service levels (capacity issues and delivery time) and their operating expenses (due to the high cost of investing in new vehicles and the capacity issue). Given the tremendous competition and simplicity with which consumers may switch LSPs, this might have a substantial impact on their bottom line. Because both LSPs and customers are interested in quick delivery, they are at odds with municipalities. According to a pricing simulation by (Gevaers, et al., 2014), while customers' environmental awareness has grown in recent years, their willingness to pay extra for a more sustainable delivery choice remains low. Faster delivery benefits merchants as well, because it increases the value of their items to their customers. Consumers, on the other hand, are residents who live in cities and are aligned with municipalities in their efforts to reduce congestion and pollution (Do Trung, et al., 2020). Consumers, maybe unwittingly, are contributing to a problem that they would prefer to avoid.

Hence, organizations, entities, and individuals that want to be sustainable, need to manage their activities and achieve positive outcomes in all three areas of sustainability: economic, environmental, and social. This idea of the triple bottom line was coined by Elkington, 1998).

2.7.1 Triple Bottom Line

Road freight transportation has an economic influence on sustainable development, mostly in the form of operational costs and traffic congestion (Campos, et al., 2019). Transportation costs frequently account for 10-20% of overall product costs, putting pressure on the logistics sector to keep costs down (Jean-Paul, et al., 2016). Transportation costs are primarily determined by the type of vehicle utilized, travel conditions, and market taxes. Freight transportation is also time-sensitive, and tiny delays in shipments caused by congestion frequently result in increased product costs and customer dissatisfaction (W.L. Eisele, 2013).

Road freight transportation has a social impact on sustainability because of pollution-induced health effects, traffic accidents, crop destruction, noise, and visual intrusion. (Campos, et al., 2019) has shown that burning diesel fuel, generates large amounts of particulate matter and nitrogen oxide, both of which are considered as primary causes of human respiratory difficulties, is the main source of pollution-induced health effects (Essen, 2008). Trucks are also disproportionately responsible for traffic accidents, according to European research, and road traffic is the most significant source of noise pollution, which is a serious public health issue.

In terms of the environment, road freight transportation has the greatest influence on sustainability due to carbon emissions, which cause global warming and climate change (Gilbert, et al., 2003). Truck tires and lubricating fluids also have negative consequences, posing a risk of contamination of water, soil, and air. The decarbonization of transportation has received a lot of attention in the scientific literature (Campos, et al., 2019). However, the majority of these policies also help to enhance social and economic conditions.

People and goods flow in the city have traditionally been treated separately in theory and practice, even though both entities share the same road infrastructure and influence one another. (Ghilas, et al., 2013) discuss one of the main benefits resulting from the integration of the two types of flows is the best use of available capacity. Furthermore, merging people and freight flows opens up lucrative business prospects because the same transportation requirements can be satisfied with fewer cars and drivers. (Pimentela & Alvelos, 2018) several authors suggest the advantages of this integration, but there is essentially no literature in which it is adequately investigated. However, a new research topic in the area of urban logistics is emerging in recent literature, seeking to promote the integrated management of goods movements in urban centers to aggregate numerous agents and services and stimulate the formation of new forms of business to support an agile distribution (lower average delivery volume and higher frequency of delivery), utilizing smaller and less polluting vehicles (e.g., bicycles). Although the papers talk about transporting and traveling intracity, there is evidence supporting the advantages of combining passenger and freight intercity transport thereby increasing total capacity utilization.

2.7.2 Carbon Policy

Various carbon policies are being implemented globally to reduce greenhouse gas emissions. The European union's cap-and-trade system is one of these. This system aims to provide companies an upper limit on their emissions and penalize those that exceed them. Companies can either keep the unused allowance or sell it, thus guaranteeing that they achieve their objectives without negatively impacting the environment. Alternatively, the United States has a revenue-neutral carbon tax which is simple and easy to implement, under which businesses must pay for every ton of carbon they emit. Carbon taxes and carbon markets (Cap and Trade), according to several research, are the most cost-effective solutions to decrease greenhouse gas emissions. (Ghosh, et al., 2018) many corporations are beginning to implement various carbon policies as the importance of incorporating environmental problems into corporate social responsibility (CSR) grows, not only due to stringent laws but also due to customer demand.

European laws on transportation emissions (from euro 1 to euro 6) (Union, 2007) have encouraged automakers to enhance their internal combustion engine vehicles (ICEVs) on a constant basis. ICEVs, on the other hand, appear to be reaching their technological and economic limits, prompting the development of transportation alternatives that are fueled by less polluting energy sources. Electrification of automobiles using lithium-ion batteries (li-ion) is arguably the most popular of these options. However, due to the imminent indirect sources of emission that would take a long time to tackle, other smart and sustainable ways of transport need to be explored and developed.

2.8 Technology and trends

Digital technologies are increasingly being used to enhance existing and innovative freight transportation and logistics provision and management (Marzenna Cichosz, 2020). This digitalization frequently results in significant changes: 1) within organizations, such as changes in business models and processes; 2) between organizations, such as governance, relational, technical, and process configurations; and 3) at the ecosystem and industry levels, such as disruptions to the status quo and the emergence of new product or service providers.

The paper also discusses technologies such as Artificial intelligence (AI) and machine learning, 5G, blockchain-distributed ledger technology, pervasive computing, data analytics, and immersive technologies are all advancing at breakneck speed. These advancements are changing and altering the FTL (full truck load transportation) sector's status quo, which has escalated since the COVID-19 pandemic (Marzenna Cichosz, 2020). Significant changes in customer behavior and expectations, aided by ubiquitous access to information, e-commerce operations, and digital services, have further changed the sector. (Logistics, 2022) From same day delivery to environment friendly deliveries, carriers need to respond from contract negotiation to the use of new technologies for customer satisfaction.

New industry business models are emerging because of digitalization, such as logistics-as-a-service, which include micro-fulfillment centers, and mobility-as-a-service (Kamargianni M., 2017). These business models could also be aided by new finance models made possible by digitization, such as the use of cryptocurrencies and the Internet of Things (IOT). Community redesign and the implications of smart cities transportation planning is also being influenced from a social standpoint (Wang, et al., 2016).

2.9 Sharing economy

A sharing economy is a conceptual model in which private individuals directly or through online and offline facilitators offer services or rent out assets. The sharing economy's business concepts are frequently centered on making it simpler to rent out underutilized assets (Skatteetaten). Sharing economy has three important characteristics: private persons are involved, commonly referred to as peer-to-peer sharing; ownership is not transferred; and digital platforms are used to facilitate or enable services. (NOU, 2017)

In Norway, the sharing economy is not particularly widespread and is mostly noticed in the accommodation sector and automobile transport industry (taxi-like & car sharing), but it appears promising with huge development potential. The future of the sharing economy is dependent on a variety of variables, including the legislative environment, technological innovation, and demographic preferences and attitudes. (NOU, 2017)

2.10 Crowdshipping / Crowd Logistics

Crowdshipping (CS) or crowd logistics (used interchangeably within literature) typically involves matching the demand and supply of logistics using online platforms. (Ermagun, et al., 2019). It allows for more efficient use of social transportation resources, lowering social logistics costs. Literature also discusses new opportunities due to the rise of mobile internet technology such as crowdsourced delivery. This approach comprises the utilization of private passenger car's surplus capacity on existing routes to support delivery operations (Arslan, et al., 2018). This might potentially enable faster and cheaper delivery by using existing traffic flows. It may also assist to mitigate the negative environmental effects such as GHG emissions and pollution further.

2.10.1 Existing Research on Crowd Logistics

An exploratory case study analysis of 57 crowd logistics initiatives from around the world, including the case company "Nimber," was carried out, and the services of CL initiatives were classified into four types: 1. storage services, 2. local delivery services, 3. freight shipping services, and 4. freight forwarding services. (Carbone, et al., 2017)

A study of 13 CL providers in Germany was conducted using a document-based data analysis and expert interviews, indicating that CL requires a deep understanding of various elements such as social, technical, and economic issues. A CL business model concept was developed for the sustainable operation of such services. The aspects that are obligatory for the practice of this concept are that the customer crowd and carrier crowd, these are essential resource for any platform or organization and should be maintained permanently, and secondly, its return on investment is typically only positive in the long term. Some implications for practice obtained from this analysis were, it is important that companies start with designing a strategy, an innovative concept, and conduct a competitive analysis before they can implement a service. Financial planning should also focus on service rearrangements and not only on the initial phase. Due to the nature of crowd logistics, various factors may influence its operation, such as geographical factors, platform and network should also be analyzed before launching a new service. From a scientific research perspective, CL is still in its infancy with limited published articles. This field requires extensive research to analyze the various factors that affect the operation of crowd logistics businesses. (Frehe, et al., 2017)

To define CL comprehensively and estimate its sustainability potential, a study performed a systematic literature review of 42 articles and conducted semi-structured interviews of 11 logistics practitioners. Along with defining CL, a collection of 18 characteristics of the engaged stakeholders that describe various CL concepts, as well as their economic, social, and environmental implications, were established. The receiver and commissioner, logistics service provider, platform provider, and the crowd were among the stakeholders. The following five characteristics of the crowd were identified: the crowd's *character,* which might be either self-employed or private. The *transportation fulfillment* might be intentional or devoted. *Incentives* might be monetary or non-monetary, with "cost-to-serve" being the most appropriate. The crowd's *motive*, whether it's environmental and community-focused, or they have a clear financial incentive. The *model choice*, such as public transport, private vehicle. (Rai, et al., 2017)

A Finnish pilot study on applying crowdshipping to library deliveries observed re-bound effects of drivers motivated by monetary compensation leading them to drive longer distances and hence causing a reduced improvement in environmental sustainability. Future research should be conducted to address the environmental risks potentially generated from drivers driving longer distances as in the current study most of the extra kilometers were made on bikes. (Paloheimo, et al., 2015)

The first study of its kind as stated by (Qi, et al., 2018) was performed with the aim to evaluate the adoption of shared mobility for home delivery services (last mile). It was performed with the context of a logistics service provider that has taken advantage of the operating cost savings associated with running a fleet of short-distance trucks for bulk transportation and for last-mile it uses shared mobility, along with the perspective of local governments that aim to reduce GHG emissions. However, based on the theoretical analysis, analytical models, and empirical parameter estimates within a realistic setting, the results suggested that shared mobility/crowdsourcing as compared to the conventional truck-only system is not scalable in terms of operating cost but does have a potential for economic benefits such as reduced fleet size, flexibility in operations, etc. However, unless low emission cars are assumed, shared mobility may not help reduce GHG emissions due to the additional trips incurred, relative to the minimum levels of emissions, even exclusively minimizing operating costs do not cause a significant increase in emissions. (Qi, et al., 2018)

A study performed by (Rai, et al., 2018) to determine which types of crowd logistics are currently being performed and whether they are supported by various stakeholder groups, using systematic literature review and semi-structured interview of 13 logistics practitioners that represented 11 companies found that the top three elements influencing the performance of the crowdshipping *platform* have been identified as “happy crowd”, “good service” and “maximal profit”. In addition, the top three factors impacting the *crowd's* readiness to work as occasional drivers were "compensation," "excellent working atmosphere," and "good platform operation”. Whereas, “qualitative delivery”, “qualitative pickup” and “care for environment” were top three factors for the *commissioner*. For the *receiver*, the top three factors were “care for the environment,” “care for society” and the “price”. For the society, the top three important elements were “high traffic safety”, “good accessibility” and “good air quality”, all these fell under attractive living environment. Currently, literature on CL is limited to city distribution and last-mile, future research could involve a sustainability impact assessment of a CL pilot project. (Rai, et al., 2018)

A study conducted using data of an operational crowdshipping platform in Belgium to assess its environmental impact and the stakeholders involved, concluded that over half of the trips made by the crowd were dedicated trips. Which increased the environmental impact of the trips compared to traditional urban parcel transport. Despite sustainability goals not being met, crowd logistics receives support from various stakeholder groups. This is because people are willing to spend their free time and/or share their vehicle capacity to earn a small financial incentive. The Platform provider has a critical role to play to achieve environmental sustainability by facilitating capacity utilization and rewarding the crowd based on their leveraged existing trips. Future research on other non-urban applications of the CS concept and their environmental impact should be performed. (Rai, et al., 2018)

In the domains of CEP (Courier, Express, package), e-commerce, and passenger transport, traditional business models are being modified and completely new business models are also developed leading to new strategies such as CL (Crowd logistics) where the carrier role is undertaken by private individuals for a minor fee. (Frehe, et al., 2017)

The results of the face-to-face interviews conducted by (Dai, et al., 2020) in China with six express delivery companies for their last mile show that (1) crowdshipping is potentially an innovative green logistics solution; (2) if the cost of express delivery completed by crowdshipping is lower than the current cost of deliveries, and if there are enough cars to ensure the task is completed, they are willing to participate in these crowdshipping activities; and (3) based on their calculations, when the crowdshipping activity is completed, the shippers are willing to pay about 30 yuan (USD 4.7) per 0.4 meter cube of goods.

Crowdshipping is gaining traction in the shipping business, with non-traditional players such as technology companies and merchants promoting it (Ermagun, et al., 2019). DHL experimented with Myways early on, a last-mile delivery strategy that allowed neighbors to pick up and deliver online purchased items. Currently, several start-up firms outside of the usual logistics context, such as Rideship, Nimber, Roadie, Deliv, and Piggybee, specialize in shipping via the crowd (Dablanc, et al., 2017). Furthermore, large retail companies are experimenting with "ordinary people" delivery. Customers are compensated or offered discounts to pick up and deliver to other customers along their route in the United States, according to Amazon and Walmart. (Marcucci, 2017) (Wang & Sarkis, 2021)

Figure 6 Crowdshipping System Conceptualization (Ukkusuri, et al., 2019)

Benefits such as reduced delivery times, economical delivery costs, higher flexibilities, increased accessibility, job opportunities and sustainability are expected from crowdshipping (McKinnon, 2016). However, CS is also subject to challenges such as network effects, safety, trust, security, and legal issues (McKinnon, 2016) (Rougès & Montreuil, 2014)

2.10.2 Crowd / Users

(Rougès & Montreuil, 2014) argued that "chicken-and-egg" dilemma is one of major obstacles in crowdsourced delivery. Since a critical mass of customers is required to attract couriers, likewise a critical mass of couriers is required to ensure quality deliveries and in turn to attract customers. As a matter of fact, most promising start-ups in the CL industry rely primarily on professionals and dedicated fleets such as Zipments courier has 95% of its couriers as professionals. (Qi, et al., 2018). Crowd is the core of CL but is often complemented with professional LSPs. Involving professional third parties are important in the case of an inadequate and/or underperforming crowd. (Rai, et al., 2017). A study conducted in Italy by (Marcucci, 2017) for investigating the potential of crowdshipping in urban areas, showed that 87% of Italian students were willing to work as driver-partners, while 93% were ready to receive their products via a crowdshipping platform.

2.10.2.1 Senders

Senders are users who use the platform to send their shipments (Le, et al., 2019). A study by (Punel & Stathopoulos, 2017) focused on potential user preferences regarding the performance of their CS driver. The conclusion was that their reputation was more influential in many settings as compared to delivery speed and cost. The main demand generating players in crowd logistics are e-retailers, retailers, and logistics businesses. These individuals typically send and receive orders from the crowd. (Rai, et al., 2017) A study investigated the criteria that distinguish CS users from non-users in 2018 and found that CS is more frequent among young individuals, men, and those who work full-time, and that those who have significant environmental and community concerns are more likely to use it. (Punel, et al., 2018)

2.10.2.2 Driver/ Bringer

Couriers, crowdshipping drivers, and driver-partners are referred to as bringers who deliver freight. The most important factors to consider when choosing a courier maybe the location of the delivery route, the price, and the reputation of the courier’s service. (Le, et al., 2019) A study conducted by (Miller, et al., 2017) in US found that people who are travelling for leisure or with flexible schedules are more likely to consider becoming occasional drivers. Drivers' compensation is a key factor that influences their willingness-to-drive and drives the platform’s success. (Le, et al., 2019)

The drivers, rather than being conventional workers or service providers, operate on their own discretion as found by (Arslan, et al., 2016). They are willing to make deliveries throughout their route in order to assist others, promote environmentally responsible deliveries, and earn some additional cash. Drivers ideally, are eager to transport a package along a route that they are currently on. This contrasts with systems where drivers just make deliveries to make money. In this situation, drivers may have a wide range of time and detour flexibility. Some drivers may just want to take a short detour to pick up a package on a route they're already on, while others may be eager to make repeated deliveries.

2.10.3 Platform

The success of a crowd-based logistics platform depends on a well-established and dense crowd network (Carbone, et al., 2017). The growing trend of crowdshipping in freight transportation has been pushed by the rapid development of app-based platform technologies that allows supply and demand to be connected (Ukkusuri, et al., 2019). "*Crowdshipping can be thought of as an example of people using social networking to behave collaboratively and share services and assets for the greater good of the community as well as their own personal advantage,*" writes (McKinnon, 2016). Furthermore, (Fung Business Intelligence, 2015) defined CS as *"a web or mobile-based courier service that digitally matches demand with supply by leveraging big groups of geographically dispersed individuals*."

2.10.4 Business model

(Rougès & Montreuil, 2014) Being amongst one of the first studies to examine business models of crowdsourced delivery platforms, identified five archetypal business models in the CS industry after analyzing 18 startups worldwide including the case company "Nimber (Former Easybring)". These models are identified as "*Courier*" with clients as B2C and Professional/Non-professional dedicated couriers operating Intra-urban, "*Intendant*" as B2C and Professional/Nonprofessional dedicated couriers operating Intra-urban, "*Intra-Urban*" as P2P or B2B and Professional/Nonprofessional dedicated couriers, and commuters as couriers, "*National*" as P2P or B2B and travelers as couriers operating Inter-urban/National, and "*Social Delivery*" as P2P or B2B and travelers as couriers operating National/International. B2C Intra-Urban is currently dominant but its ability to be successful in inter-urban delivery is doubtful. This study is restricted since it is based on public documents and no first-hand information is gathered. Future research is recommended to include qualitative and quantitative studies to identify business strategies, success factors, and difficulties experienced by start-ups in the sector, as the CS industry is very young and developing very fast. Experimentation and simulation are also required to uncover ways to increase the overall efficiency of the ecosystem. (Rougès & Montreuil, 2014)

2.10.5 Economic and Environmental impact

Last mile delivery is typically the most costly and time-consuming stage of fulfillment. Most organizations struggle to cut last-mile delivery expenses, which is where crowdshipping could come in (Le & Ukkusuri, 2019). Crowdshipping reduces the need for large delivery fleets and other assets in addition to providing speedy, consistent, on-demand product fulfillment. Because of the nature of this delivery, drivers as users on the platform are required to use their assets to accomplish product fulfillment. (Behrend & Meisel, 2018) established a mathematical and heuristic model to examine a platform that combines shipment requests with community members' planned journeys with the goal of optimizing profits. The findings calculated the benefit of combining item-sharing with crowdshipping as a function of crowdshippers detour flexibility and compensations. (Arslan, et al., 2018) have found CS as usually cost efficient as compared to traditional logistics providers in their studies. (Buldeo Rai, et al., 2017) evaluated the external costs imposed on society by crowdshipping versus professional systems while delivering goods, finding that uncontrolled usage of the platform (vehicle trips dedicated to delivering parcels) leads in greater external transportation costs and consequently higher emissions. As a result, crowd logistics may only be a viable option if the crowd makes use of current or planned vehicle trips.

Through crowd logistics, individuals can harness their dormant logistical resources to improve efficiency and reduce greenhouse gas emissions, future research can be conducted on the potential of crowd logistics to improve sustainability by considering both the logistics firms and individuals involved. (Carbone, et al., 2017) The crowd's behavior when it comes to carrying out dedicated delivery trips or taking parcels on already planned trips influences the CS's environmental impact. (Qi, et al., 2018) Carbon emissions are always less when empty kilometers are reduced (Li & Yu, 2017).

In terms of environmental sustainability, (Rai, et al., 2017) describes the efficient vehicle space usage leads to many of the advantages of crowd logistics (CL), such as reduced traffic, GHG emissions, and resource utilization. The *logistics task management* of the platform has the potential to steer the process, as it can either play an informational role in a decentralized manner or handle flows and push information to the crowd in a centralized manner. The *trajectory-dependency* is debatable; the platform may either directly link demand with supply based on inputted trajectories or independently by randomly permitting matches; random selection may lead to dedicated trips. In terms of the *geographical scale*, market size, or the extent of the CL platform, such as inter-urban, intra-urban, regional, national, and global, have an impact on environmental sustainability. The *usage of 3PL* providers is highly important since professional LSPs perform dedicated trips utilizing light-freight trucks, whereas traditional LSPs ensure aggregation effectively using experience. However, with CL, packages are processed individually, which limits the positive sustainability impact. The crowd's *transportation fulfillment*, can be intended or dedicated trip, the *modal choice*, can be use of public transportation, clean automobiles etc. The platform can therefore connect crowd incentives to a vehicle's chosen type, such as more sustainable, flexible, or more spacious, and additional costs can be compensated accordingly. And finally, the crowd's *main motivation* is decisive in the case of CL's environmental consequences. (Rai, et al., 2017)

Chapter 3 Case Description

3.1 Introduction

The preceding chapter's literature analysis emphasized several elements and possible benefits of crowdshipping, as well as referenced various scientific studies that have been conducted to establish its acceptance and noted gaps that required future research. Following in the footsteps of previous research on crowdshipping, this study focuses on an area that has not been widely researched, which is inter-city/inter-urban crowdshipping. The scope of this study focuses on existing crowdshipping activities in Norway, as well as their environmental impact. In doing so, we analyze real data from the only crowdshipping platform currently operating in Norway. This chapter contains relevant information on various facts and figures linked to the case and a brief description of the case company.

3.2 Case country – Norway

As of the first quarter of 2022, Norway has a population of around 5.4 million inhabitants (Statistics Norway, 2022). In 2017, Norway had around 17.3 inhabitants per square kilometer of the geographical area; the population growth rate in 2016 was 0.9 percent. Norway is second in Europe following Iceland in terms of low population density. Nonetheless, 80 percent of its population lives in urban areas. In 2016, the population density in urban areas was 1,947 inhabitants per square kilometer. The mainland area is 323,781 square kilometers, with a coastal length of 28,953 kilometers. (The Government , 2017)

As of 2016, Norway had a road network comprised of 94,600 kilometers, while the railway network covered 4,208 kilometers with an electrified rail network of 2,459 kilometers. It had 49 airports and 32 seaports that connect to the national transportation grid. (The Government , 2017)

According to statistics, freight transportation in Norway is gradually increasing along with the emissions generated by this sector. Another source of concern is non-optimized capacity utilization in the form of empty running, which accounted for around 30% in Norway in 2018. Similar facts can be observed in passenger transportation with low occupancy rates per vehicle. Nimber's crowdshipping platform presumably provides an opportunity to utilize under-utilized capacity and cut GHG emissions in Norway. Some key statistics associated to freight transportation, passenger transportation and their related issues such as empty running, occupancy rates are mentioned next, followed by emission figures.

3.2.1 Freight Transport

In Norway, freight transportation by road accounted for 51.6% of all tonne-kilometers in 2012 and saw a 5% increase as compared to 2011 (Vågane, 2013). In 2018, Norway's national road freight transit accounted for 18,924 million tonne-kilometers, a 1% increase from 2017, accounting for over 80% of total inland freight transportation (Eurostat, 2020). In 2019, freight transport by road increased by 2.7%, it accounted for 51% of all freight tonne-kilometers (Farstad, et al., 2020).

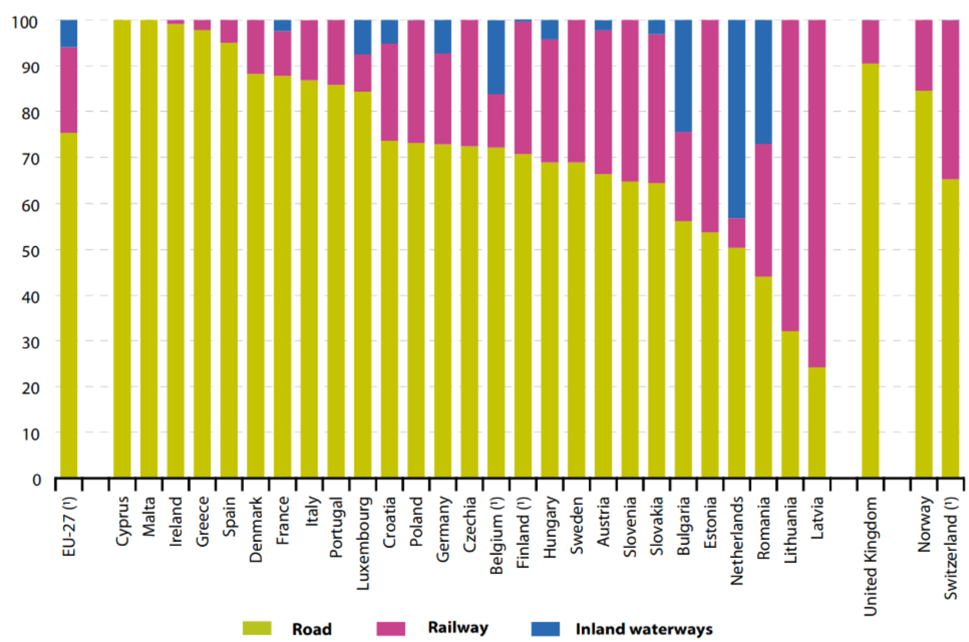


Figure 7 The modal share of inland freight transport, 2018 (% share in tonne-kilometres) (Eurostat, 2020)

The model split of inland freight transport varies from country to country depending upon the availability of the given mode. In 2018, the proportion of railway in inland freight transport in Norway was around 15%.

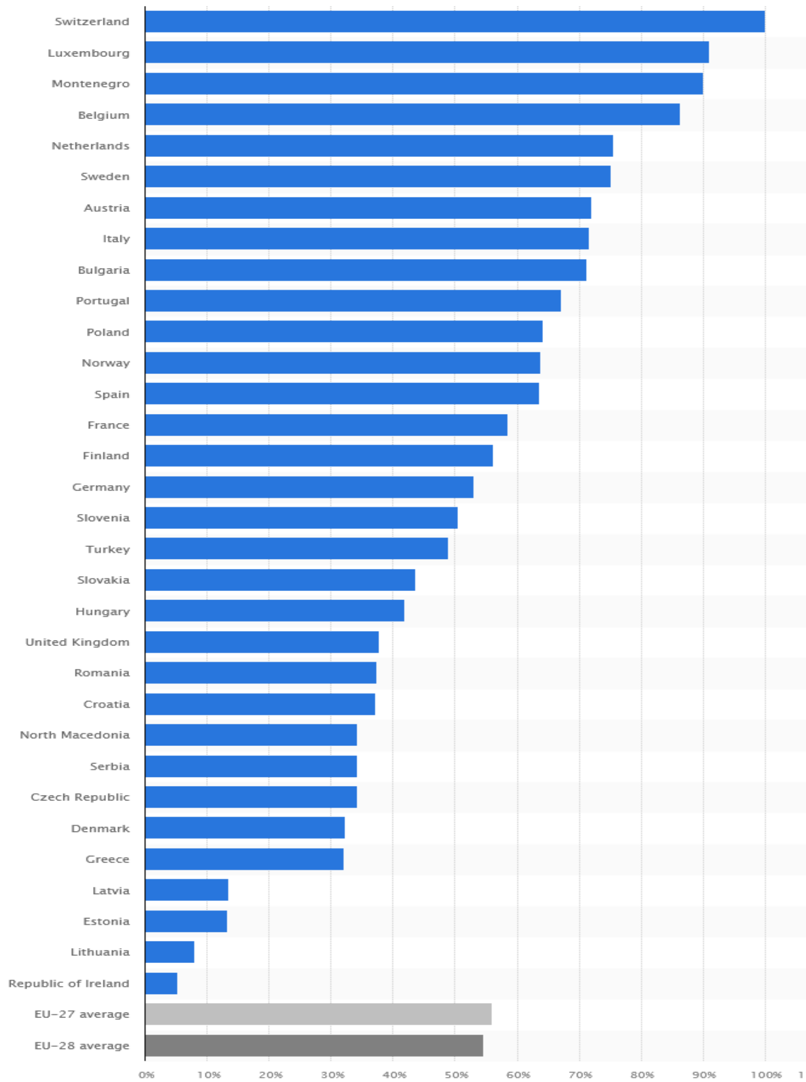


Figure 8 Electrification percentage of Norwegian Railways (Statista c, 2021)

Norway has one of the greatest proportions of electrified railway networks, accounting for around 63% of total railway network (Statista c, 2021). From 2005 to 2018, road freight has consistently accounted for more than 80% of all inland freight transport in Norway.

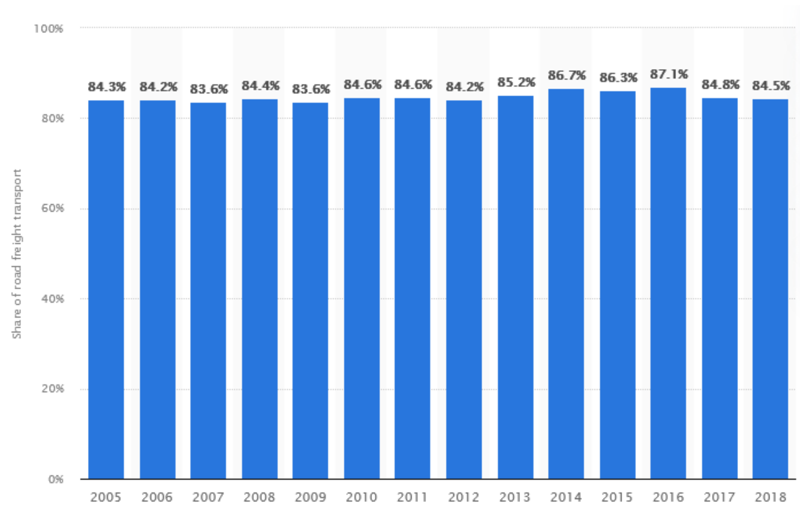


Figure 9 Road freight as a percentage of total inland freight transport in Norway from 2005 to 2018. (Statista b, 2021)

The volume of freight transported by road was 239.2 million metric tons in 2020, it has been consisting close to 250 million metric tonnes since 2009 (Statistical Research Department, 2022).

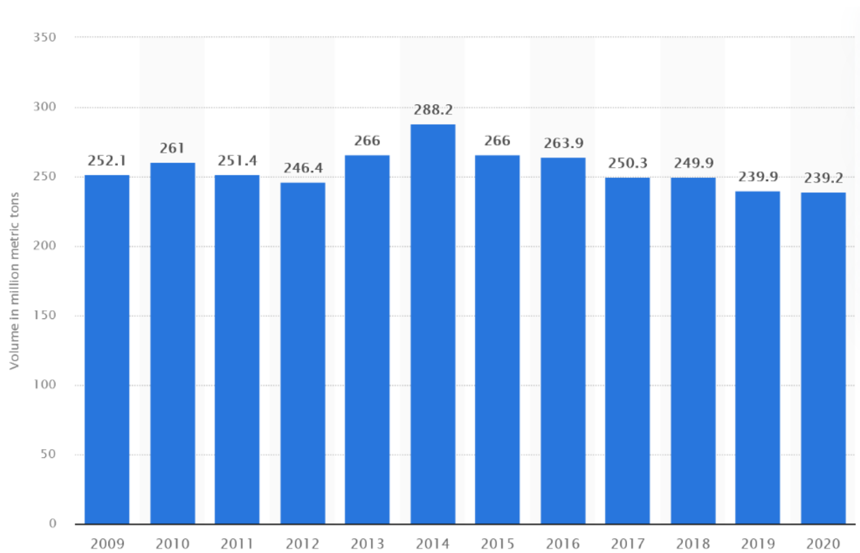


Figure 10 The volume of goods delivered domestically by road in Norway, (2009-2020) (Statistical Research Department, 2022)

Out of these, in 2020, over 139.7 million parcels weighing up to 31.5 kg were shipped in Norway through the country's courier express and parcel industry.

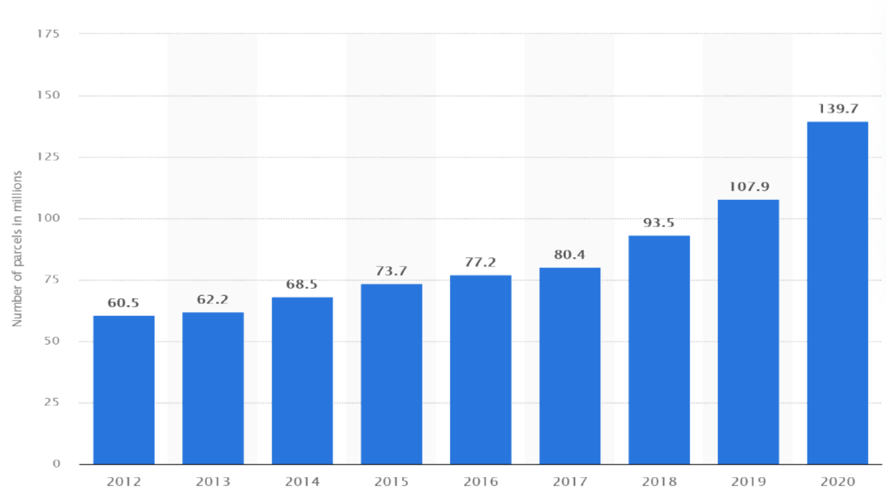


Figure 11 Volume of the Norwegian courier, express, and parcel (CEP) market from 2012 to 2020 (Statista a, 2021)

In 2018, the average vehicle load in Norway in national operations was about 15 tonne per vehicle.

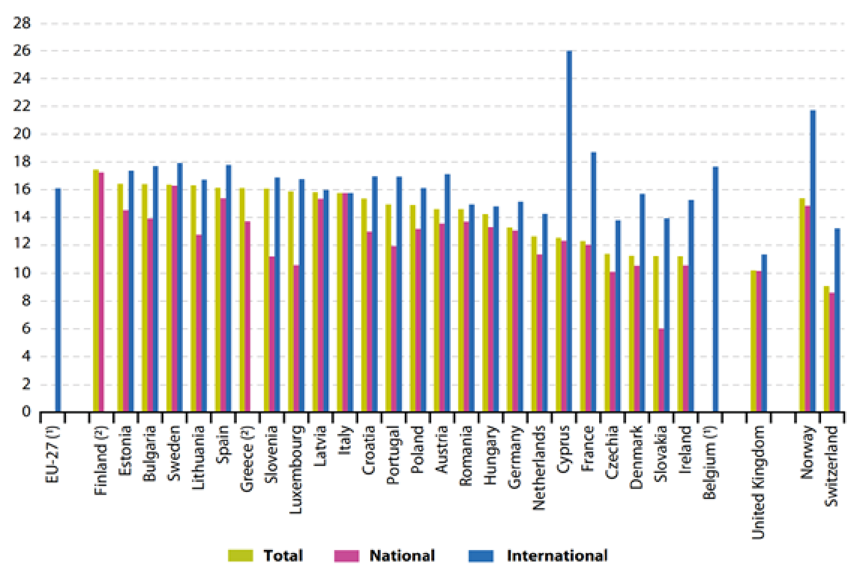


Figure 12 Average freight transport load by operation (Tonnes per vehicle) (Eurostat, 2020)

3.2.2 Empty Running

In 2018, Norway had about 105 lorries/road tractors per thousand inhabitants and about 510 passenger cars per thousand inhabitants. Approximately 30% of all transportation in Norway is running on empty. (Eurostat, 2020)

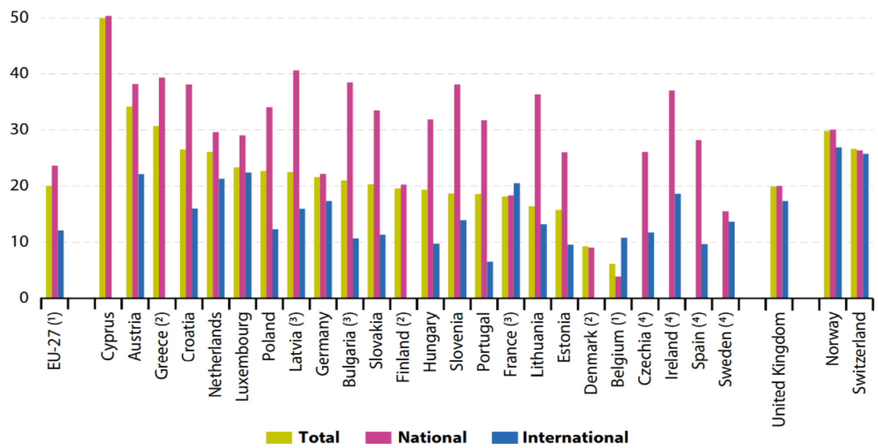


Figure 13 Empty Road trips by type of transport, 2018 (percentage share in vehicle-kilometres) (Eurostat, 2020)

3.2.3 Passenger Transport

Car drivers dominated passenger trips in Norway in 2005, accounting for 63% of all trips. On work trips, solo drivers were more common, whereas escorting trips had a greater passenger ratio. In 2005, the average occupancy rate per vehicle was 1.54, compared to 1.66 in 1985 (Institute of Transport Economics, 2009). The passenger occupancy rate per vehicle in Oslo has increased from 1.41 to 1.85 per vehicle (The Urban Mobility Observatory, 2021).

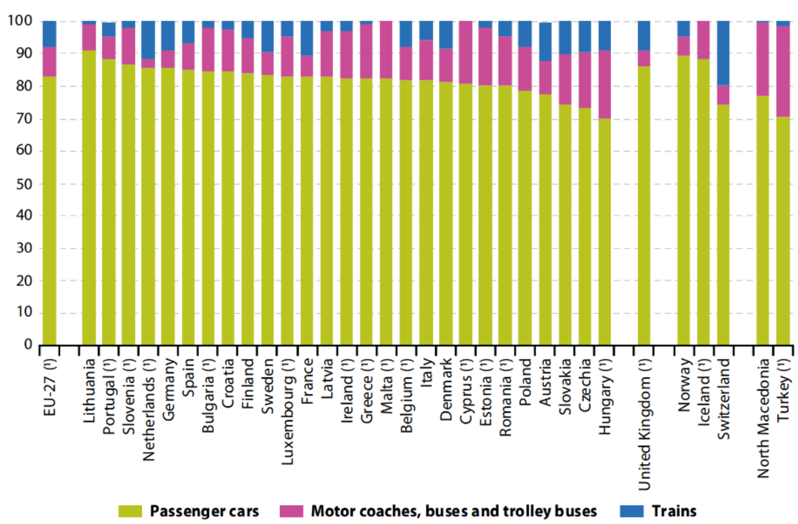


Figure 14 The modal share of Passenger transport, 2017 (% share in n passenger-kilometres) (Eurostat, 2020)

In 2019, the passenger traffic volume in Norway grew by 0.5%, which is slightly more than the previous year's growth rate. The number of passenger car kilometers also increased by 0.3%, the increase in public transport was 0.2%. Together air, rail and sea constitute only 14% of the volume of domestic passenger transport. In Norway, motorized travel by road accounts for 86% of all motorized travel. By the end of 2019, the total number of vehicles used for private transport in Norway was almost 3.4 million. Of these, 2.8 million were private passenger cars with 260,000 being electric vehicles. (Farstad, et al., 2020)

Transport Sector Emissions

The transportation sector generated the major share of GHG emissions in Norway in 2019, the share of the transport sector was 26.9% of total emissions in Norway.

GHG emissions (*) 2019

BY SECTOR (SHARES %)

TRANSPORT (**)	OTHER SECTORS	Commercial / institutional	Residential	Agriculture / forestry / fisheries	OTHER (NOT ELSE-WHERE SPECIFIED)	FUGITIVE EMISSIONS FROM FUELS	INDUSTRIAL PROCESSES & PRODUCT USE	Agriculture	Waste	Other	Indirect CO_2	TOTAL EMISSIONS	
26.9	5.7	2.9	1.2	1.6	0.2	4.2	17.8	8.5	2			100	NO

Figure 15 GHG Emissions by sector Norway (Shares %) (European Commission, 2021)

Emissions from the transportation sector in Norway have increased from 13.3 million tonnes in 1990 to 14.7 million tonnes in 2019. However, emissions have been falling since 2015.

	1990	1995	2000	2005	2010	2015	2018	2019
NO	13.3	14.1	16.2	17.1	17.6	17.0	15.6	14.7

Figure 16 GHG Emissions by Transport in Norway (Million Tonnes CO_2 Equivalent) (European Commission, 2021)

In 2019, out of the 14.7 million tonnes of emissions, road transportation had the highest share and accounted for 58 percent of total emissions with 8.5 million tonnes of emissions.

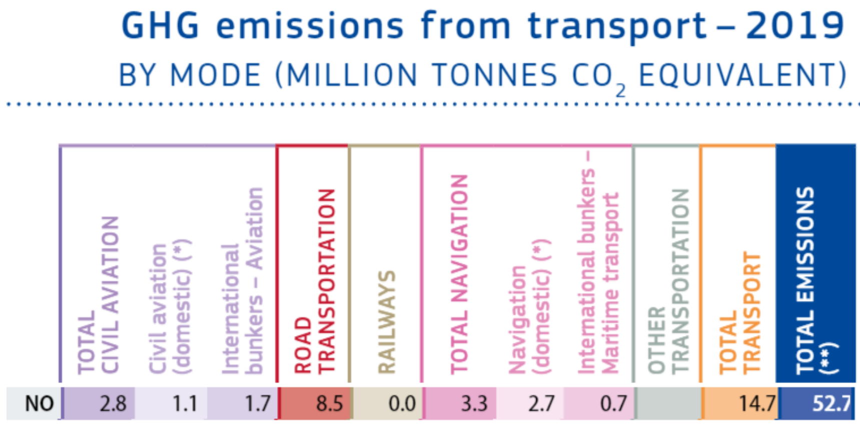


Figure 17 GHG Emissions by Transport modes in Norway (Million Tonnes CO_2 Equivalent) (European Commission, 2021)

Apart from this, increasing traffic, accidents, noise pollution, etc. are some other transport related issues. The next section introduces the case company based in Norway that offers a potential solution to some of these transport sector related issues.

3.3 Case company – Nimber

3.3.1 Introduction

Nimber AS is a 3PL service Company headquartered in London, UK, with offices in Norway and Greece, that operates a peer-to-peer (P2P) crowdshipping platform along with providing B2B 3PL service. Our area of study is its P2P crowdshipping platform that allows delivery of items from private individuals and businesses wherein each of these could be sender, recipient as well as driver (bringers). The platform has bringers that use their spare capacity to make deliveries under the motto "send anything, anywhere, at any time". It has a total 197,545 users and about 5000 bringers since inception. Customers are users that use the platform to post their delivery need which is visible to the drivers/bringers that are possibly already "on their way that way" who then respond to the customer and get matched once the customer accepts one of the bringers offer.

Nimber's P2P platform coverage area encompasses urban, regional and long routes, allowing bringers to earn money while driving locally as well as over longer trips and while commuting. The platform refers to remuneration for the drivers as a bringer reward, which is paid for each individual delivery trip. All products shipped through the platform are insured up to 10,000 NOK. The insurance fee is paid by the sender inclusive of the cost.

3.3.2 How Nimber works

Nimber, with the aim of reducing CO_2 emissions from deliveries, operates as a matching platform that links people who need to send something with others who are traveling in that direction, allowing for optimal capacity utilization, thereby lowering pollution and traffic levels.

The process of shipping items via Nimber involves the following steps:

1. Describing the item to be sent.
2. Specifying the pickup and delivery locations and times.
3. Determining a delivery price.
4. Posting the assignment.
5. Drivers with available capacity contact senders with offers.
6. The sender selects the driver based on their preferences such as price, delivery times, driver ratings, etc.
7. The bringer arrives, picks up the item and delivers it as per the agreed terms with the sender. All drivers are evaluated once their deliveries are completed.

Senders:

Senders are users that use the platform to send goods. Senders are restricted from sending goods that are hazardous, firearms, illegal or items that are prohibited by law in the area. The final price for the delivery is decided by the sender, which includes bringer reward, insurance and Nimber's service fee. Nimber proposes prices based on recorded statistics of similar size packages delivered on similar distances. However, the ultimate pricing is at the discretion of the sender. The senders can change information such the price, title, description, pickup and delivery points, and timings and users can also cancel the tasks after posting them, if they have not accepted an offer from a bringer. The sender is charged for the delivery after they confirm the item as delivered or alternatively after 24 hours from bringer's delivery confirmation.

Bringers:

Bringers are users that take on tasks as a driver. Registering to become a bringer is easy and simple. It just requires entering some relevant mandatory information and some optional information. Bringers can either search for tasks in their area or on the routes they intend to travel. Alternatively, bringers can set filters and get notifications when new items are posted. The payment for the tasks is processed once the delivery is marked as delivered by the bringer and also confirmed by the sender within 24 hrs. Bringers can earn up to 50,000 NOK per year as a private individual, in order to continue receiving assignments after earning 50,000 NOK, they must register as a company or sole proprietor.

3.4 Summary

Freight transport by road has been steadily increasing and accounts for approximately 80% of total inland freight transportation. However, approximately 30% of the Norwegian freight transportation is empty running. Similarly, car transportation dominates passenger transport in Norway, with low occupancy rates per vehicle; there were about 510 passenger cars and around 105 lorries per 1000 inhabitants in Norway in 2018. In 2019, continuing the trend, there were 2.8 million passenger vehicles in Norway, with only 9% being electric. The biggest concern with non-electric vehicle transportation is emissions. As in 2019, transportation contributed to 26.7% of total emissions in Norway, with road transportation accounting for 58% of those emissions. Apart from this, increasing traffic, accidents, noise pollution, etc. are some other transport related issues. The case company is the only crowdshipping platform based in Norway that matches senders with bringers, already traveling on the same route on which the senders want to send their goods. They have an aim to reduce GHG emissions along with offering potential solutions to some of the transport sector related issues.

Chapter 4 Research Methodology

4.1 Introduction

The chapter serves the purpose to set the groundwork for the research that was conducted. It introduces the study's principal premise as well as the research technique employed to answer the research questions. Initially, the research design chosen for this research is described. Crowdshipping is a novel phenomenon that requires further insight, this supports the use of the concept of case study. The data collected is structured in two sections, which include the survey questionnaire and transactional data from the case company. Finally, an overview of the empirical data analysis is provided. This chapter's composition is based on research onion and thus follows the six layers of research methodology as presented by (Saunders, et al., 2019).

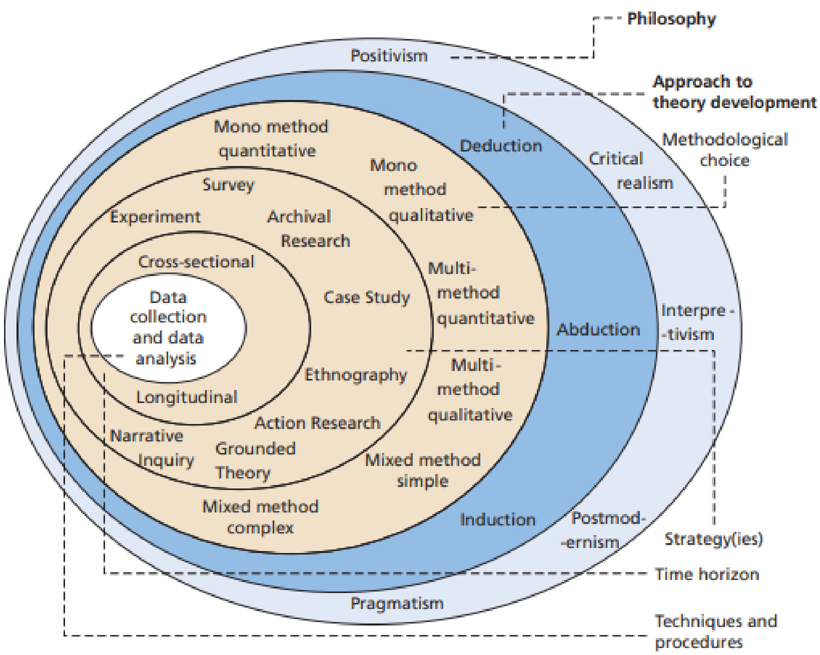


Figure 18 The Research Onion ((Saunders, et al., 2019), p 130)

The structure of this chapter is as follows: first, the concepts in each layer of the research onion are described with their types, strengths, and weaknesses, and then the selected type is mentioned along with an explanation for selection.

4.2 Research Philosophy

The research philosophy refers to a set of beliefs and assumptions that are used to develop knowledge. Although it sounds profound, it is exactly what most people do when embarking on research (Saunders, et al., 2019). There are bound to be various types of assumptions at every stage of research. These include, but are not limited to, theories about the realities of scientific inquiry (Ontological), human knowledge(Epistemological), and the extent to which one's values influence one's research(Axiological). A well-thought-out set of assumptions will help in the development of credible research philosophy. In turn, this will help to make informed decisions regarding the research methods and strategy, data collection, and analysis techniques and procedures used in the research. There are five major philosophies i.e., positivism, critical realism, interpretivism, post modernism and pragmatism are used in most of the research works. (Saunders, et al., 2019)

4.2.1 Research Philosophy - *Positivism*

Following an examination of the various philosophies, positivism was chosen as the philosophy of this study. This philosophy is employed because it highlights the positivist focus on utilizing strictly scientific methods, most of which are quantitative, to prove/test theory/laws. The concept of positivism is related to the philosophy of the natural scientist, with the aim to produce law-like generalizations through the observation of social reality. The term positivism relates to the significance of what is 'posited' - that is, 'given.' This emphasizes the positivist’s focus on strictly scientific methods that are focused on generating facts and pure data uninfluenced by human interpretation. Although, positivist research tends to be deductive these days and thus it might start with an existing theory to develop a hypothesis. These statements can provide a hypothetical explanation that can be tested and confirmed, and this can then be used to further develop a theory. However, that is not necessary and in fact original positivists stressed on inductive research, where data is collected, and observations are made prior to hypothesis being formulated and tested. Typical methods include highly structured design, large samples as well as quantitative analysis methods. Also, considering what has been "posited" in the literature as crowdshipping's positive influence freight transportation sector and the environment along with positive economic implications on its users. A systematic methodology is employed in this research to facilitate replication, and the emphasis is on collecting, analyzing, and interpreting large amounts of primary data without human bias.

4.3 Research Approach

The research onion's second layer contains the approaches to theory development, which are deductive, inductive, and abductive. Deductive and inductive approaches are based on the extent to which the research is focused on theory building or testing. Deductive approach is used when the research starts with a theory, which is often developed based on literature, a research strategy is then used to test the theory. Alternatively, an inductive approach is utilized when the research begins with collecting data to explore a phenomenon, and then a theory or conceptual framework is developed. Finally, the abductive approach is a hybrid approach that moves back and forth, instead of moving from data to theory as in the inductive approach, or from theory to data as in the case of in deductive approach, with the abductive approach, data is gathered to investigate a phenomena, explain patterns, and develop new or modify current theories, which are then tested through additional data collection. (Saunders, et al., 2019)

4.3.1 Research Approach - Deductive

The positivist research philosophy is most likely to underpin the deductive approach. (Saunders, et al., 2019), which holds true in this case. The deductive approach is best suited for this research as this study aims to demonstrate the relationship between crowd behavior and freight transportation and its environmental and economic implications based on primary data obtained through a crowdshipping platform.

(Blaikie, 2000) defined the deductive research process in six sequential steps, which are as follows.

1. A theory is developed by putting forward a tentative idea, a hypothesis, or a set of assumptions.

2. A testable proposition is deduced by analyzing existing literature or specifying the conditions under which a theory is likely to hold.

3. Next step is to examine the premises and logic of the argument that generated it. Then, assessing whether it can increase the understanding and, if so, proceeding to the next step.

4. Putting the premises to the test by gathering relevant data to measure and analyze concepts and variables.

5. If the analysis contradicts the premises, the theory is said to be false. The theory can be rejected or modified, and the process restarts.

6. If the findings accord with the premises, the theory is corroborated.

Among the essential characteristics of deduction mentioned, are the use of highly structured methodology, which ensures reliability and the possibility of replication. The research should be operationalized in a way to measure facts, often quantitatively. Finally, to generalize, the sample should be of sufficient size and representative of population. (Saunders, et al., 2019)

The theory was based on the idea that crowdshipping complements freight transport and helps reduce GHG emissions by following (Blaikie, 2000) steps for deductive research. The deductive approach evaluates the validity of assumptions and theories/hypotheses. (Patel & Patel, 2019). Thus, to test the theory, we used the deductive technique to assess the impact of crowdshipping on freight transport and the environment along with the economic implication on its users. We looked for relevant literature from published articles, books, websites, and other sources to help determine the variables and attributes to be measured. The transactional data was obtained from the case company, a questionnaire was designed and then a survey was conducted to supplement the transactional data.

4.4 Research Design

Every research has a design either implicit or explicit. (Yin, 2018). The research design is a conceptual structure in which the research would be performed with the objective to obtain relevant evidence with the minimum expenditure of time, money, and effort. (Patel & Patel, 2019) The research design should include defined objectives drawn from the research question as well as the source or sources for data collection, data collecting and analysis methodologies, ethical considerations, and any constraints that may be encountered. (Saunders, et al., 2019).

This can be achieved based on the purpose of research, which may be divided into the following types which are 1. Exploratory, 2. Descriptive, 3. Explanatory, and 4. Evaluative, or a combination of these. (Saunders, et al., 2019)

Exploratory:

An exploratory study is helpful if you are not sure about the precise nature of the issue. Thus, it can help clarify the understanding of a particular issue or phenomenon. It includes open questions to gain insights about the topic and is likely to both begin (research question) and collect data with 'how' and 'what' questions.

Descriptive:

A descriptive study aims to gain an accurate description of the situations, events, and people under study. It is important to have a thorough understanding of the phenomenon under examination. Research process is likely to both begin (research question) and collect data with 'what', 'where', 'when', 'who', or 'how' questions. It is regarded as a continuation of exploratory research and a predecessor of explanatory research. Descripto-explanatory studies refer to research that uses description and is a precursor to an explanation.

Explanatory:

A causal relationship between variables is established in an explanatory investigation. The research process is likely to both begin (research question) and collect data with 'why' or 'how' questions. The aim is to study a situation to explain the relationships between variables

Evaluative:

This study aims at finding out how well something works. The research process is likely to begin with, 'how' or include 'what' such as 'to what extent'. Data collection is likely to contain 'what', 'why' and 'how' questions.

4.4.1 Research Design - Descriptive research

The descriptive research design is most suited to this study since it attempts to describe present crowdshipping practices and their environmental and economic implications, along with the relationship between variables that affect them.

4.5 Methodological choice of research design

In general, there are three methodological choices, these are quantitative, qualitative, and mixed methods. A way to differentiate between them is to distinguish between numerical and non-numerical data. Thus, quantitative method is often used to refer to data collection or analysis methods that either generate or use numerical data such as questionnaire, graphs, or statistics etc. On the contrary, qualitative methods refer to those that either generate or use non-numerical data such as interviews, data categorization etc. (Saunders, et al., 2019) Quantitative studies rely on logical and statistical analysis to come up with conclusions, whereas qualitative research uses verbal narrative such as spoken or written data. (Ahmad, et al., 2019) Mixed methods integrates both qualitative and quantitative data collection techniques and analysis procedures. (Saunders, et al., 2019)

This distinction between qualitative and quantitative is however, both complicated and narrow, complicated as in the questionnaire may require some non-numerical data and vice versa and narrow since philosophical assumptions guide methodological choices, thus the numeric and non-numerical distinction is insufficient. (Saunders, et al., 2019)

Qualitative research design

Qualitative research is an unstructured or semi-structured approach that can study complex phenomena. It can also generate ideas for later quantitative studies. Through qualitative research, the researcher can gain a deeper understanding of people's motivations and behavior.

Qualitative research design is usually associated to interpretivism. (Saunders, et al., 2019) In qualitative research instruments such as observations, in-depth interviews, and open-ended questions are used to collect data in a natural setting. The emergence of theory from data allows researchers to construct new theories based on the data they collect. (Daniel, 2016) It provides a wider understanding of behavior by providing sufficient data on real people and situations. However, qualitative research is often criticized as lacking generalizability, because of being too dependent on the interpretations of the researcher. (Vaus, 2002) (Leedy & Ormrod, 2016). Replicability is another issue of qualitative research design. Non-use of numbers makes it difficult to analyze and simplify the findings of qualitative research. The exact explanation of the findings cannot be given because the results can vary depending on the interpretation of the researcher. (Daniel, 2016)

Quantitative research design

Quantitative research is a type of research that utilizes natural science methods, that produce numerical data and hard facts which can be measured precisely and accurately. It seeks to establish a cause-and-effect relation between two variables by the application of mathematical, computational, and statistical approaches (Ahmad, et al., 2019). The research is mainly focused on measuring phenomena in quantity. (Patel & Patel, 2019) Quantitative research is usually associated to positivism. (Saunders, et al., 2019) Quantitative research is a structured research with pre-determined approaches, variables, and hypothesis. (Creswell, 2009) Quantitative research include the utilization of statistical data, which enables savings of time and resources. The utilization of scientific methodologies allows for the possibility of generalization. Another advantage of quantitative research is its replicability. On the contrary, researcher's detachment gives the researcher an outside look, making it difficult to get in-depth knowledge of the phenomenon under natural setting. (Daniel, 2016) Since the method uses predetermined working strategies, it thus does not either encourage or require imagination and creativity. (Vaus, 2002)

4.5.1 Methodological Choice - Quantitative research design - Multi Method

Choosing the correct research design is analogous to selecting the right key to open a door, only then an appropriate method can be applied to obtain results that are valid and reliable. (Grover, 2015) Our research problem necessitates the collection of quantifiable data in order to accurately describe the situation and answer our research questions. As a positivist, the emphasis is on having a methodical approach, with a focus on obtaining and analyzing quantifiable data. As a result, the study employs a quantitative research design and includes more than one data collection approach and analytical procedure. Since it incorporates both questionnaire and transactional data from the case company this research is thus regarded as a multi-method quantitative study.

4.6 Research Strategies - Case Study & Survey

In quantitative research, a survey strategy is commonly applied. However, quantitative data and analysis can be utilized in what are typically considered as qualitative procedures, such as case study research. (Saunders, et al., 2019) A study may include multiple methods such a case study within a survey or a survey within a case study, since various methods are not mutually exclusive. (Yin, 2018) To describe the phenomenon, this study adopts a case study strategy, which is supplemented with a survey strategy.

4.6.1 Case Study Strategy

A case study is an in-depth investigation of a topic or event in its real-world context**.** A case study is a relevant approach in situations where the research questions start with "how" and "why", there is no control required over behavioral events and the study focuses on contemporary events, acknowledging that context is a major determinant in a cause-effect relationship (Yin, 2018). Case studies observe effects in real-world contexts and establish cause and effect. (Cohen, et al., 2005)

Case studies provide detailed information with high conceptual validity; they also provide an understanding of context, processes, and causes of a phenomenon, linking them with consequences. On the contrary, some drawbacks include the following: the relationships may be overstated or understated due to selection bias, it gives a weak picture of the occurrence of the phenomenon in the population under study, and the statistical significance is frequently unclear or unknown. (Flyvbjerg, 2011)

A case study research design is comprised of five components. The first three are, the study's questions, the propositions, and the case, which lead to the data to be collected, and the last two are the logic behind tying data to propositions and the criteria for interpreting the findings, which drive the study's analysis. (Yin, 2018)

Study Questions

The research questions were identified on gaps found in literature, field work with the case company and critical thinking and have been stated below.

RQ1: How are the current crowdshipping practices complementing freight transport operations?

RQ2: What are the environmental implications of a crowdshipping platform?

RQ3: What are the economic implications of a crowdshipping platform to its users?

Research Propositions

The propositions draw attention to things such as variables, attributes, relationships etc that should be investigated within the scope of the study. The propositions form the framework of knowledge, validating a concept's existence, explanation, and relationship with other ideas (Avan & White, 2001). At the completion of a research work, there is typically the need and tendency to extrapolate the findings, which may go beyond the bounds of the study objectives and methodology. The propositions are considered the initial step at that point in the research. They will serve as the foundation from which the research's inference or conclusion can be derived. In order to move in the right direction propositions must be stated since these propositions not only reflect theoretical aspects but also indicate where to look for evidence (Yin, 2018) and have been done so, below.

Proposition 1: Crowdshipping is a viable mode of freight transportation

Proposition 2: Long distance crowdshipping generates less emission than other 3PL service providers

Proposition 3: Crowdshipping is economically beneficial to its users.

Case / Unit of analysis

A key aspect in defining a case study is selecting the case to be examined and determining the study's boundaries. The case can be a person, event, organization, change process, etc. (Flyvbjerg, 2011). The case in our study is Nimber's crowdshipping platform. The boundaries of the case were specified to include bringers who were registered as individuals on the platform, thereby excluding companies. However, the survey responses were filled by a few bringers that were companies that provided some insight on them and have been mentioned in the findings. The unit of analysis is the last trip made by the bringer on the platform.

Linking data to propositions

This component foretells the processes of data analysis. It provides a framework for organizing and analyzing data in a case study. (Yin, 2018) The data related to all intercity trips were used, and the total distance travelled by the bringers from the origin to the destination, the detour distances, the emissions of the vehicles used, similarly the emissions of various transportation modes and vehicles used by the alternative 3PL players such as postal service and transporters were used. All the costs borne by the users, and the rewards and cost borne by the bringers were calculated and used.

Interpreting the findings of the study

The statistical standards serve as the criterion for interpreting the results. However, in case study research an important alternate strategy is identifying and addressing the rival explanations of the findings. This strategy helps to interpret the findings and identify the weaknesses of the study. (Yin, 2018). Alternate explanations compromising two different scenarios were used to explain the findings.

4.6.1.1 Case study type and case selection

Case studies can be either exploratory, descriptive, or explanatory**.** Case studies can be further distinguished into single case vs multiple cases and holistic cases vs embedded cases. (Yin, 2018) This study is a single case descriptive study. The single case is selected due to its uniqueness since there is only one such platform that is currently operating in Norway. In terms of the second dimension, the study is a holistic study which considers the case a whole.

4.6.2 Survey Research

Survey research is often associated to deductive approach and tends to be used for descriptive and exploratory research. (Saunders, et al., 2019) It is a strategy that falls under the non-experimental quantitative research. This procedure entails surveying a group of people in order to acquire information about them. The purpose is to learn about their characteristics, views, and previous experiences with the end goal is to infer about a large population from which the sample is drawn and surveyed. The sample should representative of the population. (Williams, 2007) It is referred to as a normative or descriptive survey (Leedy & Ormrod, 2016) and is commonly used in social sciences to gather data. (Williams, 2007)

The design of the survey is quite simple, a series of questions are posed to willing participants, their responses are summarized with percentages, counts and frequencies, or using more advanced statistical indexes. Then inferences are drawn about the population. This research employs typically a face to face or telephonic interview or written questionnaires. (Leedy & Ormrod, 2016)

The survey technique is regarded as authoritative and simple to understand, data collected from surveys can help suggest possible relationships between various variables as well as model these relationships. It enables the researcher to collect data for analysis using descriptive and inferential statistical methods, as well as provide statistical conclusions that are representative of the entire population utilizing the probability sampling methodology. However, data collected from surveys is not as wide-ranging as other methods due to the reason that the number of questions that can be asked are limited. Ensuring a representative sample, piloting the data collection instrument, and collecting and evaluating data can all take time. However, the major disadvantage of using a questionnaire as part of a survey approach is the possibility of doing it incorrectly. (Saunders, et al., 2019)

The survey strategy is utilized as a supplement to the case study, and a questionnaire was created to collect data by distributing it through email to willing respondents. The survey was conducted to validate the assumptions in our study and obtain insights into the respondent's behaviors that were not otherwise available from the case's transaction data.

4.7 Time Horizon - Cross-sectional

This is a cross-sectional study since it looks at crowdshipping activities that occurred over a certain time, which is the bringer's most recent trip between September 1st, 2021, and March 2nd, 2022.

4.8 Data collection

4.8.1 Ethical considerations

Access and ethical considerations are critical to the success of a research study. During the study's duration, we as researchers worked as interns with the case company; the company's management had granted both physical access to the company's premises as well as internet-mediated limited access to an admin portal where the data could be seen and extracted. Throughout the research, especially throughout the data collecting and analysis phases, ethical considerations were addressed carefully; no coercion was used by the researchers, objectivity was maintained, and participants' rights to privacy, confidentiality, and anonymity were ensured.

4.8.2 Sampling

The population of the study is made up of all bringers who have made trips using Nimber's crowdshipping platform. The population was made up of active bringers in the previous six months. The overall number of active bringers were 313. However, because of the case's boundaries, the companies were eliminated, reducing the target population to 244. Furthermore, some bringers information on ‘vehicles utilized for delivery' were missing, leading us to apply non-probability sampling techniques, where the probability of being for the sample to be selected is unknown. (Cohen, et al., 2005) Though, this limitation was first addressed through survey, where an initial consent request was made to all active bringers to obtain this key information, only 145 of the total bringers agreed to be surveyed out of which only 17 responded. As a result, a purposive sampling strategy was utilized further to select the sample. Purposive sampling is where the cases selected are of interest to the researcher (Vaus, 2002) and for particular purpose. (Leedy & Ormrod, 2016) The sample size of 64 was taken, the reason for choosing this sample size was that it supported the research purpose of calculating the emissions as these samples were complete in terms of transaction and vehicle information, along with other variable data necessary for the research. This decision to exclude some samples due to lack of vehicle information is not expected to have a significant impact on the research due to the fact that the sample was not picked by the researchers, but instead a lack of information reduced the possible set of cases for research. The sample is still likely to be representative of the population. Finally, the total number of P2P bringers were taken as the target population and their transaction records were studied for the descriptive portion of the research

4.8.2.1 Observations for Environmental Analysis (Transactional data, Survey):

The transactional data obtained from Nimber contained 313 bringers, of which 256 were registered as individuals and 57 were companies, 14 (2 companies and 12 individuals) out of these 313 were excluded due to their association with Nimber's B2B platform. There were then 299 (244 individuals and 55 companies) bringers who made 4287 trips. Only individual bringers were examined for the environmental evaluation using transactional data, with companies being excluded due to the previously specified case boundaries. One rationale for this exclusion was that the same assumptions that were used for individuals could not be applied to companies. Furthermore, only 83 of the 244 individuals' bringers had vehicle information available, reducing the sample size even further. Finally, 51 of these 83 bringers were chosen and their last trip was analyzed for the environmental assessment, the reason for exclusion of the remaining 32 bringers is attached in the appendix no.1

In addition to the transactional data, we received 17 survey responses, of which 13 were individuals and 4 were companies. As a result, the last trip of 64 individuals [51, transactional data, 13, survey] was analyzed for environmental assessment, and 4 companies were included for a short study, since the assumptions limitation for these companies as bringers was resolved, and it was necessary to provide a brief overview of their behavior.

Transactional data	
Companies	57
Individuals	256
Total	**313**
Drivers associated with Nimber	14
Total P2P bringers	**299**
Companies	55
Individuals	244
Target population (Private Bringers)	**244**
Vehicle info	83
Excluded	32
Selected	**51**

Survey data	
Companies	4
Individuals	13
Total	**17**

Final sample for main study	**64**
Final sample for additional study	**4**
Total sample	**68**

Figure 19 Sample size and selection

4.8.2.2 Sampling - Case study

The descriptive section of the study utilized data from the total P2P Bringer population, whereas the environmental and economic evaluation used purposive sampling for which the final sample size was 64 individuals.

4.8.2.3 Sampling - Survey

The survey was conducted by sending permission requests to the target population which was bringers that have made at least one delivery in the last six months to perform a probability sampling, since probability sampling generally result in data generalizability. (Cohen, et al., 2005) However, only 145 respondents agreed to participate in the survey of which 114 were individuals and 31 were those registered as companies. The final response rate was obtained from 19 respondents, of these, one was test response, and one was disregarded due to its association with Nimber's B2B platform. Thus, 17 responses were considered, representing 12% of those who expressed willingness and 5% of the population. The low response rate was primarily due to lack of incentive for the respondents and difficulty in remembering accurate details about the past delivery. This was seen as one of the respondents mentioned explicitly that they could not recall the origin of their last trip.

4.8.3 Primary Data

The data was collected while remaining neutral and detached, to avoid influencing the findings. The following methods were used to collect the data.

4.8.3.1 Questionnaire

To complement the information lacking in the case company's transactional data, a questionnaire was designed to collect key missing information with some behavioral questions and was distributed via email using SurveyMonkey. Questionnaires are simple to disseminate to a wide group of people. They can also be utilized by people located geographically far from the researcher, saving the researchers expenses. Another advantage of questionnaires is that they allow participants to respond anonymously as opposed to a personal interview. Participants are more inclined to be honest when addressing sensitive matters. The low return rate of this method is a drawback, as most individuals who receive them do not respond, and those who do not return are not fundamentally representative of the selected sample. Even when respondents are motivated to participate, their reading, writing, and interpreting skills influence their responses. Questions must be stated in advance and thus they be should carefully planned and constructed which is in fact essential for any descriptive study. (Leedy & Ormrod, 2016) the questionnaire used in this research is attached in appendix no.2

The questionnaire helped obtain the following information,

Variables	Description	RQ1	RQ2	RQ3
Primary reason to travel	• Reasons such as to earn extra income, • Meet friends and/or family, • Work/ Business, • Leisure/ Tourism, • Other		✓	✓
The origin and destination of the trip	Starting point before the 1st pickup & ending destination after the last delivery		✓	✓
Detour willingness	Willingness to detour (travel extra) from your original planned trip?		✓	
Vehicle used	Vehicle model and year?		✓	✓
Transport fulfillment	Whether the trip was planned or dedicated based.		✓	✓

Table 2 Survey variable description

4.8.3.2 Interview

An unstructured interview was performed with the operational team of the case company using physical access to learn about the transactional data, variables, and operations of the case company. A logistics associate, key account manager and a service design lead from the company were interviewed. This interview aided in answering both research questions one and two with the information gathered to assist in selecting and identifying variables and attributes and giving research direction to the research to a certain extent.

4.8.3.3 Postal Service

Using the case company business account on one of the major postal service providers operating in Norway, cost information of deliveries was obtained, and the key account manager was asked questions by email. The following information was obtained:

Variable/ Parameter	Description	Source	RQ1	RQ2	RQ3
The Vehicle type utilized	The vehicles utilized for Last mile, Intercity distances including trains	Key Account Manger		✓	
Load Factors	Average utilization rates of modal transport networks	Key Account Manager / Business account		✓	
Delivery cost	The delivery cost for the orders based on pickup and delivery coordinates.	Business Account			✓

Table 3 Variables and Parameter description received from postal company

4.8.4 Secondary Data

4.8.4.1 Transactional data

Transactional data from case company were details of bookings made on the platform in the previous six months, it was extracted from the platforms database. The company's technical team was contacted for the same that shared a data dump file. The dump file contained attributes and information of all the transactions recorded on the platform relating to the users, bringers, and the platform. This data dump required extensive bulk and manual cleaning. After that, attributes and observations that could help answer the research questions were extracted. Some attributes were operated upon to obtain information, some were used directly, while those that were deemed unnecessary were deleted.

The data set containing the transactional records of the past 6 months ranging from September 1st, 2021, to March 2nd, 2022, was acquired. After thoroughly cleaning the data set, a total of 84 variables were obtained. Based on the empty, duplicate values, and unnecessary data some of the variables were excluded, and the final set of 31 variables that were used for the study are as follows:

Variables	Description	RQ1	RQ2	RQ3
Id	Order id	✓	✓	✓
Title	Description of goods	✓	✓	
Pickup_location	Pickup city, country	✓	✓	✓
Delivery_location	Delivery city, country	✓	✓	✓
Size	Size of the goods which are • "1", fits in pocket (keys) • "2", fits in a bag (laptop, clothes) • "3", fits in a car (painting, guitar, pet) • "4", fits in a big car or van (chair, mirror small furniture) • "5", fits in a trailer or truck (sofas, dining table, piano, boat, etc)	✓	✓	✓
Weight	Weight of goods in kilograms	✓	✓	✓
Price	Final price to be paid by sender	✓		✓
Created_at	Order creation date	✓		
State	State of the order which are • "cancelled" orders that are cancelled and no longer active, • "incomplete" used for the B2B deliveries posted by Nimber, • "archived" orders that are completed and stored, • "bought" orders that are assigned to a driver and yet to be picked, • "picked up" orders that are picked but not yet delivered, • "delivered_wait" order delivered by bringer but not yet confirmed by the user. • "delivered" orders that are delivered, • "buyable" orders that are active and not yet bought by any bringer.	✓	✓	✓
Creator_id	Unique id assigned based on the user id who created the order.	✓	✓	✓
Winner_id	Unique id assigned based on the user id who accepted to deliver the order (bringer id)	✓	✓	✓

Pickup_lat	Pickup location_latitude	✓	✓	✓
Pickup_lon	Pickup location_longitude	✓	✓	✓
Delivery_lat	Delivery location_latitude	✓	✓	✓
Delivery_lon	Delivery location_longitude	✓	✓	✓
Pickup_country	Pickup country	✓	✓	✓
Pickup_city	Pickup city	✓	✓	✓
Delivery_country	Delivery country	✓	✓	✓
Delivery_city	Delivery city	✓	✓	✓
Distance	The distance between the pickup and delivery location in meters	✓	✓	✓
Pickup_time_range	Pickup date and time range mentioned by the user/sender	✓	✓	
Delivery_time_range	Delivery date and time range mentioned by the user/sender	✓	✓	
Dimensions	Dimensions of the goods	✓	✓	✓
Delivered_at	Date and time stamp of goods delivery by bringer	✓	✓	✓
Currency	The currency of the transaction	✓		✓
Bringer_reward	The amount bringer earns for the delivery	✓	✓	✓
Nimber_fee	Nimber's service fee	✓	✓	✓
Delivery_postal_code	Pickup postal code	✓	✓	✓
Pickup_postal_code	Delivery postal code	✓	✓	✓
Picked_up_at	Date and time stamp of goods pickup by bringer	✓	✓	✓

Table 4 CS Platform's transactional data variables

4.8.4.2 Other secondary data sources

The Norwegian public roads administration agency's website Statens vegvesen was used to obtain emission data. However, this research also uses data from report published by Transport economics Institute (TØI). The report by TØI analyzes marginal cost of damages by different modes of transport by first presenting emission factors of different transport modes and their types. These emission factors have been used in our assessments for calculations and to support our findings from data collection and analysis. Statens Vegvesen website collects emission data in kg/km from the OEMs, which use engine and chassis dynamometer testing, tunnel investigations, remote censoring, and on-board instrumentation measurements to measure car on-road fuel usage Demir, et al., 2011).

In addition to these, the study's attributes came from a variety of sources such as books, journals, articles, official government publications, and websites of major 3PL companies. They have been listed below:

Variables/ Parameters	**Description**	**Source of variable values**	**RQ1**	**RQ2**	**RQ3**
Vehicle emissions	CO_2 and NO_x of the bringer's vehicles	Norwegian public roads administration (Statens vegvesen), vehicle manufacturers, www.car-emissions.com		✓	
Volumetric weight	Volumetric weight based on dimensions and volumetric factor	www.postnord.no		✓	✓
Delivery cost	Delivery cost for parcels weighing under 35kg	www.posten.no www.ups.no			✓
3PL vehicle emissions	Standard emissions for trucks, trains, vans	Institute of transport economics, Norwegian center for transport research (Rødseth, et al., 2019)		✓	
3PL mode of transport	15% train	(Eurostat, 2020)		✓	
Train electrification	63% electrified	(Statista c, 2021)		✓	
Terminal distances	Implicitly used to find first mile, intercity, last mile distances	www.postnord.no		✓	

Table 5 Variables and parameters from Secondary sources and their description

The below mentioned are some of the variables obtained from literature which have been used in the study to answer the research questions.

Variable	Description	Reference	RQ1	RQ2	RQ3
Transportation fulfillment	The trip being planned or dedicated	(Rai, et al., 2017) (Qi, et al., 2018)		✓	✓
Modal choice	Dividing the trip as per mode of transport such as van, truck, train etc.	(Rai, et al., 2017), (Frehe, et al., 2017)		✓	✓
Crowds character	This indicates the nature of bringer being individual bringer or business bringer	(Rai, et al., 2017)		✓	✓
Additional trips incurred	The additional travelled distance (detour)	(Qi, et al., 2018)		✓	✓
Compensation	The bringers reward that relates to crowd's readiness to work	(Rai, et al., 2018) (Le, et al., 2019)	✓	✓	✓
Delivery lead time	The actual delivery range, the time required from order pickup to delivery. Also used for required delivery range and order fulfillment	(Marcucci, 2017)	✓		
Time value	Bringer's willingness to spend their free time to earn a financial incentive.	(Rai, et al., 2018)		✓	✓
Shipping fee	The price which the user is willing to pay for the delivery (cost to user)	(Punel, et al., 2018)	✓	✓	✓
Distance	The distance between the order pickup and delivery points	(Punel, et al., 2018)	✓	✓	✓

Table 6 Variables and their description from literature

4.9 Data Analysis

After the extraction, compilation, and cleaning of data, and then the subsequent selection of relevant variables and attributes, data analysis tools and methods necessary for the research were explored. The method of data analysis has been discussed below with their findings briefly addressed in the next chapter. The research starts with correlation analysis and then conducts descriptive analysis to answer the first research question and finally moves on to the other research questions by performing environmental and financial analysis.

4.9.1 Correlation Analysis

The correlation analysis below shows the correlation between vital variables that have been used in the analysis. The correlation coefficient ρ identifies dependencies if any and the strength of statistical relationship between two variables (Nickolas, 2021). The correlation coefficient might have a range of values from -1.0 to 1.0. The variables are considered to have no linear relationship when the value of is close to zero, usually between -0.1 and +0.1. (Or a very weak linear relationship). When ρ is +1, it means that the two variables being compared have a complete positive association; when one variable rises or falls, the other rises or falls in the same magnitude and the same works vice versa.

	Size	*Price*	*Distance*	*Delivery Days*	*Order Fulfillment*	*Weight*	*Volume*
Size	1.000						
Price	0.508	1.000					
Distance	0.159	0.471	1.000				
Delivery Days	0.004	-0.024	0.059	1.000			
Order Fulfillment Days	0.065	0.125	0.215	0.846	1.000		
Weight	0.331	0.431	0.043	-0.034	-0.002	1.000	
Volume	0.320	0.251	-0.049	0.153	0.187	0.607	1.000

Table 7 Correlation Analysis

After conducting correlation analysis, there were some key observations that influenced the use of those variables in the research. Size, along with weight and volume were used in the analysis, as size had attributes on the platform, selected by the user, while volume and weight were actual values of the variables given by the user. In the corelation analysis, size and the weight and dimensions, did not have a strong corelation, indicating there could be a difference in the perception of size by the user. Hence, weight and dimensions were used in the findings of second and third research question. Price had a moderate correlation with size, distance, and weight of the item to be delivered. It did not have a strong negative correlation with order fulfillment days which was our observation from the data collected from the interview. Delivery days and order fulfillment days had weak correlation with all the variables. Hence, the attributes of the item to be delivered like size, volume and weight, along with price did not have a strong relationship with delivery and order fulfilment days. Apart from these findings in the analysis, there weren't any strong corelations between the variables.

4.9.2 Descriptive Analysis

In descriptive analysis, all the selected variables from platform were studied. The transaction records or observation had to be broken down as the state of the order query, whether it was put by the user, accepted by the bringer, picked up and delivered or cancelled. The values of the variable “state” had to be merged in the following way.

Order State	Order State
Archived, delivered, delivered_wait	Delivered
bought, picked up	In-process
cancelled, incomplete	Cancelled
buyable	Buyable

Table 8 State of orders

The transactional records contained a total of 12818 orders placed by 5402 users, of these 2135 trips, 4 users and 14 bringers were eliminated due to their association with Nimber’s B2B platform. As a result, the total number of orders used for the analysis were 10683, from 5398 users.

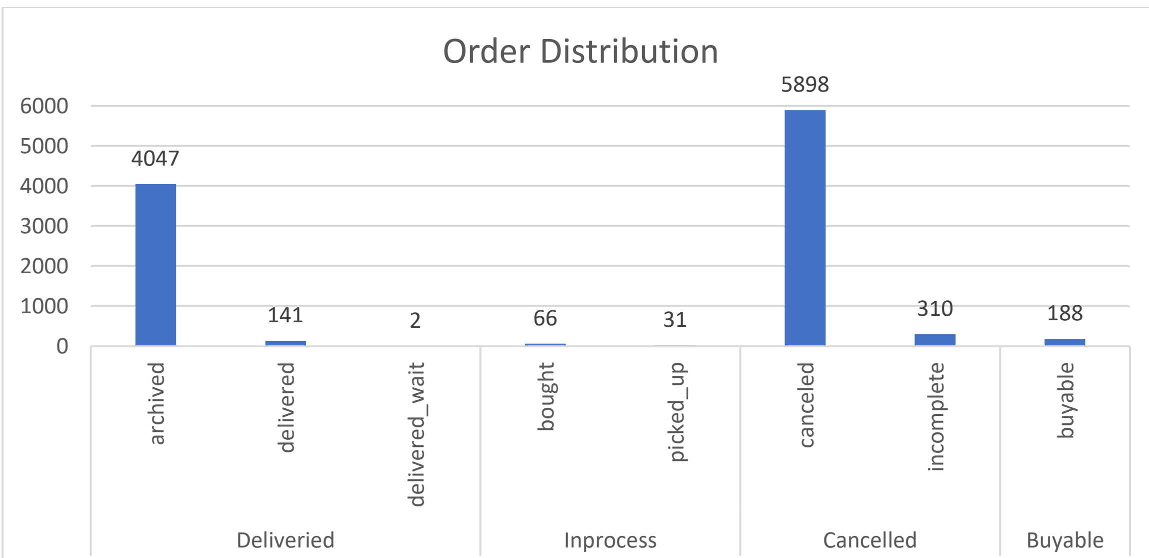


Figure 20 Order distribution as per state

Out of 10683, 4190 were “delivered” [archived, delivered, delivered wait], 97 orders were “in process” [bought, picked up] and 6208 were “cancelled” [cancelled, incomplete] and 188 were “buyable”. A total of a total of 4287 orders [delivered, in process] posted by 2445 users and delivered/accepted by 299 bringers. The 6208 orders cancelled were posted by 3673 users.

The analysis also included descriptive statistics such as central tendency measures i.e., mean, median, mode, and standard deviation, which is a measure of dispersion on the following variables:

Platform

The overall number of active users every month is compared to the total number of active bringers.

Demand side

The overall number of users over the last 6 months, as well as the total number of active unique users and orders posted by users, are calculated, and presented graphically

The total number of active users is compared to the total number of matched users (users whose orders got accepted) every month.

Supply Side

The overall number of bringers during the last six months, as well as the total number of active bringers and orders accepted by the bringers, are calculated and visually displayed.

Each month, the average orders accepted per bringers is calculated and displayed.

Orders

The total number of orders posted on the platform is compared to the total number of orders delivered by the bringers in each month, which is calculated and graphically presented.

Each month, the status of orders "delivered," "in progress," "cancelled," and "buyable" is calculated and displayed graphically.

Delivery statistics

The delivery range provided by the user is calculated over a 6-month period, with the range based on the difference between the earliest pickup date and the latest delivery date.

The actual delivery by the bringer is calculated using the difference between the pickup and delivery dates.

The order fulfillment is calculated using the difference between the creation and delivery date.

The delivery distances of the orders accepted by the bringers are visually displayed.

Size

The size of orders posted by users are compared to the sizes of orders accepted by bringers.

The weight of the orders taken by the bringers is calculated and graphically displayed.

Geography

Based on the specified location coordinates, the geography of pickup and delivery points is presented for all orders submitted by users.

Price

The price ranges of orders placed by users are compared to the price ranges of orders accepted by bringers.

4.9.3 Environmental analysis

The environmental analysis was performed to obtain findings on 64 individual bringers and 4 companies by analyzing their last trip.

Variables and calculations

Total trip: The total trip was calculated based on the orders combined by the bringer, i.e., single or multiple orders picked up or delivered jointly.

Total trip duration: The total trip duration is calculated based on the first pickup date/time till the final delivery date/time.

Total trip distance. The total trip distances are computed from the origin to destination. The pickup and delivery points are used to create a sequence of all the pickups and deliveries made by the bringer during the trip. The distances were calculated using the shortest driving path on google maps.

Total driving hours: The total driving hours are calculated based on the total trip distance.

Total fuel estimate: The trip fuel estimate is based on the total trip distance and the vehicle's fuel consumption, which is obtained from bringer’s vehivle make and model, collected from Statens vegvesen to compute the total fuel estimate and average fuel rate for that month.

Bringer's trip reward: The trip reward is calculated by adding the rewards from all orders fulfilled by the bringer on the trip.

Bringer's Per hour Earnings: The earnings that the bringer made per hour is calculated by deducting the total fuel estimate from the total reward and dividing it by the total driving hours. In this study other variables such as maintenances, road tolls, accommodation, food etc. were not included.

Transport Fulfillment: The crowd's *transportation fulfillment,* (Rai, et al., 2017) which was either dedicated or intended trip was calculated based on the Bringer's Per hour Earnings.,If the earnings were less than 188 NOK Per hour (Glassdoor, 2022) which was the national average salary for drivers in Norway, then it was considered as a planned trip otherwise it is considered as a dedicated trip.

Direct Trip Distance: This is the distance between the origin and the delivery or the pickup and the destination, basically the direct distance between the origin and destination by not considering the pickup and delivery, which is used to calculate the detour.

Detour: The detour is calculated by subtracting the direct tour distance from the total trip distance.

Package dimensions: The dimensions of the goods provided by the user are used. For those items whose dimensions are unavailable, the dimensions of similar items based on the item description are used.

Vehicles Emissions: Emission factors of the vehicle used by the bringers are obtained from Norwegian public roads administration's official website and other online sources mentioned before. The emissions of the 3PL vehicles are obtained from the TØI report (Rødseth, et al., 2019).

Bringer Emissions: The CO_2 and NO_x emissions (converted to CO_2 equivalent) are calculated based on the detour distance in case the trips are planned, and the emission of the total trip is considered when the trip is dedicated. Sample calculations are shown in appendix 15.

Total Trip Emissions Alternate Scenarios

The emissions calculations for the comparison are divided into two scenarios.

Scenario 1: A major postal service functioning in Norway is regarded as an alternative in this scenario. This company provides pick-up and drop-off service to its business clients. The emission calculations are based on the plan shown below.

	Scenario 1 (postal services)	
	One terminal	**Two terminals**
	Postal services	**Postal services**
First mile (truck 7.5-14ton)	Pickup point to the closest terminal	Pickup point to the closest terminal
Last mile (truck 7.5-14ton)	Terminal to the delivery point	Terminal to the delivery point
Intercity truck (28-40)		Between terminals
Train electric		9.45%
Train diesel (1200t)		5.55%

Table 9 Vehicle type description in scenario 1

To divide the journey into first mile and intercity and last mile segments, first the closest terminals of this postal service to the user mentioned pickup and delivery points are identified and then the distances between the pickup location to the closest terminal is calculated for first mile and the delivery point to the closest terminal for the last mile is calculated. Finally, the distances between these two terminals are then computed. In cases, where there is only one terminal involved, which means that both the pickup and delivery points are close to the same terminal, this postal service utilizes a 3.5-14T truck with an average load of 4.6T for first and last mile calculations. Thus, we have considered a 7.5-14T truck with a 4.6T load factor for the entire trips in these cases. The volumetric weight is determined using the dimensions of the goods dividing them with a volumetric factor specific to the 3PL company's location and is compared with the actual weight. The emissions are finally computed using the load capacity and the volumetric weight of the package.

If the entire trip involves two terminals, the same calculations are used for the first and last leg of the journey. However, inter-terminal distances are divided into three categories. First, rail accounts for 15% of all inland freight transit (Eurostat, 2020) Of this 15%, electric trains account for 63%, while diesel trains account for 37%. (Statista b, 2021). The average total capacity of a freight train was 50 TEU (Bayer, 2008). Emissions are calculated considering a load factor of 100% assuming full capacity at 1200T (Bayer, 2008). Finally, the remaining section of the intercity terminal distances is assumed to be done by a 28-40T truck, because the postal service employs a truck with 24T and higher capacity for longer routes and between terminals with an average load of 11.1T. The average load for 28-40T truck considered, is 15T (Eurostat, 2020). The emissions of these vehicles and trains are calculated using the distance in kilometers travelled using each mode, the volumetric and actual weight of the goods, and the emissions per kg of the vehicles. Direct emissions considered for the leg of the journey through electric trains is zero. The emissions are calculated using the average load provided by the postal service and the vehicle emissions provided in the tables below only CO_2 and NO_x are considered in this for the comparison. Sample calculations are shown in appendix 13.

The standard emissions are taken from the below tables.

Vehicle type	**Area type**	**Co_2(g)/km**	**NO_x(g)/km**
Van diesel	Town (> 100,000 inhabitants)	191	0.64
Weight class	**Area type**	**Co_2(g)/km**	**NO_x(g)/km**
7.5t -14 t	All	475	2.74
28-40t	All	940	2.34
Train type	**Area type**	**Co_2(kg)/km**	**NO_x(g)**
Freight trains	All	20.6	305.7

Table 10 Emission standards of a standard modal networks (Rødseth, et al., 2019, p. 36)

Scenario 2: Scenario 2 is primarily considered as an alternative when the user is a private individual rather than a registered business. The goods are classified into two categories based on their weight. The estimations for emissions are based on the plan presented below.

	Scenario 2			
	Less than 35kg (Postal services)		**More than 35kg(3PL)**	
	One terminal	**Two terminals**	**Less than 200 km (Van)**	**More than 200 km**
First mile (truck 7.5-14ton)	Standard car [pickup to service point] + Truck 7.5-14ton [service point to terminal]	Standard car [pickup to service point] + Truck 7.5-14ton [service point to terminal]		10% [truck 7.5-14ton]
Last mile (truck 7.5-14ton)	Truck 7.5-14ton [terminal to service point] + Standard car [service point to delivery point]	Truck 7.5-14ton [terminal to service point) + Standard car [service point to delivery point]		10% [truck 7.5-14ton]
Intercity truck (28-40)		Remaining		80%
Train electric		9.45% of total		
Train Diesel (1200T)		5.55% of total		
Full trip Van			100%	

Table 11 Vehicle Type description in Scenario 2

The postal service is considered for goods weighing less than 35 kgs, with the exception that the user delivers and picks up the goods from the closet service location. As a result, the closest postal service centers to the pickup and delivery destinations are determined, and distances between these points are calculated. Then a standard car is considered that a user uses from the pickup point to the service point (first mile) and finally from the service point to the user's delivery location (Last mile). In addition, the first mile includes the distance from the service point (closest to the pickup point) to the terminal (closest to the pickup point), and the last mile includes the distance from the terminal (closest to the delivery point) to the service point (closest to the delivery point).

This is further subdivided into cases where just one terminal is involved and cases where two terminals are engaged. All other computations are the same as in scenario 1, the emission of the typical car is based on the average emissions of all 68 trips.

For goods weighing more than 35kgs, an alternate scenario is considered, which is further divided based on the distance between the delivery and pickup points, for trips where the distance between the pickup and delivery points is less than 200 km, a dedicated van is used as the mode of transport, the emissions of this vehicle are based on the standard emissions from the table given above, and the load factor is based on the weight. However, in this case emissions of a dedicated van are considered for the delivery.

Finally, the last section is where the goods weigh more than 35 kilograms and the distance to be travelled exceeds 200 kilometers; the transporter is assumed to provide pickup and drop services, since the distances travelled are dependent on the transporters and their network, we have assumed the first and last mile to be 10% each, and the intercity/terminal to terminal distance to be 80% based on the pareto principle. The assumption is supported by calculating the pickup-terminal, terminal-terminal and terminal-delivery distances of 1843 trips to determine the average ratio of last mile and intercity travel based on the coverage of one major postal services network. Which was exactly 10.22% on first mile, 9.30% on last mile and 80.48% on the interterminal distance. The emissions are computed using the vehicles assumed to be utilized for intercity transportation by the 3PL provider, which is a 28-40t truck with a load capacity of 15t, and for first and last mile transportation, the vehicle is assumed to be a 7.5-14t truck with a 4.6t load. The load factors are taken similar to postal services. Sample calculations are shown in appendix 14.

4.9.4 Financial Analysis

The financial analysis was performed on 64 individual bringers and 4 company bringhers to obtain findings on the following

Delivery Cost to user (Crowd Shipping). The cost of delivery to the user is the price the user paid for the delivery on the platform, obtained from the transactional record. This is the consolidated cost of all the orders that the bringer delivered on the trip. The user wanting to send the order themself decide the price but can change it I needed and can also be negotiated by the bringer before confirming.

Delivery Cost to user (Scenario 1): If the customer selected a postal service provider instead of the CS, it is computed based on the pickup and delivery coordinates, the volumetric weight and the actual weight of the goods, and the rates are retrieved from the official account of a postal service provider. This is applicable when the users are businesses and opt for pickup and delivery. This is the consolidated cost of all the orders that were delivered on the trip.

Delivery Cost to user (Scenario 2): This is considered as an alternative delivery cost, if the customer is a private individual, selects a 3PL provider instead of the CS, for goods weighing less than 35kg. The standard parcel prices of a postal service are used. However, for goods weighing more than 35kg, the prices are assumed to be same as the postal services prices charged to business customers. This is the consolidated cost of all the orders that were delivered on the trip.

Fuel cost: The fuel cost estimate is considered as the bringer's cost to delivery. In this study other variables such as maintenances, road tolls, accommodation, food etc. were not included.

Bringer Earnings: If the trip was a planned trip, then the cost of detour(fuel) is subtracted from the total reward to obtain the total bringer earnings. In case the tour was dedicated, the total cost of trip(fuel) is subtracted from the total reward to obtain the total bringer earnings

Bringer Earnings with time value: In a more detail analysis, the users time value is considered as, the time the user spends on the trip or the detour and its respective cost in terms of opportunity cost is considered. If the trip was a planned trip, then the cost of detour and the opportunity cost of the time to detour is subtracted from the total reward to obtain the total bringer earnings. In case the tour was dedicated, the total cost of trip(fuel) and the opportunity cost of the time spent to travel is subtracted from the total reward to obtain the total bringer earnings. The opportunity cost is assumed to be 188 NOK per hour.

Additional emission distance (AED)

This the additional distance travelled each trip that caused extra emissions. For a dedicated trip, AED would be the total trip distance, whereas for a planned trip, it would be the detour distance.

4.9.5 Result generalization

The association between results from a given study sample and a specified target population is known as generalizability (Rothman, et al., 2013). The findings of a study may be generalizable to one target population but not to another. (Yin, 2009) case studies are often criticized for providing little basis for scientific generalization. Scientific truths are rarely established on a single experiment; rather, they are frequently built on a series of tests that have reproduced the same phenomena under various conditions.

(Yin, 2009) has also mentioned that case studies, like experiments, can only be used to prove theoretical propositions, not populations or worlds. In this sense, the case study, like the experiment, is not a "sample," and the purpose of a case study is to broaden and generalize theories (Analytical generalization), not to count the number of cases (Statistical generalization) (Yin, 2009).

In the research Encyclopaedia by (Mills, et al., 2010), (Yin, 2009) advises the following on analytic generalization

- At the start of the case study, the argument or theory should be stated clearly.
- Instead of being particular to the case study, the argument should be based on research literature.
- The findings should illustrate how the case study's findings either contradicted or supported the theory or argument.
- If the data confirm the hypothesis, researchers must present a logical and reasonable argument to explain how the findings might be applied to comparable circumstances.
- Examining competing hypotheses will bolster analytical generalization claims.

The research follows on to the advice and presents the results that are analytically generalized.

4.9.6 Assumptions of the study

The following assumptions were established for the purposes of this study. The information entered by users and bringers on their platform profiles was considered accurate. It is assumed that survey participants were considerate and provided honest responses. Some of the assumptions used to calculate the emissions are as follows:

Total Trip Assumption

The bringers entire trip was in the order of Origin-Pickup-Delivery-Destination. When either the origin or the destination was not given, they were assumed in the following manner.

If the distance between the bringer's home and the pickup location was less than 100 kilometers, the origin was the bringer's home, and the destination was the delivery city or a large city near to the delivery point.

In circumstances where the pickup was far from the home, the pickup city or a large city near to the pickup was deemed the origin, while the destination was considered the bringer's home, if the distances between home and the delivery site was than 100 kilometers, otherwise the delivery city or city close to delivery site was considered as destination.

The findings from the survey supported these assumptions.

Survey response	Origin before pickup was close to home or city	Destination after delivery was close to home or city	Either start or end at home
1	Valid	Valid	Valid
2	Valid	Valid	Valid
3	Valid	**N/A**	Valid
4	Valid	Valid	Valid
5	Valid	**Not valid**	Valid
6	Valid	Valid	Valid
7	Valid	**N/A**	Valid
8	Valid	Valid	Valid
9	**N/A**	Valid	Valid
10	Valid	Valid	**Not valid**
11	**Not valid**	Valid	Valid
12	Valid	Valid	Valid
13	Valid	Valid	Valid
14	Valid	Valid	Valid
15	Valid	Valid	Valid
16	Valid	Valid	Valid
17	**Not valid**	Valid	Valid

Table 12 Origin and destination of trip Assumption validation from Survey

The first assumption that if the address registered as "home" is close to the pickup, then home is the origin of the trip otherwise the city that is close to the pickup is the origin of the trip was valid for 14 trips, invalid for 2 trips, and excused for 1 trip due to lack of information. The second assumption about the last leg of the journey was that if the address registered as "home" is close to the delivery point, then home is the destination of the trip or the city that is close to the delivery point is the destination of the trip was valid 14 trips, invalid of 1trip and excused for 2 trips.

Direct Trip Distance

For the sake of comparison, it is assumed that if the bringer were to travel as per their plan, which is either Home- destination (delivery City) or origin (Pickup City)-Home, they would have travelled directly by skipping the pickup and delivery using the shortest travel route. This assumption is also supported by the survey results based on the origin and destination assumptions.

Dedicated Trip Assumption

If the bringer earns less than 188 NOK per hour (Glassdoor, 2022), it is assumed that the trip is not dedicated. The reason for using this assumption is that the actual motivation for the trip on the platform by the user, if it was a planned trip and the bringer utilized its excess capacity or whether the bringer made a completely dedicated trip was not available. This key information was missing in the transactional data and this limitation was addressed using the bringer earnings, since it is one of the factors that impacts the crowd's readiness to work, (Rai, et al., 2018). The average gross pay of 188 NOK per hour for driver in Norway was taken from Glassdoor and was considered as a threshold, since a driver in Norway earns on average 188 NOK per hour, we considered the trip to be planned if the driver earned less than 188 NOK per hour.

The following were the results of applying this assumption to the transactional data of 68 bringers under study. Furthermore, this research only considered fuel costs in this calculation, other costs such as vehicle maintenance, food, tolls, etc. were not included which would have further reduced the per hour earnings. (The below bringers earnings are based on total trip distance, the fuel cost and the bringer's reward, and the driving hours) appendix no.16

Bringer	Average Orders combined	Nature	Bringer's Average earnings per hour (NOK)	Transport fulfillment
8	2	P2P	274	Dedicated
1	1	B2C	33.6	Dedicated (As per survey)
56	2	P2P	63	Planned
3	1	B2C	27	Planned

Table 13 Transport fulfillment assumption

This assumption was also supported by the survey responses,

Survey response (bringer number)	If bringer earned less than 188 NOK /hr, then it is considered planned trip
2	Valid
4	Valid
6	Valid
10	Valid
14	Valid
18	Valid
20	Valid
34	Valid
40	Valid
51	Valid
53	**Not valid**
63	Valid
64	Valid
65	Valid
66	**Not valid**
67	Valid
68	Valid

Table 14 Transport fulfillment assumption validation

Out of 17 trips, 13 trips earned less than 188 NOK /hr. and the trips were not dedicated, one earned higher than 188 NOK /hr. and the trip was not dedicated, two earned higher than 188 NOK /hr and the trip were dedicated, and lastly, one earned less than 188 NOK /hr and the trip is said to be dedicated. Thus, 15 results support our assumption.

Third Party Logistics Assumption

The assumptions are made on the vehicles used by third-party logistics providers. For this purpose, we assumed that trucks used by 3PL for intercity transport are 28-40t and 7.5-14t trucks were employed for the last mile.

Another assumption is the lengths between pickup-terminal-terminal-delivery, where the last mile is pick-terminal, terminal-delivery is deemed to be 20% of the whole trip, and therefore the emissions of the package are computed accordingly. Finally, the vehicles' assumed load is similar to load factor provided for postal services for last mile.

Inter-city, Last Mile Distances Assumption.

The last mile (from pickup to terminal and from terminal to delivery) is estimated to be 20% of the whole journey, whereas the intercity distance is assumed to be 80% of the total trip. This assumption is initially based on the Pareto principle, also known as 80/20 rule, which states that about 80% of the effects of various factors are caused by just 20% of them. (Rosing, et al., 2015) This principle is applicable in many areas (Investopedia) however, our computation of 1843 actual journeys completed on the platform supports this assumption, suggesting that this approach also applies to distances. We used a major postal services terminal coverage, which is comprised of 25 terminals across Norway, calculating distances between the closest terminal to the pickup and the closest terminal to delivery, and then the distances between these two terminals. We obtained a 10.22% average distance on the first last mile leg (pickup to terminal) and 9.30% on the second last mile leg. And 80.48% on the intercity, confirming our 80-20 assumption. These estimations are limited since postal services have excellent network coverage throughout Norway, which may not be the case for other 3PL service providers. However, these estimates were utilized based on the available facts to support the assumption. (Appendix No.3)

3PL Cost Assumption

The cost for 3PL is assumed to be same as postal service provider since there are multiple 3PL companies with different cost structures. Each transporter has its own network and charges fees accordingly. Transporters request information such as items weights, dimensions, pickup, and delivery points, and then provide a personalized quote. As a result of this limitation, this study uses the pricing obtained from the postal services business account and assumes that the transporters charge the same amount. The prices of five orders were compared between two different postal services and found to be comparable.

4.10 Summary – Methodology

The study proposes that crowdshipping has a positive impact on the environment and the stakeholders of freight transportation, and then uses a deductive approach to evaluate this theory. A descriptive study design is the chosen research structure for the research objectives of describing current CS practices and their environmental and economic impact, as well as the link between variables that cause these impacts. A multi-method quantitative research approach including both questionnaire and transactional data are the methodological choices employed. Case studies and surveys were utilized as research strategies. The sample is chosen through purposive sampling, and data is collected using both primary and secondary means. There is a descriptive statistical analysis performed on the entire transactional data and then analysis performed on the samples for environmental assessment.

Chapter 5 Findings

The case company's P2P crowdshipping platforms findings have been described below. They attempt to showcase the answers to research questions, representing, how the crowdshipping practices are complementing freight transport by displaying statistics on the crowdshipping platform's demand, supply and operations, as well as what are the environmental and economic implications.

5.1 Platform- Demand and Supply

An analysis of peer-to-peer transactions of the platform over six months comprised a total of 10,683 orders posted by 5398 users of which 4287 orders were accepted by 299 bringers. Hence, users cancelled around 58% of the total orders posted, while only 40% were accepted (delivered/in process), and about 2% were still active.

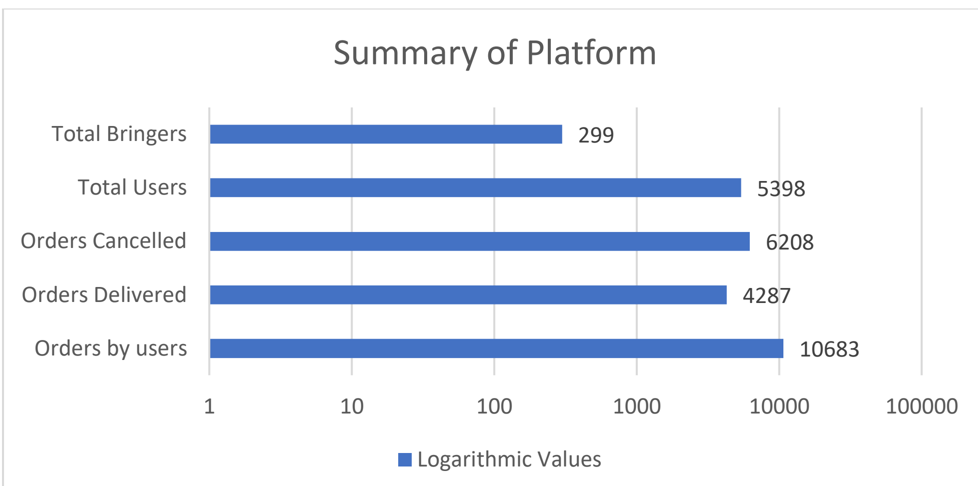


Figure 21 Case Company platform summary

Users & bringers

On the demand side of the platform, the number of active users/senders every month was roughly between 1000-1300, while on the supply side, the active users/bringers were ranging between 100-130, resulting in a 10:1 ratio. On average, there were 1138 active users and 114 unique active bringers per month. The graph below illustrates the total active users per month during the six months. [10683 orders were analyzed for active users, 4287 order were analyzed for total bringers]

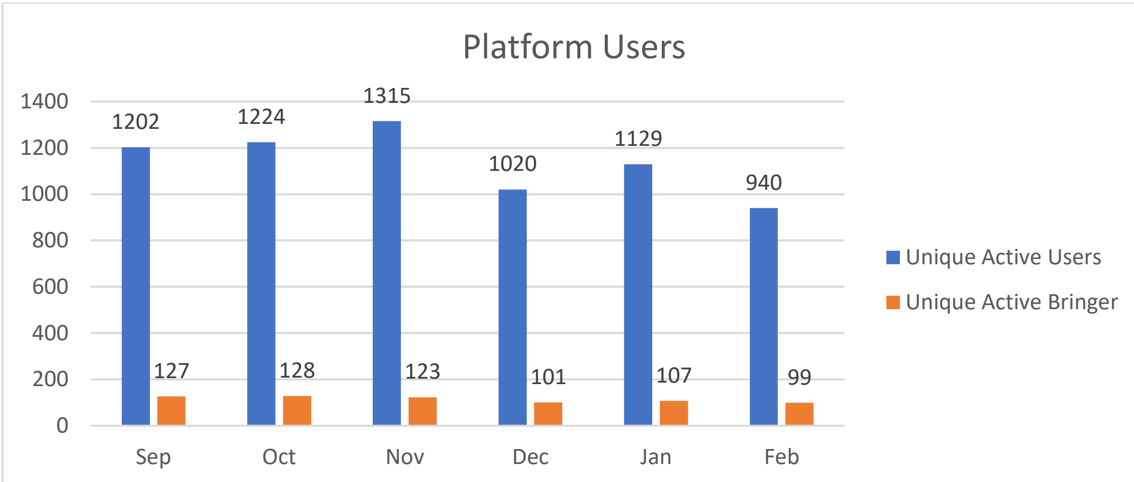


Figure 22 Platform users

Demand

The total active senders each month ranged between 1000-1300. However, the users that got matched with bringers and had their items delivered, were between 300-600. Which shows 30-45% of the users were matched with bringers. Each month, 491 users were matched with bringers on average [10683 orders were analyzed for active users, while 4287 orders were analyzed for matched users, excluding buyable, cancelled orders].

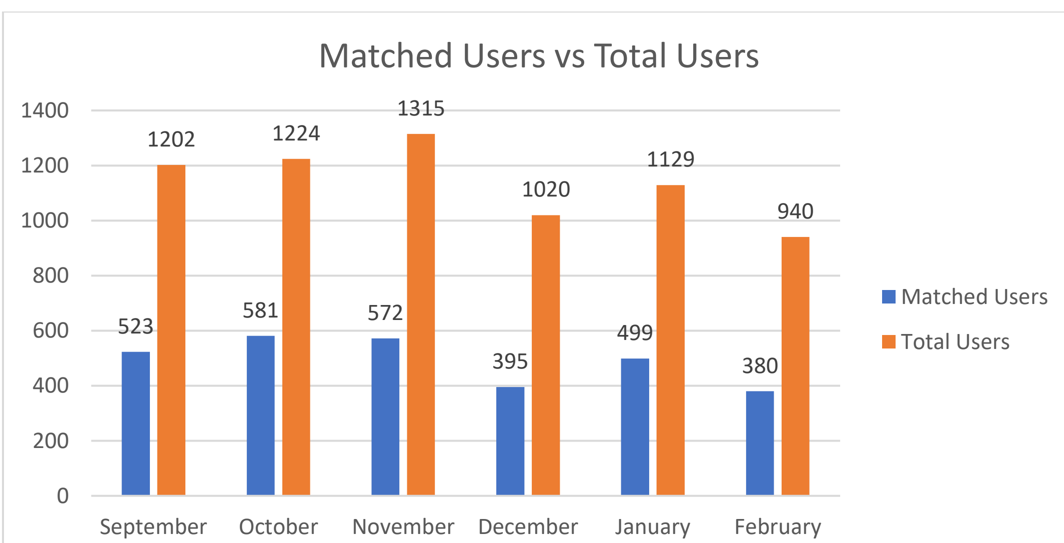


Figure 23 Number of users matched

Over a six-month period, the ratio of total order delivered/In-process was between 500 and 800.

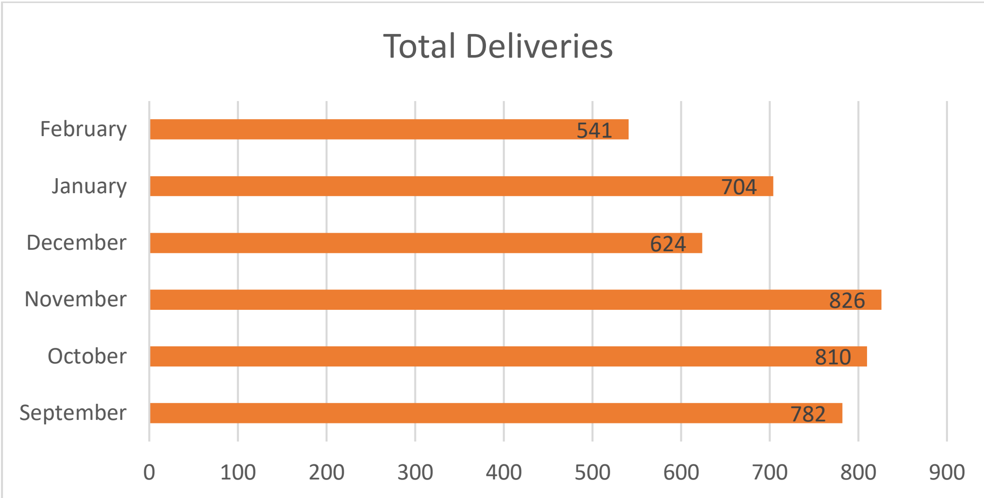


Figure 24 Delivery Numbers

Each month, the percentage of total orders delivered was between 30-40% of the total orders placed, on average 38% of the total orders were completed each month [10683 orders were evaluated for total orders, whereas 4190 orders were analyzed for delivered orders, excluding in process, buyable, and cancelled orders].

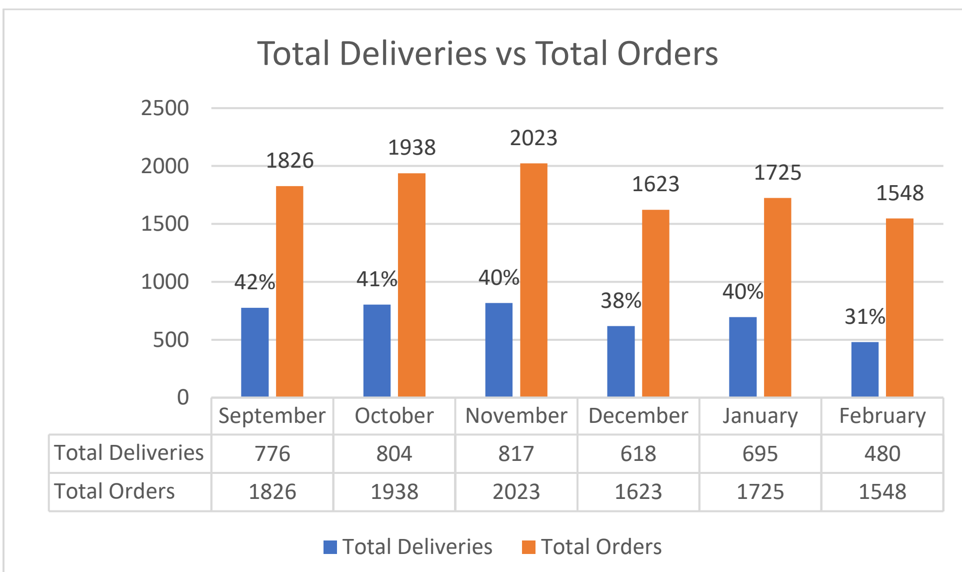


Figure 25 Orders and delivery fulfillment

The graph below depicts the number of orders in each category "delivered", "in process", "cancelled", and "buyable" in each month, demonstrating that cancelled orders outnumbered placed orders in all months. Each month, on an average 598 orders were delivered while 1034 orders were cancelled. [10683 orders were analyzed for all orders]

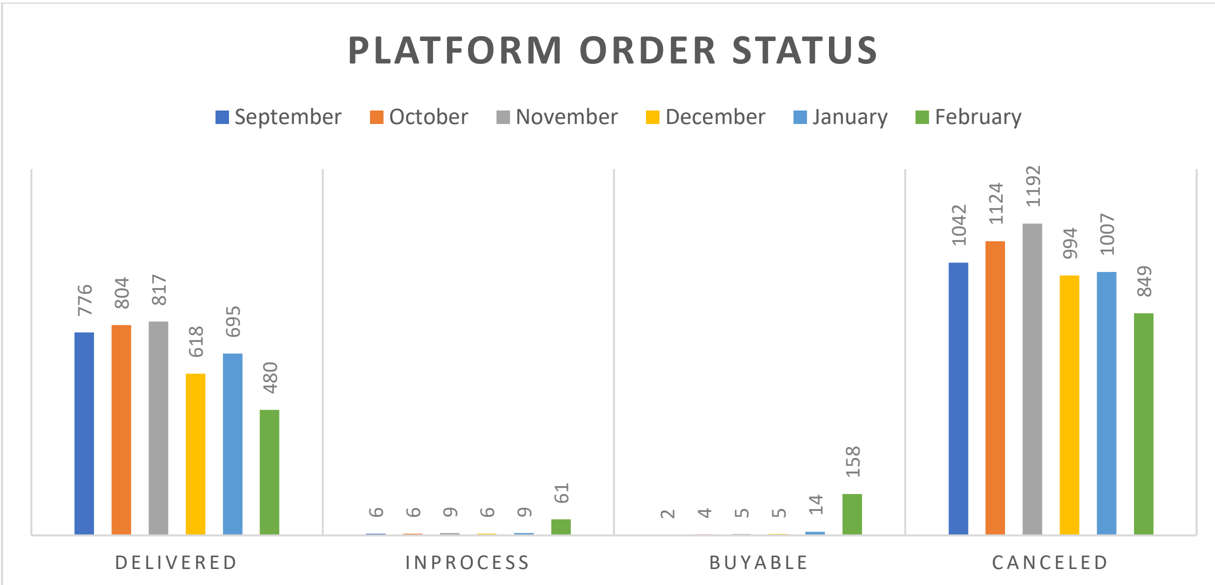


Figure 26 Total Order Status

Supply

With approximately 100-130 bringers active each month, the orders handled by bringers each month range between 500 and 850. The average number of active bringers per month was 114, with 714 orders delivered, implying that each bringer made 6 deliveries per month. The graph below depicts the number of active bringers and the total number of delivered orders over the course of six months [4287 orders were analyzed for total bringers users, excluding buyable, cancelled orders].

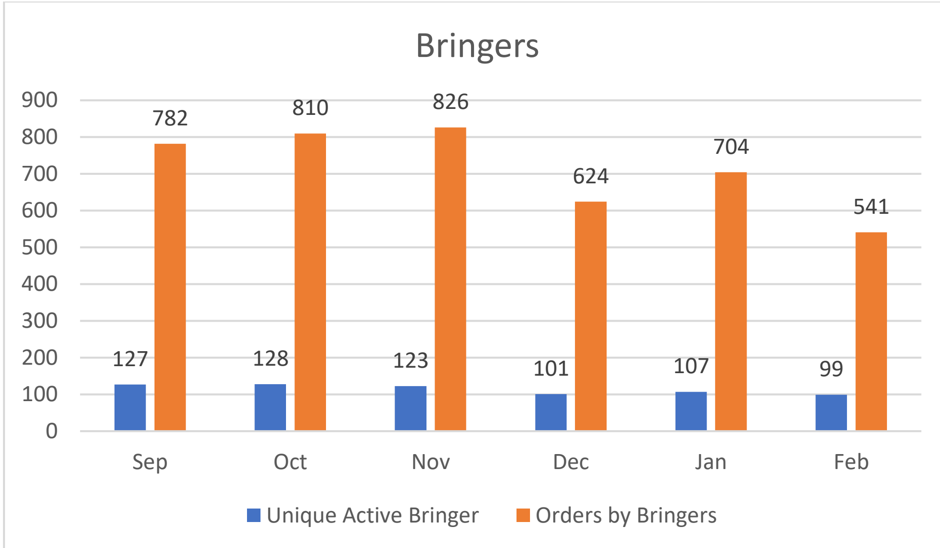
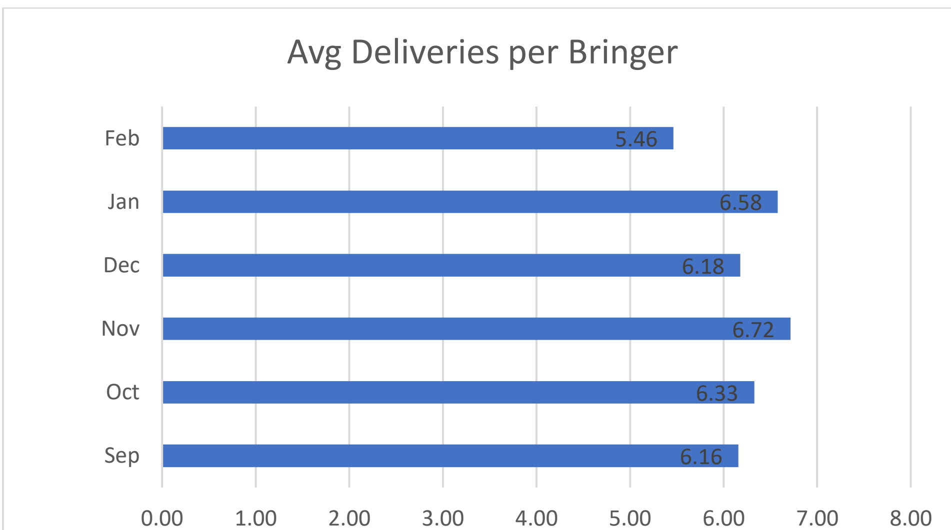


Figure 27 Delivery and Bringer Comparison

As indicated in the graph below, each bringer made close to 6 deliveries per month on an average, and this average is nearly steady over the whole six-month period.



	Sep	Oct	Nov	Dec	Jan	Feb
Avg order	6.16	6.33	6.72	6.18	6.58	5.46

Figure 28 Average delveries per bringer

5.2 Delivery statistics

Required Delivery Range

Most senders requested delivery on the same day of pickup or within a week of collection. Nevertheless, there were some cases with deliveries ranging from two to more than three weeks, the mean of the required delivery range was 1.96 days, with a median of 2 days, indicating a symmetric distribution, and a low standard deviation of 3.86 days, suggesting that most users desired delivery within 6 days, the longest delivery range was 89 days [1117 orders with delivery range provided by sender were analyzed].

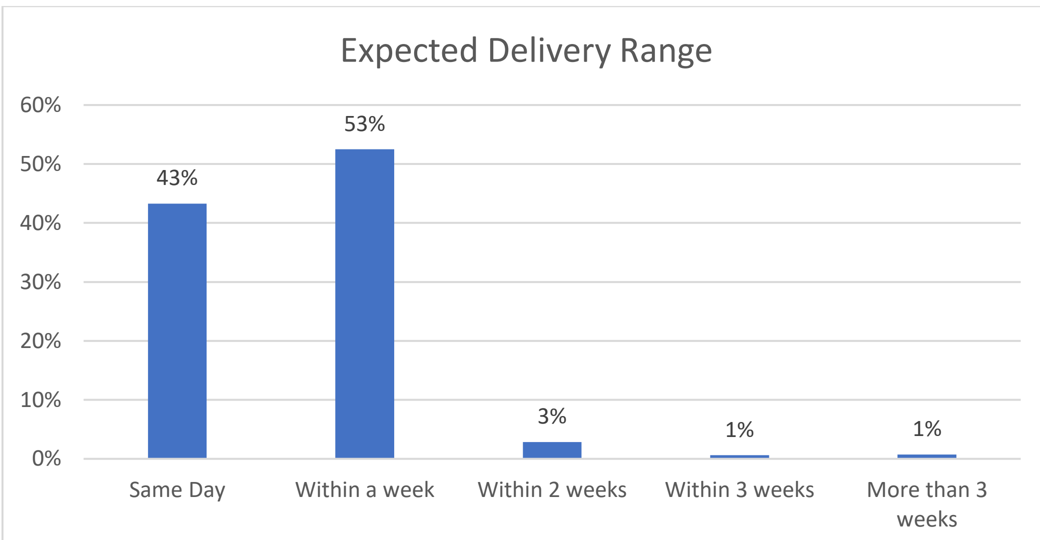


Figure 29 Expected Delivery Range

Actual Delivery

Most deliveries were made by bringers on the same day of pickup. The mean of the actual delivery range was 2.4 days, with a median of 1 day, suggesting that most of the actual deliveries were on the same day, but a standard deviation of 9.1 indicated variation due to outliers with the longest delivery time being 155 days [4022 orders that were delivered were analyzed instead of 4190 due to missing pickup dates of 168 orders].

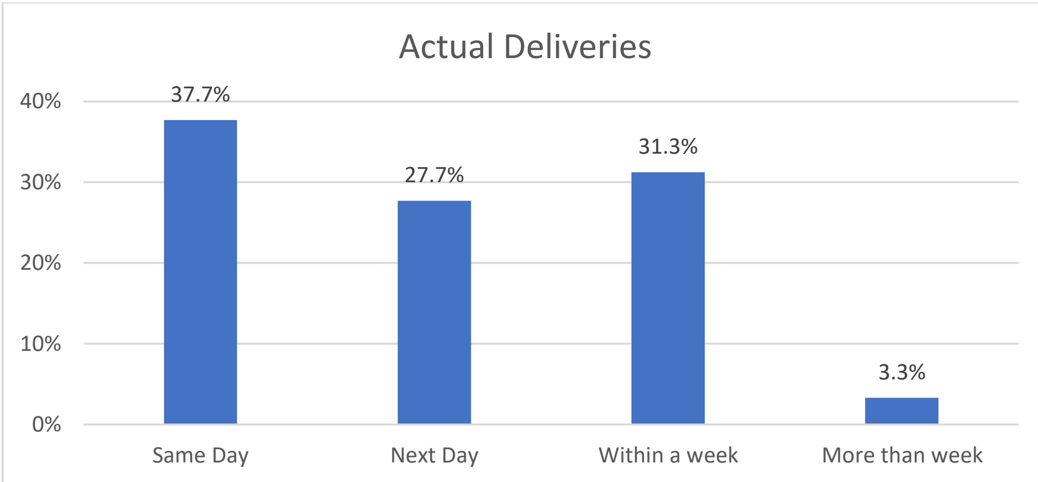


Figure 30 Actual Delivery Days

Order Fulfillment

Majority of the orders were completed within a week of creation. It was found that 210 orders which accounted for 5% of total fulfilled orders were completed same day, 15% were completed the next day, 48% were completed after the next day within the week, 22% were completed between week 1 and 2, 8% were completed within a month, and 2% were completed after a month of creation. On average the orders were completed within 6.7 days, the mode indicates that most of the orders were completed within 1 day of creation (next day). The standard deviation was 10.6, with a shortest order fulfillment time of within the day and a maximum of 156 days [4190 orders were analysed for delivered orders, excluding in process, buyable, and cancelled orders].

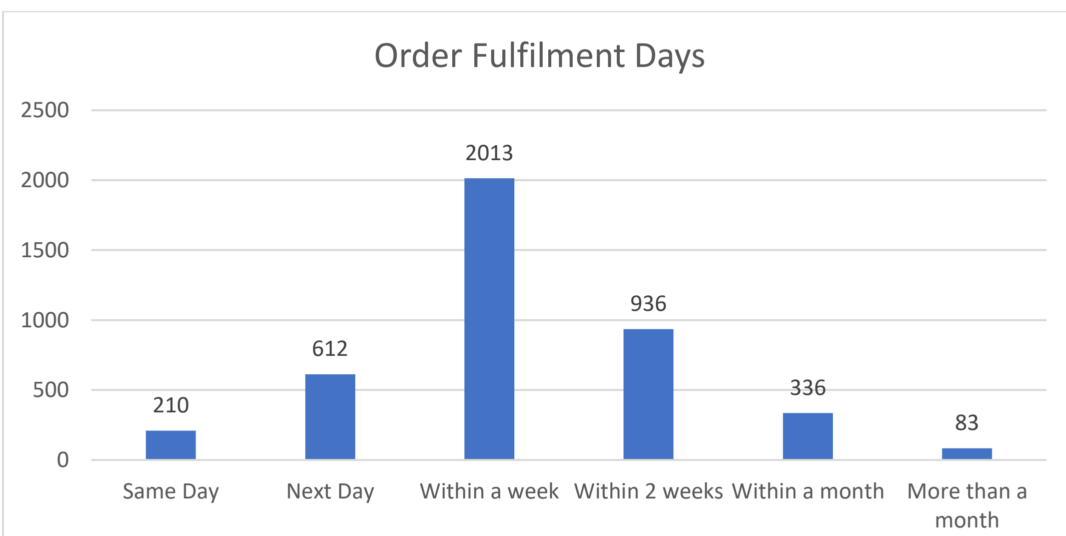


Figure 31 Order Fulfillment Days

Delivery distances

The distances between order pickup and delivery points for the majority of orders that were accepted by bringers were between 100 and 499 kilometers, accounting for approximately half of the total accepted orders; only 4% of these orders had a distance greater than 1000 kilometers. The average distance between the pickup and delivery points of the orders was 339.4 kilometers, and a standard deviation of 320.6 kilometers indicating some variation with the longest distance travelled of one order being 3651.1 kilometers [4287 orders were analyzed, excluding buyable, cancelled orders].

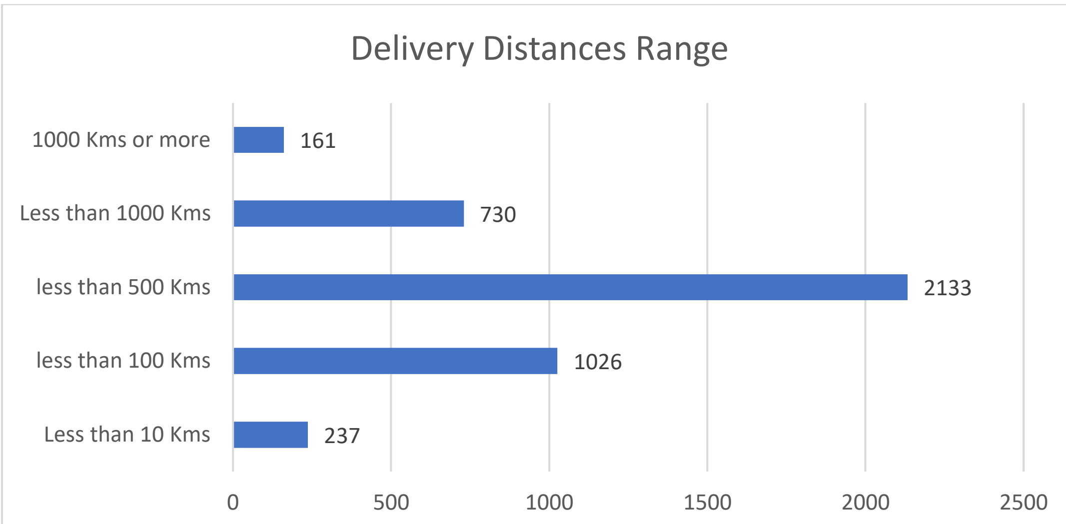


Figure 32 Range of Delivery Distances

Size

Most of the items delivered through the platform were large in size, with 36% of the orders being size 5, 31% being size 3, 28% being size 4, 3% being size 2 and 2% being size 1. The average size of the delivered order was size 4, indicating that it would fit in a large car or van [10683 orders were evaluated for total orders whereas 4287 orders were analyzed for completed orders].

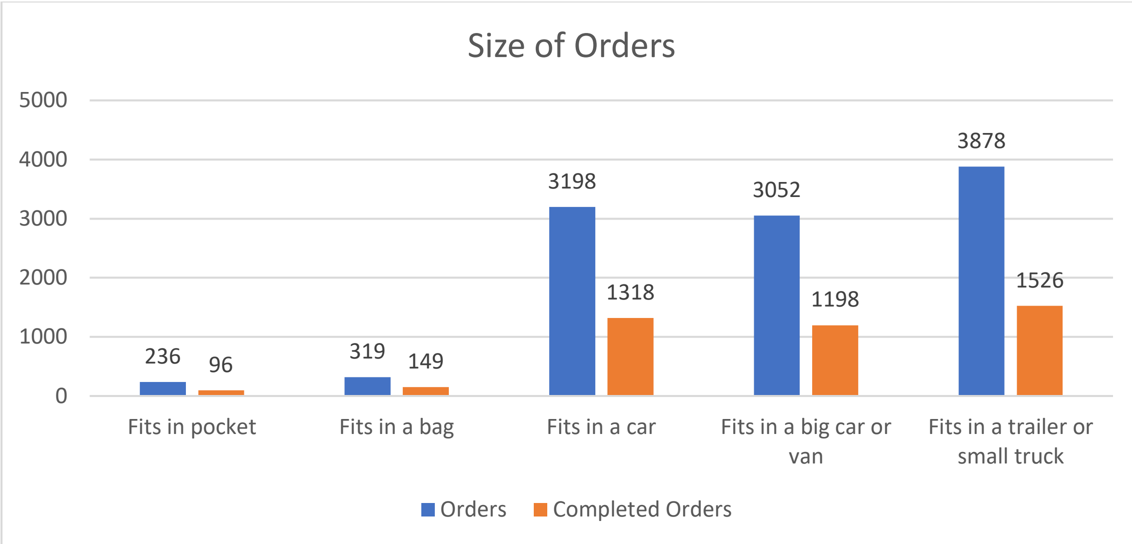


Figure 33 Size of Total and delivered Orders

Weight

The statistics on weight of the goods showed that 54% of the orders with weight information were less than 35 kg, 26% were between 35 and 99 kg, 14% were between 100 and 199 kg, and 6% were greater than 200 kg. The mean weight was 59 kg, with a high standard deviation of 128 kg [1442 orders were analyzed due to missing weight information].

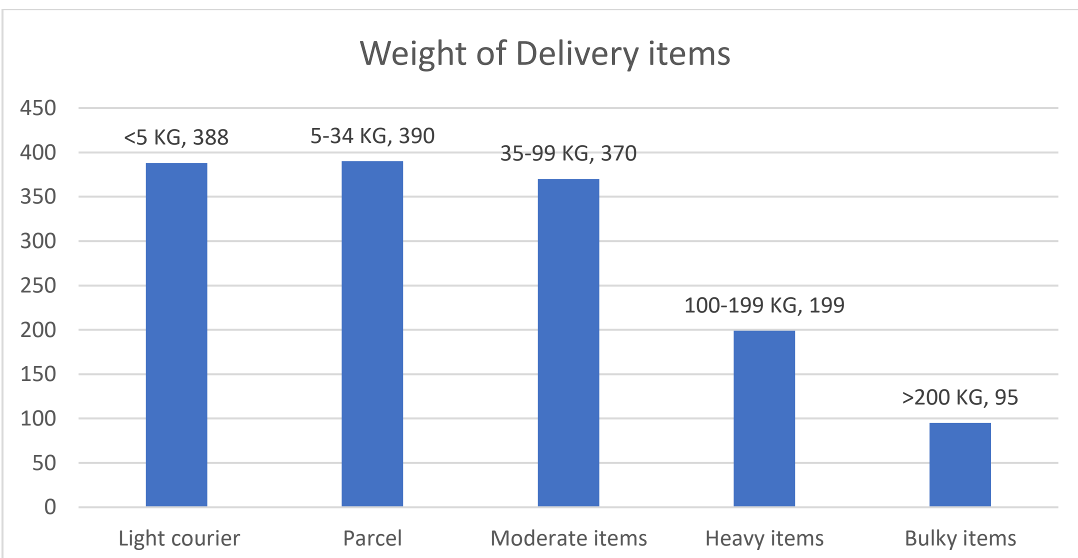


Figure 34 Weight of delivered Items

Geographical Distribution

The map below depicts the pickup and delivery locations of all orders placed by users in the preceding six months. The green points are pickup locations, whereas the blue points are delivery locations. This demonstrates that the platform's users cover the entirety of Norway’s geography [10683 orders were analyzed, all orders placed by users].

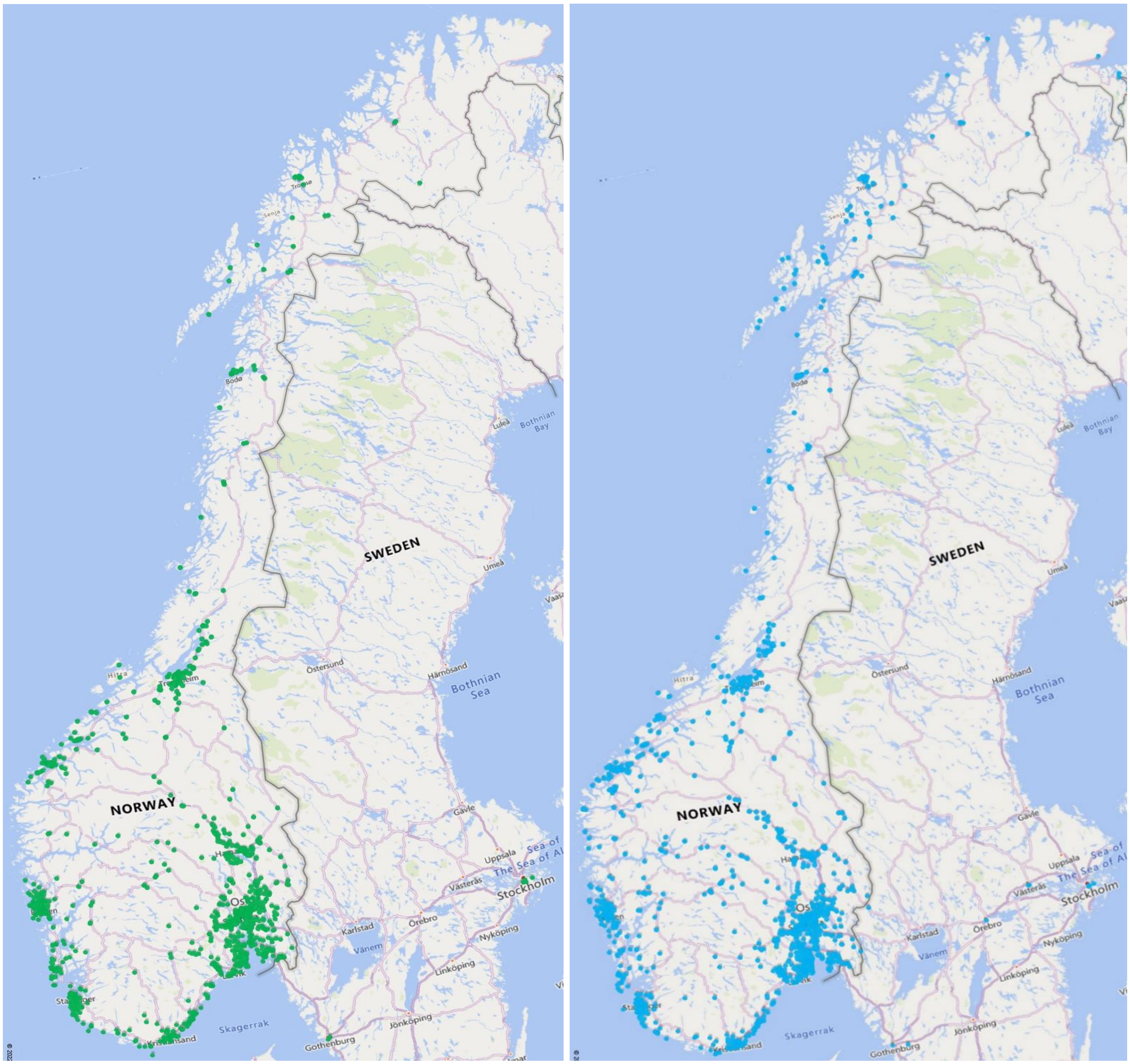


Figure 35 Location of Pickup (green) and Delivery points (blue)

The heat map of the activity is seen below, with higher volumes visible around major cities such as Oslo, Stavanger, Bergen, and Trondheim, major activity is seen around the capital “Oslo”.

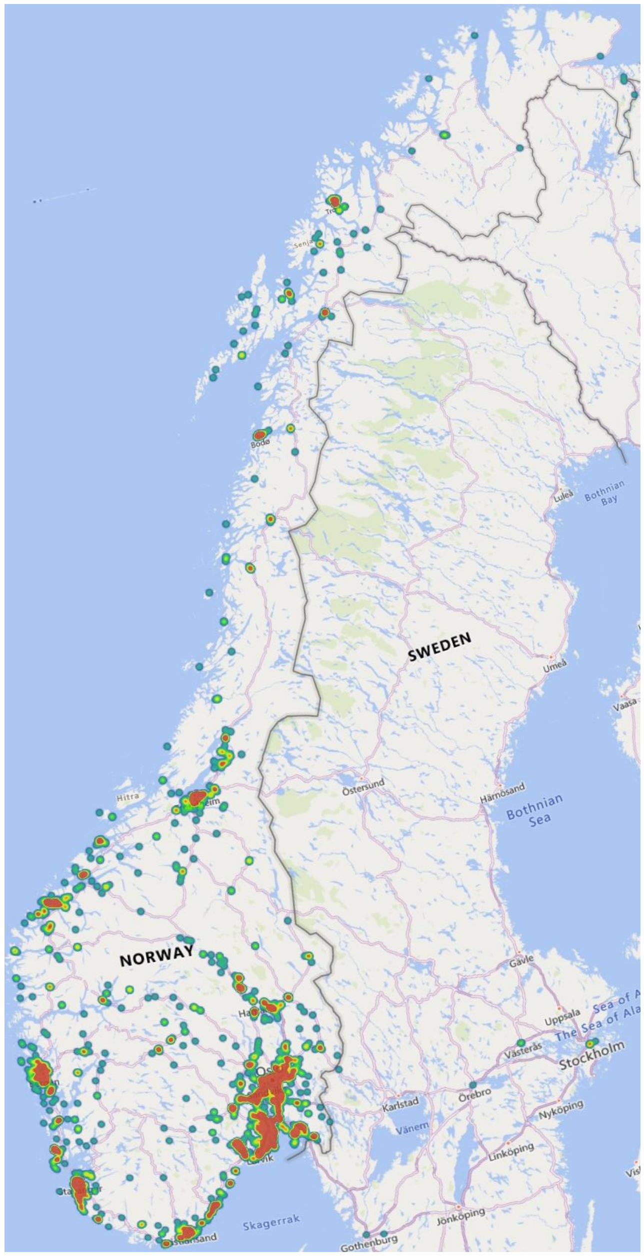


Figure 36 Platform's activity heat Map

The platform also has users from countries other than Norway, who were not considered for this study.

Price

Most user orders were completed valued between 500 and 5000 NOK, accounting for approximately 45%, with least accounting to 0.6% were those valued higher than 5000 NOK. The average price paid for the orders delivered was 1107.6 NOK. With a standard deviation of 939.2 NOK, the highest amount paid for a single order on the platform was 13467 NOK [10683 orders were evaluated for total orders whereas 4287 orders were analyzed for completed orders].

Figure 37 Price of Orders

The graph below depicts the proportion of sizes in each price interval. The lighter items fitting in a pocket, or a bag were priced NOK 100 or less whereas the heavier items were priced higher. The price of the order was hence proportional to the size of the order.

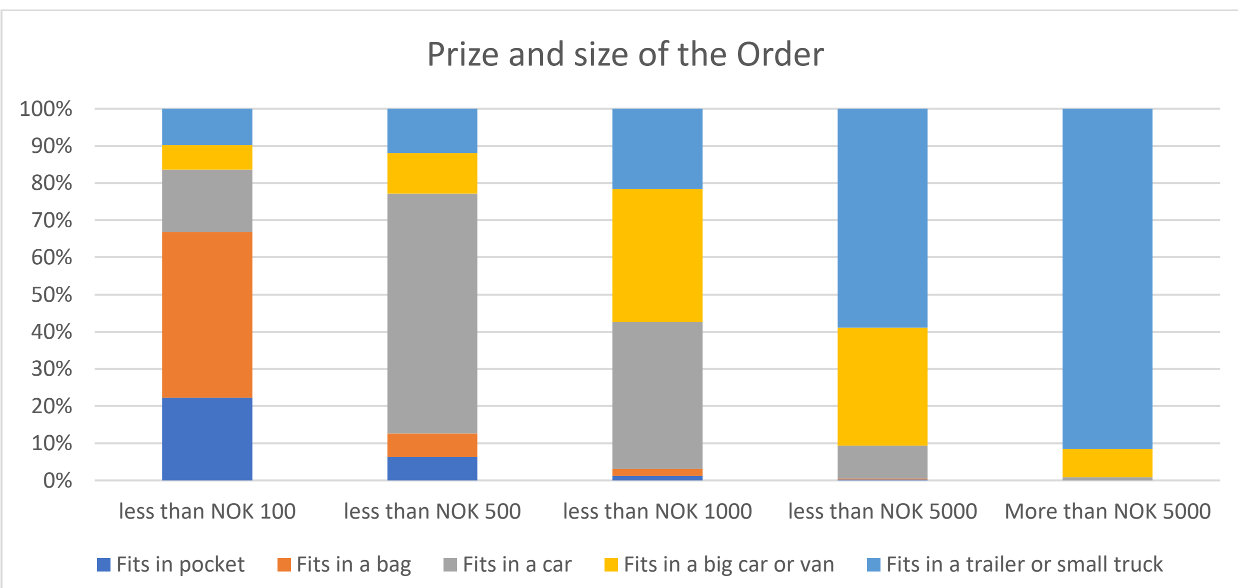


Figure 38 Prize and size of the Order

5.3 Survey Findings

We created the questionnaire, finalized the bringers to be contacted for the survey. The company took permissions from these bringers and conducted the survey on our behalf using SurveyMonkey; an initial request was sent to 313 bringers, and 145 of those initially accepted to be surveyed, giving a 46% response rate. However, once the email survey was distributed, only 19 bringers responded, of which 2 were associated to Nimber's B2C platform. Consequently, 17 people were considered, accounting for 12% of those who accepted and 5% of total active bringers.

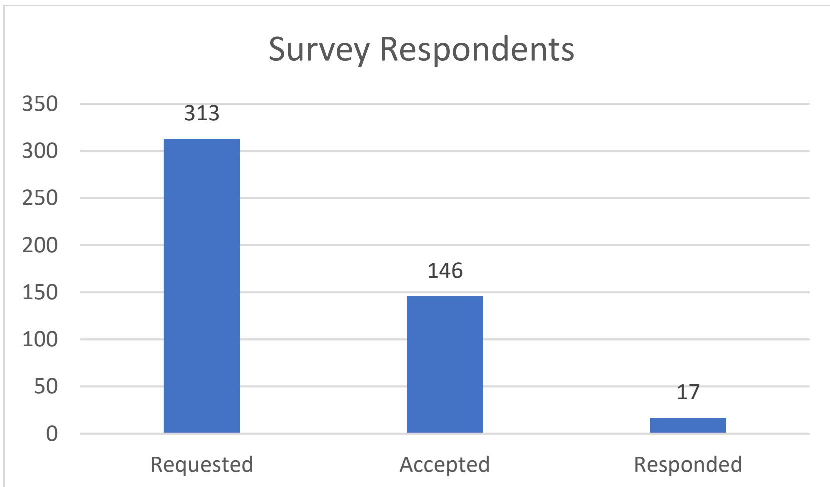


Figure 39 Sample size of the survey

Nature of Bringer

A total of 14 out of the 17 responders were individuals, while 4 were registered as companies.

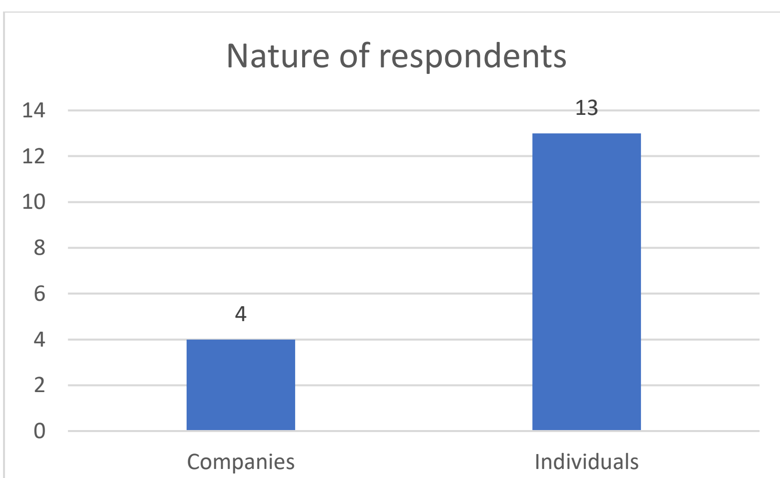


Figure 40 Type of bringer respondent

Primary reason to travel

The primary reason for travel, as stated by the bringers, was primarily to earn extra income. However, this response was rendered unusable because it was misinterpreted by the respondents, as many respondents who responded to the primary reason as "to earn extra income" also responded with ‘yes” to another question where they were asked if they would have still travelled on routes without a platform like Nimber.

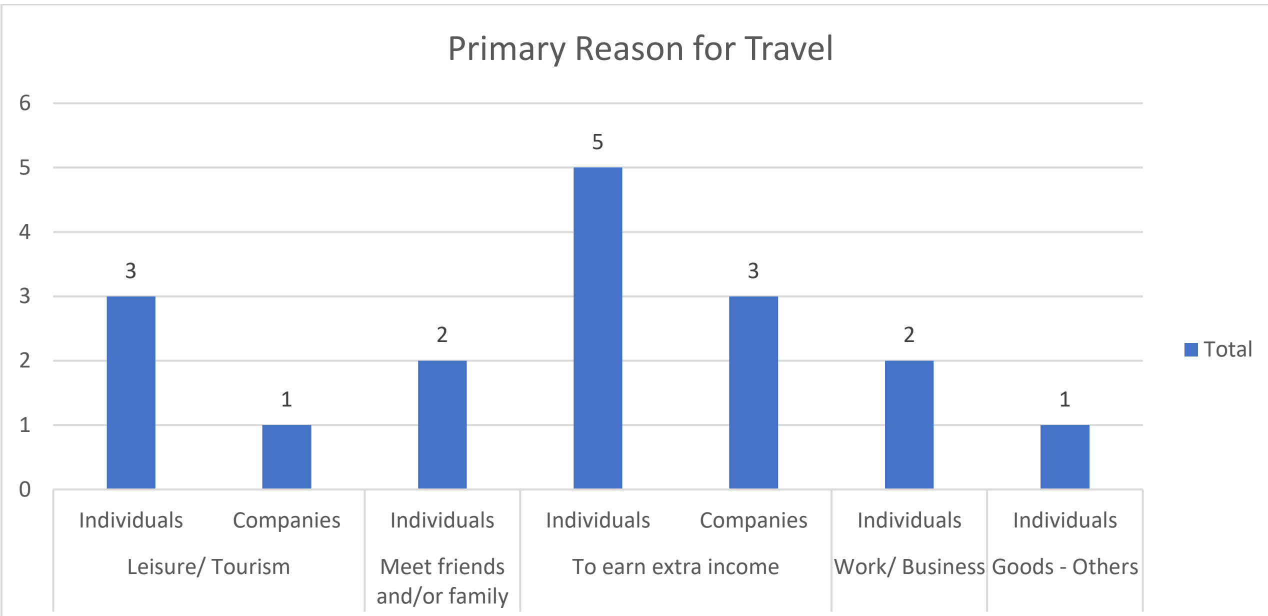


Figure 41 Respondent's reason to travel

Planned trips

According to the planned trip responses, 76% of respondents would have still travelled on these trips without a platform like Nimber, thus classifying them as planned trips rather than dedicated trips; only 24% or 4 respondents made dedicated trips. It was found that three of the four bringers registered as companies reported that they made planned trips and only one bringer made a dedicated trip.

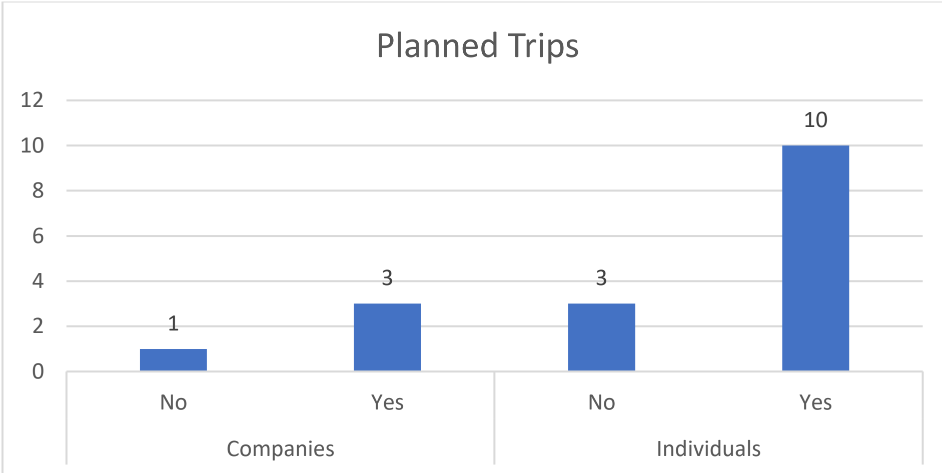


Figure 42 Respondents type of trip

Detour

The detour willingness showed that 59% of the total respondents were willing to detour between 10 and 50 km from their already planned trips, 29% were willing to detour between 51 and 100 km, one bringer was willing to make a detour between 101-200 km, while one bringer was willing to make a detour of more than 200 km, and this bringer was registered as a company.

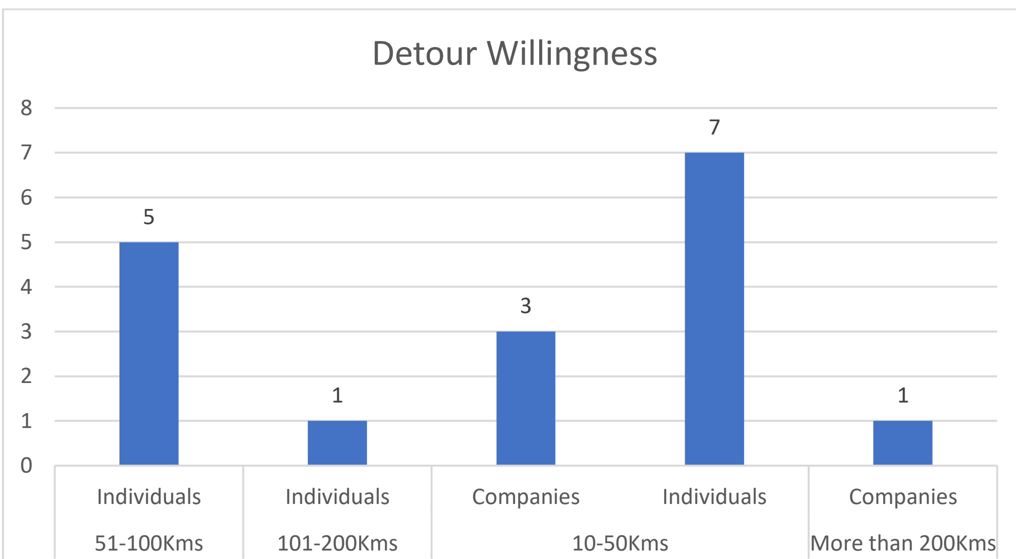


Figure 43 Willingness to detour of respondents

The below crosstab shows the relationship between the two variables which are primary reason for travel and the detour willingness of individual bringers.

Primary Reason to Travel	10-50	51-100	101-200	Total
Leisure/ Tourism	1	2		3
Meet friends and/or family	2			2
Others		1		1
To earn extra income	2	2	1	5
Work/ Business	2			2
Total	**7**	**5**	**1**	**13**

Table 15 Reason to travel and detour distance of private bringer respondents

The table shows that individual bringers are primarily willing to detour up to 50 km. When traveling for leisure, respondents were majorly willing to make a detour of up to 100 km. When meeting friends/family or on work/business trips, they were primarily willing to make a detour of up to 50 km. When traveling to earn extra income, individuals had varying levels of willingness, with two respondents willing to detour up to 50 km, two of them willing to detour up to 100 km, and one willing to detour up to 200 km. One respondent chose ‘others’ for the reason and was willing to detour up to 100 km.

A similar table for bringers registered as companies is presented below,

Primary Reason to Travel	10-50	More than 200	Total
Leisure/ Tourism		1	1
To earn extra income	3		3
Total	3	1	4

Table 16 Reason to travel and detour distance of bringer respondents who were companies

The responses from the companies revealed that the primary reason for the companies to travel was to gain extra income, and they were willing to detour only 10-50 kilometers, whereas one respondent with leisure/tourism as a primary reason to travel was willing to detour more than 200 kilometers.

Vehicles

The response on type of vehicles used showed that 29% of respondents used electric vehicles, while the remaining 71% used Hydrocarbon (HC) fuel or hybrid cars.

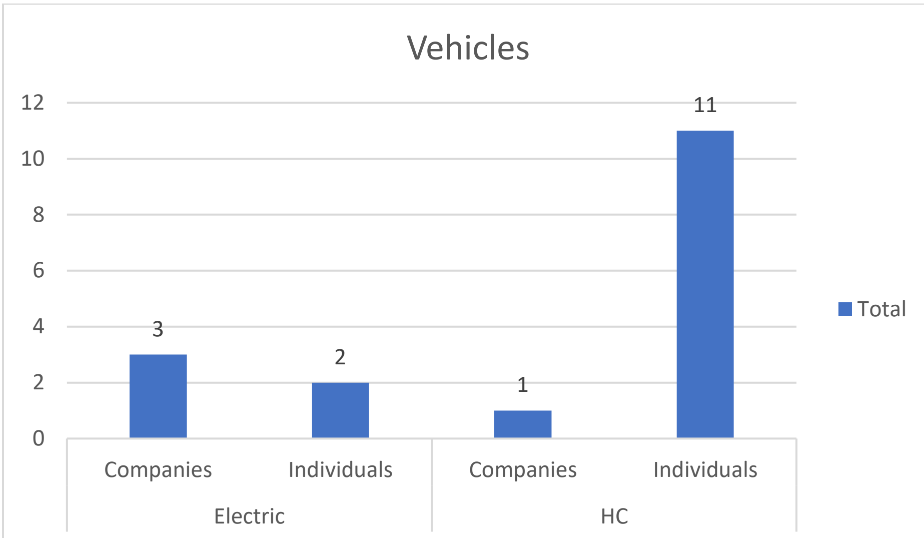


Figure 44 Respondents vehicle type

5.4 Case Study Findings

5.4.1 P2P - Individual bringers

Environmental assessment

The case company's P2P platform was assessed for its environmental impact in which only bringers registered as individuals were evaluated. A total of 64 individual bringers were considered for this analysis from the transactional data obtained from the case company, with 102 orders under evaluation. While 44 bringers delivered only one order on their most recent trip, the remaining 24 bringers consolidated orders with an average of three orders each. Finally, 56 bringers took orders on their already planned trips, while 8 made dedicated trips to deliver orders. These bringers travelled a total distance of 6845.5 km emitting about 1.11 tonne of carbon equivalent GHGs. If these deliveries were made for business users using scenario 1, 7 % additional emissions would have been generated while for private users, using scenario 2, 44% additional emissions would have been generated.

Type of Trip	Number of Orders	Bringers	AED (Km)	Actual weight (Kg)	CS Emission (Kg)	Volumetric weight (Kg)	S1 Emission (Kg)	CS vs S1	S2 Emission (Kg)	CS vs S2
Dedicated	16	8	2728.4	857.6	614.7	2208.0	86.2	421%	191.1	163%
Planned	86	56	4117.1	5012.8	502.8	21547.0	1117.6	-54%	1806.0	-71%
Grand Total	102	64	6845.5	5870.4	1117.5	23755.0	1203.8	**-7%**	1997.0	**-44%**

Table 17 Emission assessment summary as per trip type

The factors that were fundamental in influencing these emission figures were, most importantly the trip being planned or dedicated, the additional distance incurred by the bringer, the type of vehicle used, and the volumetric weight of the item delivered. There were certain extremities in the volumetric weight which also caused an increase in emission within scenario 1 and 2. Higher the additional distance and volumetric weight, higher was the emission gap between CS and scenario 1 and 2. (Appendix no.4)

The findings on type of vehicle have been further described in the table below:

Vehicle Type	Bringers	Orders	Trip Distance (Km)	AED (Km)	AED per order (Km)	CS-S1 (Kg)	% Difference	CS- S2 (Kg)	% Difference
Electric	9	9	2402.4	713.7	79.3	-36.7	-100%	-51.7	-100%
HC	53	83	26623.0	4269.8	51.4	-95.5	-8%	-792.8	-43%
Hybrid	2	10	2865.0	1862.0	186.2	45.8	109%	-35.0	-29%
Grand Total	**64**	**102**	**31890.4**	**6845.5**	**67.1**	**-86.3**	**-7%**	**-879.5**	**-44%**

Table 18 Emission assessment summary as per vehicle type

Usage of electric vehicles led to negligible direct emissions. With shorter detour distances, even HC vehicles delivering on the platform were found reducing direct emissions. The table gives an overview of various distances travelled per bringer for an order.

	Average Distances	Total Additional Distance	Number of Bringers
Detour distance per bringer	**73.5**	4117.1	56.0
Dedicated trip distance travelled per bringer	**341**	2728.4	8.0
Additional Distance travelled per bringer (AED)	**107.0**	6845.5	64.0

Table 19 Emission distances and ratios

The key metrics are the average distances which show that a bringer on a planned trip, detoured for about 73.5 km per trip while those bringers making a dedicated trip were travelling on average 341 km. For all the trips, planned and dedicated, the bringers on an average were travelling (Aggregate of additional emission distances (AED) additionally 107 km per order for delivery

5.4.1.1 Financial Analysis for users and Bringers

The monetary flow on the platform is from the user to the platform and then after the delivery of the package to the bringer after deducting commission and insurance in most cases. Their cumulative findings of have been summarized below:

Earnings by Bringers

Type of Trip	Orders	AED (Km)	Bringer Reward (NOK)	Fuel Cost (NOK)	Operating Earnings (NOK)	Earnings with Time value (NOK)
Dedicated	16	2728.4	14608	3847.9	10789.9	3264.3
Planned	86	4117.1	62410	3074.1	59335.7	47810.0
Grand Total	102	6845.5	77018	6922.0	70125.6	51074.3

Table 20 Earnings by Bringer Summary

Operating Earnings by bringers are the incentives they receive for delivering an item. It is essentially the difference between reward and fuel cost. Earnings with time value are calculated by deducting the time value of a bringer which has been assumed to be equal to the average gross salary of a driver in Norway (NOK 188/ hr.) (Glassdoor, 2022) from the operating earnings of the bringer.

The fuel cost of the dedicated trips was reflected in the financial analysis for the eight bringers that made such trips for 16 orders; five of these bringers only had a single order on their final trip, while the other three combined multiple orders. The fuel cost was dependent on the total distance travelled on their last trip which was 2728 km for these eight bringers. The consolidated fuel cost was 3848 NOK for these bringers, while the consolidated bringer reward was 14608 NOK, the consolidated operating earnings were 10790 NOK, for an average operating earning per bringer of 1349 NOK. And the earnings with time value were 3264 NOK. Hence, on average, the earnings with time value for these bringers were 408 NOK per trip. This was extra income that the bringers earned apart from their assumed time value of 188 NOK per hour. (Appendix no. 5)

The remaining 56 bringers delivered the 86 orders on their already planned trips. 39 bringers only had one order on their last trip while the remaining 17 consolidated on average 3 orders on their last trip. The fuel cost here is the fuel cost of only the detour distances. The total detour distance was 4117 km. The consolidated fuel cost was 3074 NOK while the consolidated bringer reward was 62410 NOK. The consolidated operating earnings were 59336 NOK while the earnings with time value was 47810 NOK. Hence, the average operating income per bringer was 1060 NOK, and the earnings with time value of these bringers were 854 NOK per trip. (Appendix no. 5)

Cost to User

The cost to user on the CS platform was analyzed and compared with the 2 alternative scenarios. Because users on the P2P platform can be both private individuals and businesses, the cost to user is differentiated as follows.

Scenario 1 considers users who are businesses; consequently, it pertains to users wherein postal services provide collection and delivery services and charges accordingly.

Scenario 2 applies to private individuals, and the costs for items weighing less than 35 kgs are assumed to be from a postal service (without pickup or delivery), while for items weighing more than 35 kgs, the cost of 3PL service providers are assumed to be same as the postal services charges (as in Scenario1).

Crowdshipping was a more economical alternative for all orders when compared to Scenario 1, that applies to users that are companies. Whereas the cost to individual users, crowdshipping was a cheaper alternative cumulatively for orders with volumetric weight more than 100 kgs. For items with volumetric weightless than 100 kgs and actual weight less than 35 Kgs, Scenario 2 for private individuals was cheaper, due to cost effective options offered by postal services for lighter goods and the absence of pickup and delivery to senders and recipients location. (Appendix no. 6)

Volumetric Weight (Kg)	**Orders**	**Delivery Distance (Km)**	**CS Cost (NOK)**	**S1 Cost (NOK)**	**S2 Cost (NOK)**
1-35	16	3239.8	9040	12544	3169
36-100	11	4645.5	10260	19598	9716
101-200	19	6448.2	15610	41942	31938
201-300	13	6362	15490	32812	23540
301-400	14	4845.5	18020	41664	37799
401-500	2	1168	3010	12648	12648
>501	27	10013.2	28280	174209	139481
Grand Total	**102**	**36722.2**	**99710**	**335417**	**258291**

Table 21 Cost to user Summary

5.4.2 B2C - Company Bringers

5.4.2.1 Environmental assessment

Presented below are the findings of emissions by bringers who are registered as businesses on the CS platform. A total of 4 company bringers are considered in this study, based on the survey responses. Each of these bringers only delivered one order on their most recent trip, while one of the bringers made a dedicated trip, others took orders on their already planned trips. With an observation set of 4 bringers, delivering 4 orders, they travelled a total distance of 679 km emitting about 22.4 kgs tonne of carbon equivalent GHGs. If these deliveries were made for business users using scenario 1, 1% additional emissions would have been generated while for private users, using scenario 2, 36% additional emissions would have been generated. Three of these bringers utilized electric cars, resulting in zero direct emissions. The one bringer who used an HC vehicle made a 201 km detour on their planned route. This detour is longer than the average detour distance of 74 kilometers observed in individual users. (Appendix no. 7)

Type of Trip	**Vehicle Type**	**Number of Orders**	**Bringers**	**AED (Km)**	**Actual weight (Kg)**	**CS Emission (Kg)**	**Volumetric weight (Kg)**	**S1 Emission (Kg)**	**CS vs S1**	**S2 Emission (Kg)**	**CS vs S2**
Dedicated	Electric	1	1	478	28	0	136	8.1	-100%	12.4	-100%
Planned	2 Electric / 1 HC	3	3	201	50.5	22.4	220	14.6	53%	22.4	0%
Grand Total		4	4	679	78.5	22.4	356	22.7	-1%	34.8	-36%

Table 22 Emission assessment summary of Companies

5.4.2.2 Financial Analysis for users and Bringers

The summary of the findings of companies as bringers have been summarized below:

Earnings by Bringers

The consolidated fuel cost of the one bringer that made dedicated trip was 240 NOK, and its reward for the trip was 500 NOK, the operating earnings of this bringer was 260 NOK, with a negative earning considering the time value of 1194 NOK.

The consolidated fuel cost of the other three bringers that made planned trips was 274 NOK, with a consolidated reward of 2450 NOK. The consolidated operating earnings were 2177 with an average operating income of 726 NOK per bringer. The earnings with time value were 1578, or on average 526 NOK per trip were the earnings with time value for these bringers. (Appendix no. 8)

Type of Trip	Orders	AED (Km)	Bringer Reward (NOK)	Fuel Cost (NOK)	Operational Earnings (NOK)	Earnings with Time value (NOK)
Dedicated	1	478	500	240.1	260	-1194
Planned	3	201	2450	273.5	2176.5	1578.3
Grand Total	4	679	2950	513.6	2436.4	384.4

Table 23 Earnings of Bringers as Companies

Cost to User

Crowdshipping was more economical alternative cumulatively for all orders when compared to Scenario 1, for bringers as companies. Crowdshipping was a cheaper alternative cumulatively for orders with volumetric weight more than 100 kgs. For less than 100 kgs, scenario 2 for private individuals was cheaper, due to cost effective options offered by postal services for lighter goods and the absence of pickup and delivery to senders and recipients location. (Appendix no. 9)

Volumetric Weight (Kg)	Orders	Delivery Distance	CS Cost (NOK)	S1 Cost (NOK)	S2 Cost (NOK)
51	1	429	900	1790	378
55	1	462	1060	1824	378
114	1	492	1200	2489	2489
136	1	461	670	2802	2802
Grand Total	4	1844	3830	8905	6047

Table 24 Cost to user for deliveries by companies

5.5 Summary of findings

The findings of the case company's P2P platform present a high demand from 5398 users wanting to send 10,683 orders in a 6-month period. Out of these, 4287 orders which were about 40% of the total orders were accepted by 299 bringers who delivered them. On an average, each bringer delivered 14 orders. Majority of the users requested deliveries to be made within a week after pickup with 43% wanting same day delivery. The average number period for order fulfillment was about 7 days, right from user posting an order query to the bringer delivering to the recipient. The average delivery distance was 339 km, indicating long distance deliveries. Items to be delivered were mostly between size 3 and 5, indicating items that could fit in a car or a small truck with an average weight of 59 Kg. The pickup and delivery requests covered whole of Norway with higher demand from big cities. The average cost to deliver an item was 1107 NOK which was proportional to the size of the item to be delivered with large items costing more and vice versa in most observations. The above summary of findings of transaction data shows how CS platform of case company, complements the freight transport sector. These findings reflect upon the first proposition showing the viability of the crowd shipping and address the first research question.

The survey undertaken to collect missing behavioral attributes and variable data on bringers and, support our assumptions, was responded by 17 valid bringers out of which 4 were companies. It was observed that 13 out of 17 respondents had a trip already planned, prior to accepting the delivery order. The remaining 4 respondents made dedicated trips to earn extra income. Most of the respondents were willing to detour or drive for a dedicated trip between 10 to 100 km.

The in-depth assessment of emissions and finances was performed on a sample of 64 drivers who delivered 102 orders. In the emission evaluation it was found, during their trips to deliver the orders, the bringers who had a planned trip, detoured 73.5 km per trip generating 9 kg of emission whereas the bringers that made a dedicated trip for the orders, travelled 341 km, generating 77 kg of emissions per trip. The aggregate of additional emission distance by all the bringers of the sample were 107 km emitting 17 kg of carbon equivalent emissions. 14% of the bringers used electric vehicles, 3% used hybrid while the remaining 83% used hydrocarbon fuelled vehicles. On comparing these crowdshipping deliveries with two different scenarios of 3PL service providers, it was found that 7% additional emissions would have been generated if a postal company would have been used in scenario 1 for business users or 44% additional emissions would have been generated in scenario 2 for private individuals using 3PL service providers. Similarly, the bringers who were companies, out of the case boundaries, generated 1% and 36% lower emissions when compared with scenario 1 and 2 respectively. These findings reflect upon the second proposition demonstrating crowdshipping generates less emission than other 3PL service providers while transporting goods over long distance and address the second research question.

In the financial assessment, it was found that each Bringer on an average received a reward of 1114 NOK for their planned trip whereas those who made a dedicated trip received 1826 NOK per trip. The operational earnings calculated by deducting the fuel cost was 1060 NOK and 1349 NOK per bringer for their respective planned or dedicated trips. The earnings with time value however revealed the bringers who delivered on planned trips received 854 NOK per trip and those bringers who made dedicated trips, earned 408 NOK each trip. The bringers who were registered as companies, outside the case study boundary, also showed similar findings with the bringer making dedicated trip lost 1194 NOK whereas those making planned trips made 526 NOK per trip, considering the time value. Cost to user on the CS platform was compared with two scenarios, one of postal service for business users (S1) and the other of 3PL service provider for private individual users. For lighter items with volumetric weight less than 100 kg, scenario 2 costed less than CS and scenario 1 whereas for all the items with volumetric weight more than 100 kg, CS costed less than scenario 1 and 2. These findings reflect upon the third proposition demonstrating that crowdshipping is more economical for senders wanting to deliver a package compared to other 3PL services and is beneficial to bringers as well who are delivering the package, thus also addressing the third research question.

Chapter 6 Discussion

In the case company's CS platform, the concept of crowdshipping which is based on extra social capacity (in private cars) can be seen at work. Out of the sample investigated, it was seen most of the bringers were crowd that had planned trips and used their excess capacity for delivering goods on or off their way (detour). The platform complemented the freight transport sector by delivering packages over long distances, primarily medium to large in size, something that could fit in a car to a small truck in less than a weeks' time from the date of request. Most of the users expected the goods to be delivered within two days of pickup, and actual delivery statistics revealed that the goods were delivered within two days on average, indicating that the delivery time expectations were met on average and the delivery performance may be deemed reliable. With larger goods delivery being requested more, the platform can be deemed as more appealing for freight transport, primarily furniture, household appliances, automotive components along with other type of items.

The platform did not require users to specify the actual weights and dimensions of the packages, which made emission calculations complicated, given how essential these variables are for estimating them. However, this could be the case company's way of simplifying user experience by letting them fill the size closest to their item to be delivered compared to postal services and other 3PL service providers which need accurate dimensions and weight requirements. According to the findings, case company's CS platform had users and bringers from all over Norway, covering cities, towns and rural areas. However, the heat map shows that they are more prevalent in the southern part of the country and mostly around urban areas. These could be attributed to densely populated areas having large number of crowds moving from one city to another and similarly higher number of users, wanting to send packages.

Emission assessment revealed that the postal services and other 3PL service providers produced more emissions than the CS platform. This could be because of the detour distance on the CS platform being significantly less than the delivery distance, along with the use of electric vehicles that led to lower emissions than in scenario 1 and 2. The price levels quoted by the users were such that they were not sufficient to make dedicated long trips without consolidating orders. This discouraged dedicated trips and it is evident from the number of planned and dedicated trips.

Planned long distance trips were better incentivized considering added fuel cost and time value and led to lower emissions.

Although the postal services and most of the 3PL service providers have efficient operations because of load consolidation leading to high-capacity utilization, they still produced higher emissions when transporting large items (in terms of volumetric weight), and when having longer first mile and last mile deliveries. However, postal services have goals of making their last mile electric by 2030 in accordance with government policies (The Government , 2017) making them even more sustainable. For CS to compete with these, it would require not only better matching leading to smaller detours, but also higher ratios of electric cars used by bringers, it is also achievable considering that Norway already has the highest proportion of electric cars per capita than any other country in the world and has positive future goals in this regard such as making all new sales of passenger cars to be zero-emission only, by 2025. (The Government, 2021)

These findings show that the CS's emission factor is largely dependent on individual bringer's behavior, having a planned trip or making dedicated trips, the detour distances, vehicles used and size of the items. The bringer's detour distance, which directly affects emission, can be lowered by matching the bringers planned trips with the orders, as opposed to the existing algorithms of matching the orders with the bringers.

From financial assessment, all bringers had an incentive to be a part of the CS platform because they made significant earnings through it or else were able to pay partly or fully for their already planned trips in terms of their fuel expenses. However, when their time value was considered, few bringers had negative earnings, indicating that bringers valued their time differently or it was a possibility that they did not consider their time value while delivering the items. The cost to user showed that CS was a more cost-effective option for users when compared to postal services for items weighing more than 35 kgs. However, if the items weighed less than 35 kg, Scenario 2 was seen as more cost-effective wherein the user used a postal delivery service without pickup and home delivery, which could be seen as an inconvenience.

The data collected and findings reveal details about service level attributes of transporting packages through CS platform. Convenience of deciding pickup and drop location, flexibility of pickup and delivery time, zero or very low packaging cost and same day or next day delivery of picked up items, can be considered to make CS very attractive to users. There is additional research required to explore, study and present findings in service levels of CS.

Lastly having companies registered on the case company's crowdshipping platform are essential as volume of users are higher, while the active bringers are lesser in number, and until a minimum viable population of crowd is reached, the CS platform might not function appropriately on its own. Thus, apart from user-initiated cancellations, a low number of active bringers is viewed as one of the possible reasons for order cancellation. With a large geographical network and high demand, ratio of bringers needs to be increased. And with the CS in nascent stages, with the right policies and business model, the bringer to user ratio would need to be improved for the platform to be able to operate without companies as bringers (Rai, et al., 2017).

Chapter 7 Research Conclusion

7.1 Conclusion

The purpose of this study was to thoroughly describe how current crowdshipping practices complement freight transportation, as well as their economic and environmental implications.

Crowdshipping is a sharing economy concept that is currently in its early stages but is thought to have enormous potential. It enables the delivery of goods in a sustainable manner by allowing individuals to transport goods on already planned trips.

This study examined at Norway's only crowdshipping platform and performed a descriptive study on its data. Norway, as a long and narrow country with a densely populated southern region, might be viewed as a challenging geography for goods transportation. It is, nonetheless, an ideal location for crowdshipping, with around 510 passenger automobiles per thousand residents and very low passenger occupancy rates.

The research questions served as the research's blueprint. A descriptive analysis was conducted to determine how present crowdshipping practices are complementing freight transportation. It was found that users covered the entire Norwegian territory in terms of orders and delivery. Most of the activity, however, was centered near cities and to the south. The goods were delivered in a short amount of time and mostly within the user's specified delivery range. There were 5398 active senders. However, there were only 299 active bringers which resulted in imbalance between demand and supply on the CS platform over the last six months. During the six-month period under study, the platform accepted all types of goods with varying dimensions and weights, ranging from 400 grams to 5000 kgs.

The environmental impact of crowdshipping revealed that, as compared to its alternatives, CS has a positive impact on the environment and generated lesser emissions. However, the emissions were affected by factors such as the weight of the items and in particular, the detour distance. Even though the incentive for intercity orders was insufficient to motivate the bringer to make a dedicated trip, there were few bringers making dedicated trips to earn extra income. On the planned trips, the reward still motivated the bringers to make detours since the bringers either earned money or covered a portion of their already planned trips after making detours. In terms of environmental impact, the detour distance was decisive along with the vehicle type.

Crowdshipping provides a more flexible option to its users since there are fewer restrictions on allowable weights, dimensions, packaging, and so on. It was also seen as a more cost-effective option for heavier items when compared to scenarios where the same pick and drop service was provided by a 3PL provider such as a transporter or postal service. It is also considered as cost-effective from the perspective of the bringers since they either earn money or cover a portion of their already planned trips by engaging in crowdshipping.

Based on the research findings, all the three propositions are approved. From the findings on demand and supply and operations along with the insights discussed, it can be said that crowdshipping is a viable mode for freight transportation in Norway. It generates lesser emissions than the other 3PL service providers mentioned in the paper. It is a cost-effective delivery solution for its users and economically beneficial for its bringers. Similarly, the paper attempts to answer all the three research questions. It can be concluded that crowdshipping has potential and substantially complements the freight transportation industry. The findings also support that goods transported over long distances using crowdshipping, generate lesser emissions than 3PL service providers and have positive economic implications on its users.

7.2 Limitations

Although we are confident in the findings of this research, a major constraint of this research is the novelty of the concept. Since there is no previous research to which we can compare our findings, we cannot imply that these findings are applicable to other crowdshipping platforms in different settings and worlds.

Other limitations of this research were lack of certain crucial information regarding the weight and dimension of the delivered goods. These were determined based on the item's description and taken from e-commerce websites.

The planned and dedicated trips are considered based on the assumption that if the bringer earns higher than 188 NOK per hour, they would be willing to make a dedicated trip. However, this is a limitation of this research because most of the bringers have their own time value. It is unlikely that the bringers would be willing to make a dedicated trip for less than 188 NOK per hour, considering the total cost of the trip from origin to destination, and all other expenses. This is a limitation as time value is different for everyone. A bringer could make a dedicated trip for lower earnings with them perceiving their time value accordingly. Similarly, a bringer might not make dedicated trips if they consider their time value higher. However, it was observed that individuals who made dedicated trips earned 293 NOK per hour on average after deducting fuel costs, which indicated a higher reward as incentive for the bringers making such trips. This makes our emission assessment conservative with possibly more bringers making planned trips, thereby reducing emissions even further (appendix no.10).

The trips with more than two orders consolidated were still considered planned based on the 188 NOK/hr assumption. However, it can be argued that the number of consolidated orders is higher and should not be considered as planned trips but considering the driving time on these trips in relation to the total earnings (only including fuel cost), they earned on average 103 NOK per hour (appendix no.11), making it difficult to assume these as dedicated trips. Additional study can be undertaken by collecting primary data from the crowd on their genuine motivation for the trips, as well as their actual origin and destination.

Another limitation was the use of the parameters for the train ratio of postal services, which was assumed to be 15% of the total, with 63% being electric and 37% being diesel based on literature. However, the ratios differ depending on the postal service as well as the regions in Norway, with the south having a higher proportion of electric trains than the north. Future research accurately mapping the train percentages for postal services is recommended to better assess the environmental impact of crowdshipping, as postal service emissions are used as a benchmark for this assessment.

The commercial vehicles and their load factors considered for scenarios 1 and 2 were of standard vehicles taken were from data collected from literature and a postal company. Postal companies and 3PL service providers, however, would have their own dedicated fleet operating with its respective load factor affecting the emission assessment. Similarly, the mix of type of modal transport of trucks and vans on roads and electric and diesel trains on rail, would differ between postal companies and 3PL service providers.

Due to a lack of primary data, the cost to the user in scenario 2 is based on postal service costs. Therefore, further investigation into this is recommended, focusing on smaller regions and obtaining primary data from transporters operating in those locations. The 80-20 percentage ratio for the scenario 2 is based on the network of a large postal service provider. However, because each transporter has its own network, changes in these percentages may have an impact on the emissions findings. Nevertheless, it is probable that the last mile distance which generates the most emissions, will be increased. The cost of a standard car to transport goods from the pickup location to the service point in Scenario 2 was ignored considering it to be negligible. From the Scenario 2 perspective further research is recommended focusing on smaller regions, obtaining primary data from transporters operating in those locations to calculate and compare the emission and cost outcomes in more precise manner.

7.3 Future research

Future aim and possibly an important addition to research would be to map the resulting greenhouse gas emissions as fully as possible. This would include not only direct emissions during the journey but also indirect emissions from upstream and downstream processes. The upstream processes include the processing and provision of fuel or electricity, as well as the production of the vehicle. The downstream processes include the regular maintenance of the vehicle and its disposal, as well as the provision of the necessary infrastructure (roads, petrol stations, etc.). Platforms like Myclimate or Mobitool that use high-quality data for sustainability assessments to calculate the total emissions including the indirect emissions could be used for a more comprehensive comparison in future.

Further research is also recommended to examine the behavior of all platform users, including their reason for using the platform, identifying patterns in their behaviors and on other issues such reasons for order cancellation. A similar analysis of bringers and their motivation can indeed be helpful to provide insights into how the number of active bringers can be increased. Further research on crowdshipping platforms is also recommended in order to improve the matching algorithms to reduce detours.

The findings of this study are case specific; further research is recommended to generalize the findings using multiple case study techniques, including a different geographical location to assess the environmental and financial impact.

This study has conducted an in-depth analysis of individual bringers while only providing a brief analysis of the behavior of bringers registered as companies. Further research is highly recommended to analyze the behavior of these companies in detail to identify whether these companies have a similar positive influence since the overall impact of the crowdshipping platform is dependent on both individual and company bringers registered on the platform.

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Appendix

Appendix 1

Bringers excluded from transactional data for environmental assessment.

S/n	Reason for exclusion
1	Used from survey responses
2	Used from survey responses
3	Used from survey responses
4	Used from survey responses
5	Used from survey responses
6	Pickup date issue (two pickups same time, actual distance 4hrs)
7	Pickup date issue (two pickups same time, actual distance 37mins)
8	Pickup date issue (two pickups in 10 mins, actual distance 3 hrs)
9	Pickup date not available (last delivery combined, only bought date of one order available)
10	No origin or destination near pickup or delivery point
11	No origin or destination near pickup or delivery point
12	No origin or destination near pickup or delivery point
13	No origin or destination near pickup or delivery point
14	No origin or destination near pickup or delivery point
15	No origin or destination near pickup or delivery point
16	No origin or destination near pickup or delivery point

17	Nimber
18	Intracity
19	Intracity
20	Intracity
21	Intracity
22	Intracity
23	Intracity
24	Intracity
25	Intracity
26	International
27	Car info missing- just mentioned size 4
28	Car info missing- just mentioned size 4
29	Car info missing- just mentioned size 4
30	No origin or destination near pickup or delivery point
31	Address na, address in Denmark
32	Address na

Appendix 2

<u>Survey questionnaire</u>

Nimber's Sustainability Assessment Form

1. What was your primary reason to travel while completing the last delivery?

(Nimber helps you earn an extra source of income and works towards reducing number of vehicles on the road. About your last trip: was your trip planned for a reason other than earning an extra income? Select the reasons below or select just to earn extra income)

- To earn extra income
- Meet friends and/or family
- Work/ Business
- Leisure/ Tourism
- Other:

2. What was your starting point before the 1st pickup (mention city or postcode)

____

3. What was your end destination after the last delivery (mention city or postcode)

____

4. How many Kilometers are you willing to detour (travel extra) from your original planned trip? (Total number of kilometers for all pickups and deliveries in one trip)
    - Less than 10
    - 10-50
    - 51-100

- 101-200
- More than 200

5. What is your Vehicle model and year? *

____

6. Considering all your trips completed using the Nimber platform, would you still have travelled and done most of those trips without Nimber?

(For example: You might use Nimber while making trips for some personal or business work and you probably would have done those trips without a platform like Nimber. In that case answer YES. But if you generally use Nimber **just** to earn an extra income and you probably would not do those trips without a platform like Nimber, answer NO)

- Yes
- No

Appendix 3

Inter-city, last mile distances assumption calculations

Order Nr.	Pickup-terminal distance	terminal	Terminal to Terminal Distance	Terminal	Terminal-delivery distance
1	9	trondheim	279	alesun	5
2	6	alesun	98	andalsnes	121
3	57	styrn	151	andalsnes	61
4	5	trondheim	711	Bodo	138
5	2	stienkjer	788	harstad	4
6	87	sandnes	87	haugesund	26
7	8	oslo	139	larvik	11
8	14	kristiandsand	199	larvik	16
9	17	oslo	955	mo I rana	89
10	4	Drammen	52	oslo	12
11	12	trondheim	232	otta	55
12	29	stokmarknes	665	Post Nord Alta	138
13	3	kongsvinger	122	ruds fltata	27
14	4	oslo	139	ruds fltata	56
15	9	kristiandsand	226	sandnes	13
16	3	Bergen	219	sandnes	15
17	7	Drammen	317	songdal	116
18	49	Bergen	226	stavanger	8
19	14	trondheim	131	stienkjer	33
20	14	trondheim	927	stokmarknes	60
21	28	Bergen	292	styrn	57
22	63	Drammen	1782	tromso	97
23	75	stienkjer	131	trondheim	36
24	4	Bergen	104	voss	62
25	4	alesun	0	alesun	61
26	13	trondheim	279	alesun	16
27	14	trondheim	279	alesun	4
28	137	trondheim	279	alesun	12
29	10	ruds fltata	390	alesun	23
30	21	ruds fltata	390	alesun	10
31	5	oslo	528	alesun	10
32	8	oslo	528	alesun	20

1807	123	oslo	475	trondheim	40
1808	123	oslo	475	trondheim	14
1809	244	mo I rana	484	trondheim	13
1810	6	Drammen	523	trondheim	14
1811	14	Drammen	523	trondheim	19
1812	16	Drammen	523	trondheim	13
1813	17	Drammen	523	trondheim	14
1814	21	Drammen	523	trondheim	31
1815	23	Drammen	523	trondheim	20
1816	21	larvik	610	trondheim	46
1817	32	larvik	610	trondheim	14
1818	63	larvik	610	trondheim	9
1819	130	larvik	610	trondheim	11
1820	41	larvik	610	trondheim	9
1821	2	Bergen	615	trondheim	14
1822	2	Bergen	615	trondheim	17
1823	2	Bergen	615	trondheim	14
1824	12	Bergen	615	trondheim	13
1825	89	Bodo	712	trondheim	15
1826	66	haugesund	731	trondheim	17
1827	51	kristiandsand	807	trondheim	11
1828	2	sandnes	911	trondheim	15
1829	5	sandnes	911	trondheim	14
1830	15	sandnes	911	trondheim	14
1831	18	sandnes	911	trondheim	18
1832	81	stokmarknes	927	trondheim	108
1833	27	Bergen	104	voss	90
1834	17	gol	188	voss	29
1835	37	sandnes	290	voss	8
1836	17	ruds fltata	352	voss	4
1837	13	oslo	366	voss	69
1838	14	oslo	366	voss	90
1839	28	oslo	366	voss	92
1840	30	oslo	366	voss	46
1841	83	oslo	366	voss	14
1842	33	larvik	384	voss	7
1843	28	trondheim	516	voss	14
	57205		450171.4		52009
	10.226%		**80.476%**		**9.298%**
			559385.4		

Appendix 4

Crowd Shipping and alternate scenario comparisons for individual bringers.

Bringer	Transport Fulfillment	Vehicle	Additional Emission Distance	Actual weight	Volumetric weight	Number of orders combined	Detour Emissions	Total CS Emissions	Scenaro1 Emissions (S1)	Emissions Difference	Scenaro2 Emissions (S2)	Emissions Difference
1	Planned	HC	52	5.0	5.0	1.0	12.0	12.0	0.4	11.7	1.9	10.2
2	Planned	HC	46	13.5	174.0	1.0	12.0	12.0	7.4	4.6	11.3	0.7
3	Planned	HC	16	10.0	54.0	1.0	4.2	4.2	3.7	0.5	5.7	-1.5
4	Planned	HC	5	14.0	16.0	1.0	1.1	1.1	0.9	0.2	1.4	-0.3
5	Planned	HC	11	22.5	180.0	1.0	2.8	2.8	10.9	-8.1	16.5	-13.8
6	Planned	HC	22	370.0	2525.0	1.0	5.3	5.3	89.9	-84.6	115.1	-109.8
7	Planned	HC	13	59.0	107.0	2.0	4.8	4.8	7.9	-3.1	9.8	-5.0
8	Planned	HC	195	14.0	42.0	1.0	40.3	40.3	3.5	36.9	4.1	36.3
9	Planned	HC	14	1.5	2.0	1.0	3.4	3.4	0.1	3.3	0.7	2.7
10	Planned	HC	10	40.0	112.0	1.0	2.0	2.0	3.3	-1.2	3.8	-1.8
11	Planned	HC	11	20.0	476.0	1.0	2.1	2.1	52.7	-50.7	82.3	-80.2
12	Planned	HC	10	250.0	305.0	2.0	2.6	2.6	18.7	-16.0	25.9	-23.3
13	Planned	HC	14	3.0	5.0	1.0	2.9	2.9	0.1	2.7	2.0	0.9
14	Planned	HC	172	15.0	54.0	1.0	36.2	36.2	1.2	35.1	1.7	34.5
15	Planned	HC	4	10.0	28.0	1.0	0.8	0.8	1.4	-0.5	4.9	-4.1

16	Planned	HC	10	65.0	186.0	2.0	2.9	2.9	7.9	-5.0	10.1	-7.2
17	Planned	HC	6	28.0	175.0	1.0	1.0	1.0	9.2	-8.1	11.4	-10.4
18	Planned	HC	2	20.0	48.0	1.0	0.3	0.3	7.1	-6.8	11.0	-10.7
19	Planned	HC	11	2.1	2.0	1.0	3.1	3.1	0.1	3.0	0.5	2.6
20	Planned	HC	10	13.0	120.0	1.0	1.7	1.7	3.6	-1.8	63.4	-61.6
21	Planned	HC	77	120.0	89.0	2.0	8.9	8.9	5.3	3.7	8.2	0.8
22	Planned	HC	69	18.0	27.0	1.0	20.1	20.1	1.7	18.3	5.6	14.4
23	Planned	HC	40	149.0	230.0	2.0	8.1	8.1	31.4	-23.3	40.2	-32.1
24	Planned	HC	2	770.0	2766.0	2.0	0.5	0.5	156.7	-156.3	221.7	-221.2
25	Planned	HC	61	128.0	274.0	3.0	17.9	17.9	10.8	7.0	16.0	1.8
26	Planned	HC	6	20.0	20.0	1.0	1.4	1.4	0.8	0.6	1.3	0.2
27	Planned	HC	41	74.0	235.0	2.0	7.7	7.7	13.7	-6.0	20.2	-12.5
28	Planned	HC	75	80.0	360.0	1.0	17.6	17.6	19.6	-2.0	28.4	-10.8
29	Planned	HC	51	60.0	120.0	1.0	9.6	9.6	16.1	-6.4	18.7	-9.1
30	Planned	HC	25.7	20.0	35.0	1.0	6.8	6.8	0.6	6.2	1.0	5.8
31	Planned	HC	25	5.0	13.0	1.0	3.0	3.0	0.5	2.5	1.2	1.7
32	Planned	HC	34	5.2	16.0	2.0	8.4	8.4	1.0	7.4	1.8	6.6
33	Planned	HC	38	15.0	36.0	1.0	4.0	4.0	0.5	3.5	1.0	3.1
34	Planned	HC	93	30.0	114.0	1.0	15.7	15.7	2.5	13.3	51.5	-35.8
35	Planned	HC	11	16.8	110.0	2.0	1.7	1.7	6.7	-5.0	7.5	-5.9
36	Planned	HC	30	75.0	230.0	1.0	5.6	5.6	12.9	-7.3	20.4	-14.8

37	Planned	Electric	5	10.0	60.0	1.0	0.0	0.0	3.6	-3.6	5.0	-5.0
38	Planned	HC	5	215.0	661.0	2.0	1.1	1.1	39.3	-38.2	51.2	-50.1
39	Planned	HC	8	25.0	207.0	1.0	1.5	1.5	14.6	-13.1	19.9	-18.5
40	Planned	Electric	4	20.0	28.0	1.0	0.0	0.0	0.9	-0.9	1.4	-1.4
41	Planned	HC	31	52.0	361.0	1.0	7.2	7.2	20.2	-13.0	31.9	-24.7
42	Planned	HC	8	730.0	3895.0	1.0	0.9	0.9	284.4	-283.5	423.3	-422.4
43	Planned	HC	37	167.0	394.0	2.0	9.8	9.8	24.3	-14.5	34.5	-24.7
44	Planned	HC	213	66.0	202.0	3.0	43.0	43.0	11.6	31.5	14.0	29.1
45	Planned	Electric	4	10.0	41.0	1.0	0.0	0.0	1.8	-1.8	2.3	-2.3
46	Planned	HC	6.8	30.0	114.0	1.0	0.8	0.8	3.6	-2.9	34.6	-33.9
47	Planned	hybrid	105	143.0	157.0	2.0	5.6	5.6	11.0	-5.4	15.6	-10.0
48	Planned	Electric	72	76.0	76.0	1.0	0.0	0.0	4.5	-4.5	5.0	-5.0
49	Planned	HC	80	40.0	88.0	1.0	3.4	3.4	3.8	-0.4	3.6	-0.2
50	Planned	Electric	6	0.3	1.0	1.0	0.0	0.0	0.0	0.0	1.9	-1.9
51	Planned	Electric	57	3.0	10.0	1.0	0.0	0.0	0.3	-0.3	1.3	-1.3
52	Dedicated	HC	117	85.0	389.0	2.0	0.0	24.3	12.5	11.8	15.0	9.3
53	Planned	HC	33	118.0	3228.0	1.0	6.6	6.6	60.4	-53.8	58.3	-51.8
54	Dedicated	Electric	396	98.0	333.0	1.0	0.0	0.0	19.1	-19.1	25.0	-25.0
55	Dedicated	Electric	65.4	10.0	14.0	1.0	0.0	0.0	0.2	-0.2	2.9	-2.9

56	Planned	hybrid	1757	183.1	841.0	8.0	82.1	82.1	30.9	51.2	107.2	-25.1
57	Planned	Electric	104.3	28.0	175.0	1.0	0.0	0.0	6.2	-6.2	6.8	-6.8
58	Dedicated	HC	1277	508.0	922.0	7.0	0.0	341.1	52.2	288.9	57.5	283.6
59	Planned	HC	226.3	213.0	635.0	5.0	56.6	56.6	37.8	18.8	53.8	2.8
60	Planned	HC	42	128.8	346.0	4.0	5.7	5.7	16.2	-10.5	63.2	-57.5
61	Dedicated	HC	114	102.6	191.0	2.0	0.0	32.9	2.3	30.6	33.1	-0.2
62	Dedicated	HC	174	70.0	484.0	1.0	0.0	50.6	9.9	40.6	46.6	4.0
63	Dedicated	HC	374	69.0	251.0	1.0	0.0	106.6	11.3	95.2	13.8	92.8
64	Dedicated	HC	211	108.0	360.0	1.0	0.0	59.2	10.4	48.9	40.1	19.2

Appendix 5

Earning by bringers (Individuals)

Bringer	Transport Fulfillment	Fuel Cost	Earnings	Earnings with Time value
1	Planned	64.1	35.9	**-135.8**
2	Planned	96.2	243.8	130.8
3	Planned	25.7	524.3	483.7
4	Planned	7.7	482.3	467.3
5	Planned	14.4	545.6	517.4
6	Planned	42.8	557.2	501.5
7	Planned	17.4	1562.6	1525.4
8	Planned	177.6	402.4	**-88.0**
9	Planned	17.8	212.2	175.4
10	Planned	23.7	476.3	452.0
11	Planned	16.3	1513.7	1480.1
12	Planned	14.8	2025.2	1998.6
13	Planned	10.7	129.3	86.0
14	Planned	211.5	168.5	-308.9
15	Planned	5.0	415.0	405.7

16	Planned	38.0	1982.0	1949.2
17	Planned	5.8	594.2	579.3
18	Planned	2.1	1997.9	1991.4
19	Planned	14.6	645.5	615.8
20	Planned	5.7	564.3	538.3
21	Planned	74.9	1815.1	1587.8
22	Planned	94.1	665.9	505.7
23	Planned	49.4	2660.6	2556.0
24	Planned	3.4	1196.6	1190.6
25	Planned	80.2	1489.8	1322.7
26	Planned	10.0	690.0	676.4
27	Planned	53.6	1536.4	1429.6
28	Planned	90.2	1139.8	924.0
29	Planned	38.3	1461.7	1322.1
30	Planned	36.3	183.7	98.8
31	Planned	18.9	431.2	368.7
32	Planned	42.3	847.7	763.3
33	Planned	32.6	227.4	125.3
34	Planned	115.5	304.5	**-37.8**
35	Planned	7.2	892.8	864.8
36	Planned	27.2	1202.8	1112.2

37	Planned	1.4	298.6	286.9
38	Planned	5.6	3374.4	3359
39	Planned	6.7	1493.3	1470.4
40	Planned	1.6	448.4	437.5
41	Planned	35.8	1944.2	1853.1
42	Planned	8.6	2051.4	2031.5
43	Planned	59.1	2640.9	2529.0
44	Planned	181.1	1518.9	905.5
45	Planned	1.7	498.3	484.1
46	Planned	6.4	343.6	323.0
47	Planned	46.1	953.9	617.8
48	Planned	19.8	580.2	360.8
49	Planned	70.1	669.9	368.3
50	Planned	1.8	278.2	230.3
51	Planned	31.2	308.8	122.8
52	Dedicated	145.5	970.0	591.8
53	Planned	34.5	865.5	729.5
54	Dedicated	166.5	1838.0	1031.8
55	Dedicated	19.5	278.5	94.3
56	Planned	596.2	3033.8	**-1584.3**
57	Planned	32.6	467.4	176.7

58	Dedicated	2184.2	4035.8	404.3
59	Planned	319.5	3490.5	2787.7
60	Planned	28.3	2251.7	2144.6
61	Dedicated	192.8	807.2	396.7
62	Dedicated	188.4	801.6	337.8
63	Dedicated	568.6	1431.4	303.4
64	Dedicated	382.5	627.5	104.2

Appendix 6

Cost to user (Individual bringers)

Bringer	**Number of orders combined**	**Delivery Distance**	**Consolidated CS Cost**	**Consolidated S1 Cost**	**Cost Difference**	**Consolidated S2 Cost**	**Cost Difference**
1	1,0	189	200	1967	90 %	278	28 %
2	1,0	320	500	2845	82 %	2845	82 %
3	1,0	602	760	1679	55 %	1679	55 %
4	1,0	465	680	761	11 %	378	**-80 %**
5	1,0	492	750	3075	76 %	3075	76 %
6	1,0	338	820	26594	97 %	26594	97 %
7	2,0	1317	2050	3995	49 %	2008	**-2 %**
8	1,0	494	800	1987	60 %	378	**-112 %**
9	1,0	165	360	411	12 %	129	**-179 %**
10	1,0	184	690	2269	70 %	1032	33 %
11	1,0	849	1800	8958	80 %	8958	80 %
12	2,0	1126	2590	6361	59 %	6361	59 %
13	1,0	136	250	420	40 %	278	10 %
14	1,0	108	540	1485	64 %	229	**-136 %**
15	1,0	253	600	1072	44 %	258	**-133 %**
16	2,0	365	2520	4313	42 %	3303	24 %
17	1,0	397	820	2864	71 %	2864	71 %

18	1,0	1210	2420	2702	10 %	2702	10 %
19	1,0	287	900	411	-119 %	129	**-598 %**
20	1,0	569	780	2435	68 %	2435	68 %
21	2,0	1044	2420	3131	23 %	1425	**-70 %**
22	1,0	272	1000	1136	12 %	229	**-337 %**
23	2,0	1182	3290	6121	46 %	4296	23 %
24	2,0	378	1600	25910	94 %	25910	94 %
25	3,0	599	2180	5047	57 %	3093	30 %
26	1,0	210	940	828	-14 %	229	**-310 %**
27	2,0	565	2000	5130	61 %	3811	48 %
28	1,0	403	1500	6590	77 %	6590	77 %
29	1,0	817	1830	3106	41 %	3106	41 %
30	1,0	53	350	1272	72 %	229	**-53 %**
31	1,0	231	610	684	11 %	129	**-373 %**
32	2,0	269	1210	1045	-16 %	258	**-369 %**
33	1,0	102	380	1288	70 %	229	**-66 %**
34	1,0	90	600	2419	75 %	2419	75 %
35	2,0	490	1170	3381	65 %	516	**-127 %**
36	1,0	459	1500	3448	56 %	3448	56 %
37	1,0	338	440	1934	77 %	378	**-16 %**
38	2,0	917	4140	10446	60 %	6135	33 %
39	1,0	529	1830	4579	60 %	4579	60 %

40	1,0	325	630	1076	41 %	258	**-144 %**
41	1,0	481	2380	5025	53 %	5025	53 %
42	1,0	548	2500	42811	94 %	42811	94 %
43	2,0	460	3390	5643	40 %	4661	27 %
44	3,0	467	2270	5595	59 %	1421	**-60 %**
45	1,0	289	700	1800	61 %	129	**-443 %**
46	1,0	91,2	510	1733	71 %	1733	71 %
47	2,0	495	1400	4279	67 %	1374	**-2 %**
48	1,0	438	800	1941	59 %	916	13 %
49	1,0	127	1000	1651	39 %	1651	39 %
50	1,0	153	400	411	3 %	129	**-210 %**
51	1,0	87	490	422	-16 %	129	**-280 %**
52	2,0	111	1460	4062	64 %	2923	50 %
53	1,0	97	1190	20715	94 %	12516	90 %
54	1,0	333	2400	3842	38 %	3842	38 %
55	1,0	60	420	628	33 %	129	**-226 %**
56	8,0	508	5120	18314	72 %	10109	49 %
57	1,0	58,7	600	1869	68 %	1869	68 %
58	7,0	960	7980	17698	55 %	8619	7 %
59	5,0	481	4930	11721	58 %	6787	27 %
60	4,0	1115	3040	6984	56 %	5240	42 %
61	2,0	104	1390	3359	59 %	3359	59 %

62	1,0	122	1210	3690	67 %	3690	67 %
63	1,0	374	2420	2892	16 %	2892	16 %
64	1,0	211	1260	3157	60 %	3157	60 %

Appendix 7

Crowd Shipping and alternate scenario comparisons for Company bringers.

Bringer	Transport Fulfillment	Vehicle	Additional Emission Distance	Actual weight	Volumetric weight	Orders combined	Detour Emissions	Total CS Emissions	Scenaro1 Emissions (S1)	Emissions Difference (CS – S1)	Emissions Difference	Scenaro2 Emissions (S2)	Emissions Difference (CS- S2)	Emissions Difference
65	Planned	HC	114	18,5	51,0	1	22,4	22,4	4,0	18,3	456 %	7,6	14,7	193 %
66	Dedicated	Electric	478	28,0	136,0	1	0,0	0,0	8,1	-8,1	-100 %	12,4	-12,4	-100 %
67	Planned	Electric	25	20,0	55,0	1	0,0	0,0	3,1	-3,1	-100 %	4,0	-4,0	-100 %
68	Planned	Electric	62	12,0	114,0	1	0,0	0,0	7,4	-7,4	-100 %	10,8	-10,8	-100 %
							Total	22,4	22,7	-0,3	-1 %	34,8	-12,4	-36 %

Appendix 8

Earning by bringers (Companies)

Bringer	Transport Fulfillment	Fuel / Energy Cost	Bringer Reward	Earnings	Earnings with Time value
65	Planned	238,4	660	421,57	78,1
66	Dedicated	240,1	500	259,9	-1193,9
67	Planned	10,1	790	779,9	705,7
68	Planned	25,0	1000	975,0	794,5

Appendix 9

Cost to user (Company bringers)

Bringer	Number of orders combined	Delivery Distance	Consolidated CS Cost	Consolidated S1 Cost	Cost Difference	Consolidated S2 Cost	Cost Difference
65	1	624	900	1790	-50 %	378	-100 %
66	1	478	670	2802	-76 %	2802	-100 %
67	1	513	1060	1824	-42 %	378	-100 %
68	1	646	1200	2489	-52 %	2489	-100 %

Appendix 10

Operational earnings of the dedicated trips (Individuals)

Bringer	Transport Fulfillment	Fuel Cost	Bringer Reward	Earnings	Operational Earnings / Hour
52	Dedicated	145.5	1090.0	970.0	366.1
54	Dedicated	166.5	2000.0	1838.0	356.9
55	Dedicated	19.5	298.0	278.5	257.1
58	Dedicated	2184.2	6220.0	4035.8	208.9
61	Dedicated	192.8	1000.0	807.2	369.7
62	Dedicated	188.4	990.0	801.6	325.0
63	Dedicated	568.6	2000.0	1431.4	238.6
64	Dedicated	382.5	1010.0	627.5	225.4

Appendix 11

Per hour earnings (Excluding time value for induvial bringers, making planned trips while consolidating more than 2 orders)

Bringer	orders combined	Nature	Bringer's Per hour Earnings	Transport Fulfillment
25	3	P2P	73	Planned
44	3	P2P	107.7	Planned
60	4	P2P	95.6	Planned
59	5	P2P	150.5	Planned
56	8	P2P	90.4	Planned
			103.44	

Appendix 12

Alternate scenarios vehicle/mode emission calculation supplements

	load reference	LOAD CAPACITY	CO2	NOX	WEIGHT	NOX CO2 Equivalent	Emissions	Emissions Per KM	Emissions KG PER KM PER KG	WEIGHT <35	WEIGHT >35
LAST MILE 2 (7.5-14T)	from Postal Service (7.5 to 10t) - use case 3	4600	475.00	2.74		816.52	1291.52	1.29152	0.000280765		
INTERCITY (28-40T)	EUROSTAT	15000	940.00	3.24		965.52	1905.52	1.90552	0.000127035	Remaining	INTERCITY ACTUAL
TOG DISEL	IRS-2008/267	1200000	20600	306		91188	111788.00	111.788	9.31567E-05	37% of the 15% of total	
TOG EL									0.00	67% of the 15% of total	
SHORT DISTANCE VAN	TOI Report	100%	191.00	0.64		190.72	381.72	0.38172	0.38172	LAST MILE ACTUAL	

Appendix 13

Scenario 1: Sample calculations

Order	pickup to termi	terminal to termi	terminal delive	total distan	pickup-delivery distance	closet terminal neaer pick	closet terminal neaer deliv	TERMINAL INVOLVE	Actual weigh	3pl WEIGHT	Postal Service Price	Posten Price
246532	3	52	16	71	40.3	Drammen	oslo	2	10	14	628,00	129
264817	9	52	15	76	40.9	Drammen	oslo	2	82.6	104	1 770,00	0
264792	10	52	14	76	45.9	Drammen	oslo	2	20	87	1589	-
247684	23	0	35	58	53.5	oslo	oslo	1	20	35	1272	229
246566	59	0	10	69	59.1	oslo	oslo	1	27	84	1 587,00	448
246546	62	139	13	214	62.5	larvik	oslo	2	58	305	2475	-
242701	23	52	10	85	68.5	Drammen	oslo	2	15	36	1 288,00	229
262940	1	87	13	101	77.2	haugesund	sandnes	2	20	201	3917	-
234444	68	139	5	212	77.6	larvik	oslo	2	28	175	1869	-
272186	6.7	87	26.5	120.2	88	sandnes	haugesund	2	118	3228	20715	12516
265940	98	0	15	113	90.7	oslo	oslo	1	30	114	1 733,00	-
248370	15	139	36	190	101	oslo	larvik	2	30	180	2 369,00	-
249871	49	52	10	111	104	oslo	Drammen	2	15	54	1 485,00	229
262798	11	139	38	188	105	oslo	larvik	2	108	360	3 157,00	-
265471	48	139	10	197	114	larvik	oslo	2	3	10	422,00	129
243385	26	92	12	130	122	Drammen	larvik	2	70	484	3 690,00	-
265576	6.1	139	23	168.1	123	OSLO	ruds fltata	2	56	269	3 884,00	-
263935	36	139	99	274	133	larvik	oslo	2	16	33	1 271,00	448
234044	74	0	73	147	135	kristiandsand	kristiandsand	1	54	193	2 337,00	-
258008	34	94.2	7	135.2	135	stavanger	haugesund	2	30	114	2 419,00	-
249881	12	139	40	191	136	oslo	larvik	2	3	5	420,00	278
266112	41	139	14	194	138	larvik	oslo	2	20	28	1 076,00	258
243239	9	144	9	162	144	Bergen	haugesund	2	0.3	1	411	129
263511	27	104	90	221	160	Bergen	voss	2	40	88	1 651,00	-
266810	33	139	13	185	161	larvik	oslo	2	1.5	2	411,00	129
266410	12	225	62	299	161	Bergen	songdal	2	69	251	2 892,00	-
272293	36	139	16	191	166	ruds fltata	oslo	2	13	120	2 435,00	-
263256	115	0	66	181	167	kristiandsand	kristiandsand	1	15	21	760,00	378
241745	87	87	26	200	178	sandnes	haugesund	2	NULL	0	0	0

Order	First leg	Last Leg	intercity Truck	Train Deis	train elect	First leg	Last Leg	intercity Truck	Train Deise	train electi	Total Emissions
246532	3	16	41.4	3.9	6.7	0.01	0.06	0.07	0.01	0.00	0.15
264817	9	15	40.6	4.2	7.2	0.26	0.44	0.54	0.04	0.00	1.28
264792	10	14	40.6	4.2	7.2	0.24	0.34	0.45	0.03	0.00	1.07
247684	23	35				0.23	0.34	0.00	0.00	0.00	0.57
246566	59	10				1.39	0.24	0.00	0.00	0.00	1.63
246546	62	13	106.9	11.9	20.2	5.31	1.11	4.14	0.34	0.00	10.90
242701	23	10	39.3	4.7	8.0	0.23	0.10	0.18	0.02	0.00	0.53
262940	1	13	71.9	5.6	9.5	0.06	0.73	1.83	0.10	0.00	2.73
234444	68	5	107.2	11.8	20.0	3.34	0.25	2.38	0.19	0.00	6.16
272186	6.7	26.5	69.0	6.7	11.4	6.07	24.02	28.28	2.01	0.00	60.38
265940	98	15				3.14	0.48	0.00	0.00	0.00	3.62
248370	15	36	110.5	10.5	18.0	0.76	1.82	2.53	0.18	0.00	5.28
249871	49	10	35.4	6.2	10.5	0.74	0.15	0.24	0.03	0.00	1.17
262798	11	38	110.8	10.4	17.8	1.11	3.84	5.07	0.35	0.00	10.37
265471	48	10	109.5	10.9	18.6	0.13	0.03	0.14	0.01	0.00	0.31
243385	26	12	72.5	7.2	12.3	3.53	1.63	4.46	0.33	0.00	9.95
265576	6.1	23	113.8	9.3	15.9	0.46	1.74	3.89	0.23	0.00	6.32
263935	36	99	97.9	15.2	25.9	0.33	0.92	0.41	0.05	0.00	1.71
234044	74	73				4.01	3.96	0.00	0.00	0.00	7.97
258008	34	7	73.9	7.5	12.8	1.09	0.22	1.07	0.08	0.00	2.46
249881	12	40	110.4	10.6	18.0	0.02	0.06	0.07	0.00	0.00	0.15
266112	41	14	109.9	10.8	18.3	0.32	0.11	0.39	0.03	0.00	0.85
243239	9	9	119.7	9.0	15.3	0.00	0.00	0.02	0.00	0.00	0.02
263511	27	90	70.9	12.3	20.9	0.67	2.22	0.79	0.10	0.00	3.78
266810	33	13	111.3	10.3	17.5	0.02	0.01	0.03	0.00	0.00	0.06
266410	12	62	180.2	16.6	28.3	0.85	4.37	5.74	0.39	0.00	11.35
272293	36	16	110.4	10.6	18.0	1.21	0.54	1.68	0.12	0.00	3.55
263256	115	66				0.68	0.39	0.00	0.00	0.00	1.07
241745	87	26	57.0	11.1	18.9	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 14

Scenario 2: Sample calculations

(The trucks used by postal service companies have a 3.5-14T capacity. In this research paper, 7.5-14T capacity truck emissions have been considered as per available data)

Less 35 Kg, Single Terminal

																								Less than 35kg(postal services)	
Order	USERPICK TO Service point(POST)	Closet service point(POST) TO TERMIN	TERMINAL TO TERMINAL	TERMINAL TO Closet service point(POST)	Closet service point TO DELIVERY POINT (USER	TOTAL	TRAIN	TRUCK	pickup to terminal	terminal to terminal	terminal delivery	total distance	pickup-delivery distance	closet terminal near pickup	closet terminal near delivery	TERMINAL INVOLVED	Actual weight	3pl WEIGHT	weight	Postal Service Price	Posten Price	COSTTOUSER	ONE TERMINAL	TWO TERMINALS
247684	1	22.1	0	35.2	1	59.3	8.895	-8.895	23	0	35	58	53.5	oslo	oslo	1	20	35	Less than 35	1272	229	229	YES	
246566	5.9	62.2	0	10.8	0.5	79.4	11.91	-11.91	59	0	10	69	59.1	oslo	oslo	1	27	84	Less than 35	1 587,00	448	448	YES	
263256	1	112	0	63.4	3.7	180.1	27.015	-27.015	115	0	66	181	167	kristiandsand	kristiandsand	1	15	21	Less than 35	760,00	378	378	YES	

USER TO DELIVERY POINT	DELIVERY POINT TO TERMINAL	TERMINAL TO TERMINAL	TERMINAL TO PICKUP POINT	PICKUP POINT TO USER		
STANDARD CAR	3.5-14TON	N/A	3.5-14TON	STANDARD CAR		Total Emissions
0.2	0.217171896		0.3459	0.2		0.963074643
1.18	1.466942108		0.25471	0.1		3.001652313
0.2	0.660359791		0.37381	0.74		1.974170602

Less than 35 Kg, 2 terminals

																							Less than 35kg(postal services)	
Order	USERPICK TO Service point(POST)	Closet service point(POST) TO TERMIN	TERMINAL TO TERMINAL	TERMINAL TO Closet service point(POST)	Closet service point TO DELIVERY POINT (USER	TOTAL	TRAIN	TRUCK	pickup to terminal	terminal to terminal	terminal delivery	total distance	pickup-delivery distance	closet terminal near pickup	closet terminal near delivery	TERMINAL INVOLVED	Actual weight	3pl WEIGHT	weight	Postal Service Price	Posten Price	COSTTOUSER	ONE TERMINAL	TWO TERMINALS
264978	1	7	470	2.5	1	481.5	72.225	397.775	7	470	3	480	468	oslo	Bergen	2	38	170	greator than 35	4 306,00	756	756		YES
253688	1	8.4	615	1	1	626.4	93.96	521.04	14	615	1	630	695	trondheim	Bergen	2	23	69	Less than 35	2 365,00	378	378		YES
235597	1	9	440	11.1	1	462.1	69.315	370.685	12	440	12	464	552	oslo	sandnes	2	23	53	Less than 35	1 831,00	378	378		YES
252681	1	18.3	139	83.7	1	243	36.45	102.55	18	139	79	236	202	oslo	larvik	2	20	20	Less than 35	828	229	229		YES
265732	1	19.7	470	7.1	1	498.8	74.82	395.18	20	470	7	497	478	oslo	Bergen	2	36	158	greator than 35	3 053,00	756	756		YES
239089	1	21.2	180	43.6	1	246.8	37.02	142.98	20	180	37	237	196	oslo	gol	2	40	94	greator than 35	1 666,00	656	656		YES
256410	1	23.6	229	94	1	348.6	52.29	176.71	17	229	94	340	291	stavanger	kristiandsand	2	17	41	Less than 35	1 355,00	378	378		YES
253491	1	24.8	229	32.2	1	288	43.2	185.8	23	229	34	286	245	stavanger	kristiandsand	2	2.1	2	Less than 35	411,00	129	129		YES
242701	1	28.2	52	9.3	1	91.5	13.725	38.275	23	52	10	85	68.5	Drammen	oslo	2	15	36	Less than 35	1 288,00	229	229		YES
241434	1	30.2	446	9.2	1	487.4	73.11	372.89	26	446	9	481	472	Bergen	Drammen	2	76	76	greator than 35	1941	916	916		YES
235541	1	32.5	384	13.4	1	431.9	64.785	319.215	33	384	7	424	374	larvik	voss	2	41	110	greator than 35	2 754,00	756	756		YES
257503	1	35	288	53.2	1	378.2	56.73	231.27	35	288	54	377	203	Drammen	kristiandsand	2	8	9	Less than 35	452	129	129		YES
261147	1	41.8	290	13.4	1	347.2	52.08	237.92	37	290	8	335	260	sandnes	voss	2	10	41	Less than 35	1 800,00	129	129		YES
249871	1	49.4	52	20.2	1	123.6	18.54	33.46	49	52	10	111	104	oslo	Drammen	2	15	54	Less than 35	1 485,00	229	229		YES
247211	1	78	336	15	1	431	64.65	271.35	76	336	16	428	254	kristiandsand	oslo	2	0.2	5	Less than 35	420,00	129	129		YES

USER TO DELIVERY POINT	DELIVERY POINT TO TERMINAL	TERMINAL TO TERMINAL			TERMINAL TO PICKUP POINT	PICKUP POINT TO USER		
STANDARD CAR	3.5-14TON	INTERCITY TRUCK	Train disel	train electric	3.5-14TON	STANDARD CAR		Total Emissions
0.2	0.33411061	8.59030647	0.42320631	0	0.119325217	0.2		9.866948608
0.2	0.16273152	4.56711985	0.2234641	0	0.0193728	0.2		5.372688268
0.2	0.13392501	2.49576181	0.1266248	0	0.165174177	0.2		3.32148579
0.2	0.10276007	0.2605481	0.02512715	0	0.470000974	0.2		1.258436293
0.2	0.87390982	7.93184641	0.40746514	0	0.314962421	0.2		9.928183785
0.2	0.55950893	1.70736116	0.11994439	0	1.150688167	0.2		3.937502644
0.2	0.27166842	0.92038013	0.07389553	0	1.082069148	0.2		2.748013235
0.2	0.01392595	0.04720608	0.00297803	0	0.01808128	0.2		0.482191349
0.2	0.28503285	0.17504107	0.01703062	0	0.094000195	0.2		0.971104733
0.2	0.64441233	3.60011672	0.19151643	0	0.19631104	0.2		5.032356519
0.2	1.00373565	4.46065082	0.24563079	0	0.41384793	0.2		6.5238652
0.2	0.08844104	0.26441377	0.01759831	0	0.134430386	0.2		0.904883506
0.2	0.48117543	1.2391876	0.07359876	0	0.15425241	0.2		2.348214203
0.2	0.74896929	0.22953132	0.03450795	0	0.306258699	0.2		1.71926726
0.2	0.10949843	0.17235428	0.01114177	0	0.021057391	0.2		0.71405188

More than 35 Kg, less than 200 km

															More than 35kg(3rd party transporter)			pickup to delivery emission
Order	pickup to terminal	terminal to terminal	terminal delivery	total distance	pickup-delivery distance	closet terminal near pickup	closet terminal near delivery	TERMINAL INVOLVED	Actual weight	3pl WEIGHT	weight	Postal Service Price	Posten Price	COSTTOUSER	Less than 200 (3.5-14TON)	More than 200 (3.5-14TON)		VAN(FULL)
264817	9	52	15	76	40.9	Drammen	oslo	2	82.6	104	greator than 35	1 770,00	0	1770	YES			15.61
264792	10	52	14	76	45.9	Drammen	oslo	2	20	87	Less than 35	1589	-	1589	YES			17.52
262940	1	87	13	101	77.2	haugesund	sandnes	2	20	201	Less than 35	3917	-	3917	YES			29.47
265940	98	0	15	113	90.7	oslo	oslo	1	30	114	Less than 35	1 733,00	-	1733	YES			34.62
248370	15	139	36	190	101	oslo	larvik	2	30	180	Less than 35	2 369,00	-	2369	YES			38.55
262798	11	139	38	188	105	oslo	larvik	2	108	360	greator than 35	3 157,00	-	3157	YES			40.08
243385	26	92	12	130	122	Drammen	larvik	2	70	484	greator than 35	3 690,00	-	3690	YES			46.57
265576	6.1	139	23	168.1	123	OSLO	ruds fltata	2	56	269	greator than 35	3 884,00	-	3884	YES			46.95
234044	74	0	73	147	135	kristiandsand	kristiandsand	1	54	193	greator than 35	2 337,00	-	2337	YES			51.53
258008	34	94.2	7	135.2	135	stavanger	haugesund	2	30	114	Less than 35	2 419,00	-	2419	YES			51.53
272293	36	139	16	191	166	ruds fltata	oslo	2	13	120	Less than 35	2 435,00	-	2435	YES			63.37

More than 35 Kg, more than 200 Km

															More than 35kg(3rd party transporter)	pickup to terminal	terminal to terminal	terminal to delivery		
Order	pickup to terminal	terminal to terminal	terminal delivery	total distance	pickup-delivery distance	closet terminal near pickup	closet terminal near delivery	TERMINAL INVOLVED	Actual weight	3pl WEIGHT	weight	Postal Service Price	Posten Price	COSTTOUSER	More than 200 (3.5-14TON)	3.5-14TON	INTERCITY (28-40T)	3.5-14TON		Total Emissions
261807	14	549	11	574	551	sandnes	oslo	2	10	54	Less than 35	1 679,00	-	1679	YES	0.870	3.959	0.870		5.699
238319	16	313	38	367	337	oslo	songdal	2	25	92	Less than 35	2647	-	2647	YES	0.948	4.312	0.948		6.208
234444	68	139	5	212	77.6	larvik	oslo	2	28	175	Less than 35	1869	-	1869	YES	1.042	4.738	1.042		6.822
235366	15	412	5	432	429	larvik	stavanger	2	50	97	greator than 35	2 396,00	-	2396	YES	1.177	5.352	1.177		7.705
261437	45	375	10	430	340	ruds fltata	trondheim	2	70	100	greator than 35	2 419,00	-	2419	YES	1.207	5.492	1.207		7.906
249894	16	226	13	255	221	kristiandsand	sandnes	2	88	180	greator than 35	2 337,00	-	2337	YES	1.289	5.862	1.289		8.440
270093	25	471	19	515	492	oslo	Bergen	2	12	114	Less than 35	2 489	-	2489	YES	1.648	7.498	1.648		10.795
266119	12	1204	29	1245	1182	alesun	stokmarknes	2	20	48	Less than 35	2 702,00	-	2702	YES	1.678	7.632	1.678		10.988
271255	13	336	4	353	327	kristiandsand	oslo	2	13.5	174	Less than 35	2 845,00	-	2845	YES	1.725	7.845	1.725		11.294
266421	42	275	38	355	319	ruds fltata	larvik	2	28	175	greator than 35	2 864,00	0	2864	YES	1.744	7.934	1.744		11.423
246546	62	139	13	214	62.5	larvik	oslo	2	58	305	greator than 35	2475	-	2475	YES	1.833	8.336	1.833		12.001
240921	11	471	13	495	455	oslo	Bergen	2	28	136	Less than 35	2 802,00	-	2802	YES	1.890	8.598	1.890		12.378
266410	12	225	62	299	161	Bergen	songdal	2	69	251	greator than 35	2 892,00	-	2892	YES	2.107	9.585	2.107		13.799
244254	14	474	12	500	494	trondheim	oslo	2	22.5	180	Less than 35	3 075,00	-	3075	YES	2.527	11.494	2.527		16.548
240208	10	440	11	461	552	oslo	sandnes	2	54	196	greator than 35	3 582,00	-	3582	YES	2.537	11.540	2.537		16.614
261568	12	418	48	478	538	trondheim	gol	2	180	205	greator than 35	3942	-	3942	YES	2.751	12.515	2.751		18.017

Appendix 15

Bringers Emission calculation (Crowdshipping)

S/n	ORDER ID'S	First pickup	Last delivery	Days	Trip distance	TOUR	Total drive Hours	Reward	Vehicle registration Information	Mileage	Fuel Rate	Fuel Estimate	Earnings	Per hour Earnings	AVG COST PER KM	Transport Fulfillment	Extra KM	CO2 emission (g/km)	NOx emission (mg/km)	Carbon Equivalent Emissions	Total Emissions
3	235802	13/09/2021	15/09/2021	2	488	Midsund(h)-Ålesund(p)-Hamar(d)-**Hamar**- (YYYN)	7.4666667	1230		0.66l per 10km	16.044	587.2	642.8	86.1	1.2	Planned	75.0	166.0	231.0	0.2	17.6
4	234097	04/09/2021	05/09/2021	1	256	Åsgårdstrand(H)-Tønsberg(P)-Kristiansand(D)-**Kristiansand**-	3.4	450		0.47 litres per 10	16.044	193.0	257.0	75.6	0.8	Planned	25.0	112.0	21.2	0.1	3.0
6	243239	27/10/2021	27/10/2021	0	159	**Åsane**-pickup-delivery-home (N-Y-Y-Y)	6.75	280		16 kWh/100 km	1.86	47.3	232.7	34.5	0.3	Planned	6.0	0.0		0.0	0.0
7	257382, 257089	30/12/2021	03/01/2022	4	1121	lier(H)-Prestfoss-blokkebervegn-*stavanger*-drobak-lier(H) -	17.6	1890		0.56l per 10km	17.38	1091.0	799.0	45.4	1.0	Planned	77.0	114.0	6.9	0.1	8.9
8	256410, 255636, 249894	22/12/2021	23/12/2021	1	660	Stavanger(h)-Sandnes(p)-Ålgård(p)-Tvedestrand(d)-*Arendal(d)*-Brennåsen(p)-Stavanger(d)-Stavanger(h) - (YYYY)	9.6166667	1570		47km per 3.785l	16.3305	868.0	702.0	73.0	1.3	Planned	61.0	222.4	236.0	0.3	17.9
9	247720, 239783	01/12/2021	08/12/2021	7	922	(h)- Bergen(p)-*oslo(d)-oslo(p)*-bergen(d)-bergen(h)- (yyyy)	14.7	3380		0.69l per 10km	16.3305	1038.9	2341.1	159.3	1.1	Planned	5.0	157.0	195.6	0.2	1.1
10	260707	23/01/2022	23/01/2022	0	556	**OSLO**- gjettum(p)-sandness(d)-stavanger(h) -(N-Y-Y-Y)	7.3833333	2750		0.56l per 10km	19.1	594.7	2155.3	291.9	1.1	Planned	8.0	98.0	38.4	0.1	0.9
11	247684	21/11/2021	21/11/2021	0	78.7	**OSLO**-Hosle(p)-jessheim(d)-mogreina(h) - (N-Y-Y-H)	1.3833333	220		0.84L per 10km	16.808	111.1	108.9	78.7	1.4	Planned	25.7	220.0	150.8	0.3	6.8
12	253490, 253688	21/12/2021	28/12/2021	7	1330	Bergen(h)-Bergen(p)-*Trondheim(p)- trondheim(d)*-bergen(h)-	20.25	1580	Hidden	8.2l per 100km	16.3305	1781.0	-201.0	-9.9	1.3	Planned	13.0	275.0	313.0	0.4	4.8
13	234492, 234044, 235597, 235366	09/09/2021	14/09/2021	5	1157	Stavanger (p) - Spangereid(p)-Arendal(d) - *Oslo(d)-oslo(p)* - sandefjord(p)-Sandnes(d)-stavanger(d)-stavanger(h) (YYYY)	15.7	2280		4.2l per 100km	16.044	779.6	1500.4	95.6	0.7	Planned	42.0	130.0	19.0	0.1	5.7
25	266810	25/02/2022	25/02/2022	0	179	Posgrum(h)-Borgemarka (p)-Oslo(d)-**Oslo**- - (YYYN)	2.5	230		0.67l per 10km	19.0045	227.9	2.1	0.8	1.3	Not Money	14.0	172.0	235.0	0.2	3.4
26	258376	06/01/2022	06/01/2022	0	241	Heimdal(h)- trondheim(p)-kristiansund(d)-**kristiansund**- (YYYN)	4.2333333	100		0.69l per 10km	17.8585	297.0	-197.0	-46.5	1.2	Not Money	52.0	199.0	108.7	0.2	12.0
27	249881	23/12/2021	23/12/2021	0	150	**Oslo**-oslo(p)-Skien(d)-Skien(h)- - (N-Y-Y-H)	2.4666667	140		0.47l per 10km	16.3305	115.1	24.9	10.1	0.8	Not Money	14.0	145.0	200.0	0.2	2.9
28	238319, 239089	28/09/2021	10/10/2021	12	375	Nittedal(h)-Oslo(P)-Stabekk(p)-Hemsedal(d)-Gaupne(d)-**Gaupne**- - (YYYN)	6.5333333	2020		17 MPG	17.19	1425.0	595.0	91.1	3.8	Not Money	10.0	221.0	234.0	0.3	2.9
29	241442, 241879	25/10/2021	26/10/2021	1	380	kopervisk(h)-Kopervik(p)-Aksdal(p)-Porsgrunn(d)-Porsgrunn(D)-**Porsgrunn**- (YYYN)	6	1200		1 litres per 10 km	17.19	653.2	546.8	91.1	1.7	Not Money	2.0	171.0	216.1	0.2	0.5
30	265940	22/02/2022	22/02/2022	0	98	Fredrikstad(h)-Fredrikstad(p)-oslo(d)-**oslo**- - (YYYN)	1.5833333	350		0.47l per 10km	19.9595	91.9	258.1	163.0	0.9	Not Money	6.8	99.0	39.7	0.1	0.8

Appendix 16

Bringer's earnings based on total trip distance, the fuel cost, the bringer's reward, and the driving hours

Bringer	Orders combined	Nature	Bringer's per hour earnings	Transport fulfillment
1	1	P2P	-46.5	Planned
2	1	P2P	-88.9	Planned
3	1	P2P	-53.2	Planned
4	1	P2P	-30.7	Planned
5	1	P2P	-14.5	Planned
6	1	P2P	-20.7	Planned
7	2	P2P	-9.9	Planned
8	1	P2P	-5.2	Planned
9	1	P2P	0.8	Planned
10	1	P2P	15.8	Planned
11	1	P2P	18.4	Planned
12	2	P2P	22.2	Planned
13	1	P2P	10.1	Planned
14	1	P2P	8.6	Planned
15	1	P2P	30.7	Planned
16	2	P2P	91.1	Planned
17	1	P2P	39.5	Planned

18	1	P2P	34.9	Planned
19	1	P2P	62.3	Planned
20	1	P2P	30.1	Planned
21	2	P2P	45.4	Planned
22	1	P2P	70.1	Planned
23	2	P2P	70.6	Planned
24	2	P2P	91.1	Planned
25	3	P2P	73.0	Planned
26	1	P2P	130.8	Planned
27	2	P2P	95.0	Planned
28	1	P2P	86.1	Planned
29	1	P2P	67.1	Planned
30	1	P2P	78.7	Planned
31	1	P2P	75.6	Planned
32	2	P2P	128.3	Planned
33	1	P2P	69.9	Planned
34	1	P2P	53.8	Planned
35	2	P2P	10.4	Planned
36	1	P2P	100.1	Planned
37	1	P2P	48.1	Planned
38	2	P2P	159.3	Planned
39	1	P2P	75.0	Planned

40	1	P2P	66.3	Planned
41	1	P2P	173.6	Planned
42	1	P2P	82.2	Planned
43	2	P2P	78.0	Planned
44	3	P2P	107.7	Planned
45	1	P2P	67.4	Planned
46	1	P2P	163.0	Planned
47	2	P2P	72.1	Planned
48	1	P2P	55.6	Planned
49	1	P2P	134.6	Planned
50	1	P2P	34.5	Planned
51	1	P2P	104.5	Planned
52	2	P2P	**217.0**	Dedicated
53	1	P2P	**268.1**	Planned (survey response)
54	1	P2P	**356.0**	Dedicated
55	1	P2P	**257.1**	Dedicated
56	8	P2P	90.4	Planned
57	1	P2P	185.8	Planned
58	7	P2P	**208.9**	Dedicated
59	5	P2P	150.5	Planned
60	4	P2P	95.6	Planned
61	2	P2P	**369.7**	Dedicated

62	1	P2P	**325.0**	Dedicated
63	1	P2P	**238.6**	Dedicated
64	1	P2P	**225.4**	Dedicated
65	1	B2C	-64.5	Planned (survey response)
66	1	B2C	33.6	Dedicated (survey response)
67	1	B2C	72.0	Planned (survey response)
68	1	B2C	73.9	Planned (survey response)