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E-scooter – convenience versus environment: a green innovation value chain analysis of transportation in urban areas

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Abstract

The need for more sustainable transport methods have been highlighted due to challenges such as traffic congestion, greenhouse gas emissions and pollution in urban areas. The shared electric scooters have become increasingly popular and have been promoted as a solution to the mentioned problems. However, this type of micromobility has been prone to criticism and the demand for stricter regulations has intensified. This master thesis applies the Green Innovation Value Chain (GIVC) as a framework for analyzing the environmental and financial performance across the links of five stakeholder: manufacturer, distributor, customer, government and environment. In this case, the shared e-scooters are compared with the more conventional alternative, public transit. From the results, we conclude that public transit is more attractive, both financially and environmentally, than e-scooters. Especially for the governments and the customers, as well as the environment, e-scooter proves to not be comparable with public transit.

Keywords: green innovation value chain; e-scooters; shared micromobility; public transit

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Sincerely, Anne Dahl and Jens Arne Haug

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1. Introduction

Urban areas are facing challenges related to traffic congestion, greenhouse gas emissions and environmental pollution, which highlights the need for more sustainable means of transportation (Moreau, de Jamblinne de Meux, Zeller, D'Ans, Ruwet & Achten, 2020; Dacko & Spalteholz, 2014). Shared dockless electric scooters (e-scooters) have become a common sight in cities all over the world since the first launch in September 2017 in Santa Monica (Møller & Simlett, 2020; Gössling, 2020). The e-scooters are promoted as a way of solving problems related to traffic congestion, pollution levels, the first- and last-mile problem and is proclaimed to be an environmentally friendly means of transportation (Hollingsworth, Copeland & Johnson, 2019). However, the e-scooters have been subject to increasing criticism, mainly concerning careless parking, injuries on both riders and pedestrians and the short lifetime of the scooters (Moreau et al., 2020; Møller & Simlett, 2020). With the emergence of e-scooters in the urban transportation picture, the question therefore remains to be answered:

How beneficial are e-scooters in urban areas; both individually and for the society, both business-wise and for the environment?

This thesis will apply the Green Innovation Value Chain (GIVC) framework introduced by Olson (2013a). This framework compares the economic and environmental performance of green technologies with conventional technologies in each link of the value chain, namely the manufacturer, the distributor, the customer, the government and the environment. GIVC has earlier been used to examine hybrid cars and PV solar technologies (Olson, 2013a; Olson, 2014). This framework will help understand the profitability and costs for each mentioned stakeholder, in order to grasp an understanding of the attractiveness of e-scooters versus other urban transportation (public transit), as well as their environmental impact.

If the e-scooter purely substitutes cars in urban areas, it is intuitively easy to understand the benefits of e-scooters through most perspectives. However, research conducted in Oslo has found that only eight percent of all electric scooter users substitute cars (privately owned or taxi) given the distance they travel with the e-scooters. The majority (60%) would have walked, 23% would have used public transit, and six percent would have used privately owned or shared city bikes if the e-scooters had not been available (Fearnley, Berge & Johnsson, 2020). In other words, given the popular alternatives for travelers in the urban areas, it becomes less intuitively easy to understand which form of transportation is the better alternative for all stakeholders, both financially and environmentally.

Since walking obviously is better than any other transportation method both environmentally and cost-wise, this thesis will focus on public transit compared to e-scooters. Our paper will concentrate on the comparison between the two types of transportation with base in Oslo, Norway. There are several reasons behind this decision. Firstly, it is because the public has widely adjusted for both forms of transportation. Ruter manages all public transport in Oslo, with just under 400 million passengers in 2019, generating 8 992 million NOK in annual revenue (Ruter, 2020). E-scooters, since its introduction in 2019 in Oslo, have become massively popular, with currently 6 competitors in the shared industry. It is estimated that there are over 10 000 shared e-scooters in Oslo (NTB, 2020a). Secondly, one of the aspects of the analysis will include governmental costs of having both forms of transportation, where one (Ruter) receives subsidies from the government, while the other (e-scooters) causes a significant amount of injuries. As Norway has a state funded health system, the injuries caused are funded by taxpayer's money. Thirdly, as mentioned, public transport's biggest rival has become e-scooters, as over 20 % of e-scooters riders substituted from said public transport. Hence, it will be interesting to see whether these substitutes are regarded viable for the different stakeholders.

2. Background

2.1 Shared micromobility

Electric innovations and the sharing economy have disrupted urban transportation, resulting in a change where travelers are replacing privately owned cars and public transit for shared transportation. The emergence of green business models with green products have expanded greatly in the past years as a result of the global focus on environmental sustainability (Bocken, Short, Rana & Evans, 2014). The majority of green innovation and business strategy literature have for years encouraged private and public organizations to produce greener products with the idea that it does not only help the environment, but it will also increase profitability and create a competitive advantage (Porter & Reinhardt, 2007). However, a literature review finds that less than 10 percent of green product development research are based on empirical data, while the rest is prescriptive (Baumann, Boons & Bragd, 2002).

The sharing economy has emerged as a consumption model that is perceived to be a profitable and more sustainable alternative to ownership (Belk, 2007; Botsman & Rogers, 2010). Sharing platforms allow consumers to become less dependent on individual ownership, which may contribute to a lower demand for materials and a decrease in energy use (Frenken, 2017). Sharing is defined as "the act and process of distributing what is ours to others for their use, and/or the act and process of receiving or taking something from others for our own use (Belk, 2007, p. 126). Instead of traditional ownership, there is an increasing demand by consumers of a temporal access to goods, which can be categorized as "access-based consumption" (Bardi & Eckhardt, 2012). Access-based consumption has been defined as "transactions that may be market mediated in which no transfer of ownership takes place" (Bardi & Eckhardt, 2012, p. 881). Compared to sharing where two or more people share the benefits and costs related to the possession of an item, access-based consumption refers to consumers who access an object on a short-term basis (Belk, 2007; Bardhi & Eckhardt, 2012).

The micromobility revolution is transforming urban transportation across the globe and has been proposed as a possible solution to the challenges faced in urban areas as mentioned above. Shared micromobility is used to describe the shared use of small-sized vehicles such as bicycles and scooters for travelling short distances (Shaheen & Cohen, 2019; Eccarius & Lu, 2020). This service model facilitates short term access when needed, without concerns regarding storage, maintenance and parking (Shaheen & Cohen, 2019). In some cases, shared micromobility has resulted in increased mobility, a decrease in the use of automobiles, reduced greenhouse gas emissions, health benefits and economic development (Shaheen & Cohen, 2019). Researchers have estimated that theoretically, micromobility could account for all passenger trips that are shorter than eight kilometers, which would cover 50-60% of all passenger trips in China, the U. S. and the European Union (Heineke, Kloss, Scurtu & Weig, 2019).

However, due to constraints regarding weather, age, fitness ability, adoption by customers and limited space for shopping bags, it is more likely that micromobility can capture between 8 to 15 percent (Heineke et al., 2019).

2.2 Shared e-scooters

Shared dockless e-scooters, a motorized version of the traditional kick-scooter, has been promoted as an alternative to conventional urban mobility (Moreau et al., 2020). E-scooters are offered as a short-term rental service that makes it possible for consumers to conveniently drive around in urban areas (Moreau et al., 2020; Gössling, 2020). Dockless indicates that the users can retrieve and return the e-scooter at any destination, without concerns regarding parking (Moreau et al., 2020; Hollingsworth et al., 2019; Fang, Agrawal, Steele, Hunter, Hooper, 2018). With its low cost, availability and accessibility, the e-scooter has become one of the most popular modes of micromobility (Sikka, Vila, Stratton, Ghassemi & Pourmand, 2019). The flexibility of the e-scooters have been recognized as a possible solution to the first- and last-mile gaps in transportation i.e. the distance between public transport stops and the user's home or end destination (James, Swiderski, Hicks, Teoman & Buehler, 2019; Shaheen & Cohen, 2019; Hollingsworth et al., 2019; McKenzie, 2020). Additionally, the e-scooters do not require bike-friendly clothing or any physical effort and cycling skills (Caspi, Smart & Noland, 2020). Moreover, shared e-scooters are suitable for intermodal travels, a term used to describe a single trip where at least two different types of transportation are combined (Oostendorp & Gebhardt, 2018). Intermodality has become important, especially in larger cities since it is believed to be a contributor to reducing the use of private vehicles and a solution to problems related to emissions, traffic congestion and the shortage of parking spaces (Dacko & Spalteholz, 2014). The Boston Consulting Group has estimated that the e-scooters can reach a market value of US$ 40-50 billion by 2025 (Schellong, Sadek, Schaetzberger & Barrack, 2019).

In order to use the e-scooters, the customers need to download a mobile phone app and fill in their payment information. By using the mapping interface, the users can locate available e-scooters nearby. The scooters are unlocked and ready to use by scanning the QR-code. Once the electric scooter is unlocked, the user can drive within an area that is predefined by the provider which is called geofence. The scooters can be retrieved and returned at any destination since they are dockless (Moreau et al., 2020). Eventually, when the battery is running low or when the scooters need maintenance, an employee or freelance charger will collect the scooters to charge the battery or bring them to the warehouse for repairs. Finally, the scooters are returned to strategic locations where the users can easily find them (Moreau et al., 2020).

2.3 Ruter

Ruter AS is a publicly owned company that manages the public transit in Oslo and Viken (formerly Akershus). The public transit system in Oslo includes trams, trains, buses, subways and ferries. 42% of Ruter's costs were covered by public subsidies (3,9 billion NOK), and they had approximately 5,5 million departures with 398 million travelers in total in 2019 (Ruter, 2020). In 2018, Ruter set an ambitious goal that all public transit in Oslo and Viken will be emission free by 2028 (Ruter, 2018). In this case, emission free refers to emissions from the motor of the vehicle. Since the metros and trams in Oslo already are emission free, it is especially their buses and ferries that are facing a major transformation. So far, 10% of 1200 buses are electric, which reduces the CO_2 emissions with 5500 tons each year (Vestrum, 2020).

2.4 The framework

The traditional way of examining the activities for a firm was through value chain analysis. This analysis has commonly recognized the different activities' financial value to the firm, to grasp an understanding of which activities are sources for cost or competitive advantage for the firm. The various parts of the firm, logistics, operations, and marketing/sales were all analyzed as a part of the value contribution or retention for the firm. This tool for analyzing has later been developed, from product manufacturing business having traditional logistics, to service and other non-manufacturing firms that do not follow the traditional business model (Stabell & Fjeldstad, 1998). However, the traditional value chain analysis has a limited approach towards analyzing firms in scope of environmental impact. To address this limitation, Porter and Reinhardt (2007) suggested to consider emissions produced throughout the various activities as costs, and that "the simple ratio of profits to total emissions in the value chain can be a very telling measure of potential climate impact" (Porter & Reinhardt, 2007, p. 2).

2.4.1 Value chain

However, consumers often fall under the value-action gap when met with green products. Studies on adoption of green technology finds that there is a gap between consumers' all-agreeing attitude towards green technology versus their severely rarer pro-green behavior and consumption. Consumers most often sacrifice traditional attributes, such as quality of product, price, and convenience, when consuming greener products compared to non-green products (Olson, 2013b). The value-action gap concerning consumers purchases represents trade-offs several stakeholders have to consider in pro-green behavior. Thus, the traditional value-chain analysis, with its internal analysis, does not address the broader aspect of innovations to understand its financial/value attractiveness for the different stakeholders.

2.4.2 Life-cycle assessment

A popular multi-stakeholder approach in green studies of firms, is the life cycle assessment (LCA). This tool of analysis assesses the environmental impact of a manufactured product's life cycle, i.e. from material, via manufacturing and usage, to disposal and waste management (ISO, 2006). Initially, as the concept of LCA grew in interest, it also received criticism for its limitations (Ayres, 1995, Finnveden, 2000), especially in terms of its lack of financial perspective in its assessment (Norris, 2001). There have been several prior attempts to implement a financial aspect to the LCA tool. Norris (2001) argues for a tool, life cycle costing (LCC), which includes the cost-effectiveness of alternative investments and decisions from the buyer/user perspective. However, Olson (2014) counters that this only included the costs of one stakeholder, and not the cost of other stakeholders.

Nevertheless, the similarities of LCA and GIVC are that both tools focus on both the internal and external parts of the chain, in contrast to value-chain analysis, and the impact of connection between links on the results (Olson, 2014). Moreover, the GIVC uses the LCA's environmental assessments combined with financial results to analyze and identify links which may result in the greener technology being less attractive for the potential buyer, i.e. causing the appearance of green value-action gap.

2.4.3 Green Innovation Value Chain

The Green Innovation Value Chain (GIVC) concept bases on the notion of the value-action gap, that there are only a smaller portion of self-proclaimed green consumers who accept valuable trade-offs when choosing the greener products (Ambec & Lanoie, 2008). Thus, a major assumption for the GIVC approach is that for a popular adoption of green technology to be predictably successful, it must create a 'win-win-win' outcome for the firms, customers, and government (taxpayers) that support the adoption of the technology (Olson, 2013b). In terms of governmental impact, green products often require a government subsidy to be perceived attractive in the eyes of the buyer. Moreover, public transit requirement of subsidies is critical, especially when funding local public transit (Hess & Lombardi, 2005). The GIVC concept addresses the green technology's reliance on subsidies to perceive as financially attractive for the customer. As mentioned, the green consumers may require trade-offs of conventional attributes of a product, and so the subsidy should compensate for the tradeoff in order to encourage the usage of greener technology.

The government justifies these subsidies by focusing on achieving their environmental objectives. However, some studies shows that the overall LCA between diesel and electric buses are not one-sided; in some states in US conventional diesel buses are preferable to electric buses due to the overall global impact caused by the batteries uses, contradicting the ideas in US's Clean Air Act which identifies diesel buses as way worse than electric buses (Cooney, Hawkins & Marriot, 2013). Thus, with the LCA, the GIVC framework does not only address the subsidies, and financial part, but the environmental aspect is vital in the overall understanding of the attractiveness for technologies in question. The attractiveness of green technology is often reduced to not attract the mass markets, making it difficult for green technology businesses to achieve profitable economy of scale making it more difficult to achieve the price range mass markets demand to adopt the green technology due to trade-offs, exemplified with hybrid cars (Olson, 2013a). And, again proven the importance of subsidies for green technology.

In April 2018, the Norwegian government decided that small, electric vehicles such as e-scooters should be seen as equivalent to ordinary bicycles (Endr. i forskrift om krav til sykkel, 2018, §2-5). Generally, the e-scooter users can drive in the same areas as when cycling and walking. The users are allowed to drive the e-scooters at a maximum speed of 20 kilometers per hour. Even though the e-scooter companies have chosen an age limit of 18 years, there is no general age limit for using the e-scooters in Norway. In addition, there is no requirement of using a helmet, even though the providers strongly recommend their users to wear one. Further, it is only allowed to be one person at each scooter at once (Strømme, 2019). Lastly, it is not permitted to drive the e-scooters under the influence of alcohol. The demand for stricter regulations in Oslo has been a frequently discussed subject. In February, the city council of Oslo announced that they are working on measures to cope with problems related to e-scooter injuries and pollution (Gjerde, 2020). However, this summer, the debate regarding e-scooters has intensified, and Oslo public emergency ward (Oslo skadelegevakt) has recommended that the e-scooters should not be allowed to use at night in order to reduce the number of injuries. This is due to the fact that more than half of the injuries related to e-scooters happen between 10 pm and 7 am (NTB, 2020b). The Norwegian government has announced that they will introduce new regulations regarding the e-scooters before the summer of 2021 (Harnes, 2020). A big part of this GIVC analysis is calculating the costs of injuries, both for the government and for the individual's life quality.

In order to assess the long-term financial viability of a green product, Olson (2014) emphasize on calculating with minimal governmental subsidies, and thus isolate the economic side of the business, in the GIVC concept. However, in this paper, as both sides in question are considered green within their industries, we will compare the governmental subsidies versus other governmental costs such as the health care system for both e-scooters and public transit, in order to fully understand the total impact and attractiveness for the key stakeholders. Thus, this GIVC analysis will be the first to examine two perceivable green technologies, where public transit is regarded as the conventional technology and e-scooter is regarded as the new innovation.

The concept of GIVC will determine the attractiveness of e-scooter versus public transit, both in terms of environmental and financial attractiveness, for all key stakeholders. The attractiveness of one link of the chain will positively or negatively influence the willingness to adapt for other links in the chain. The links included in our paper are similar to Olson (2013b, 2014): 1) manufacturer, 2) distributor, 3) customer, 4) government, and 5) the environment. The GIVC analysis (Figure 1) will assess the attractiveness of each link individually and by combining all links, to grasp an understanding of whether the emergence of e-scooter is better than the conventional alternative of public transit.

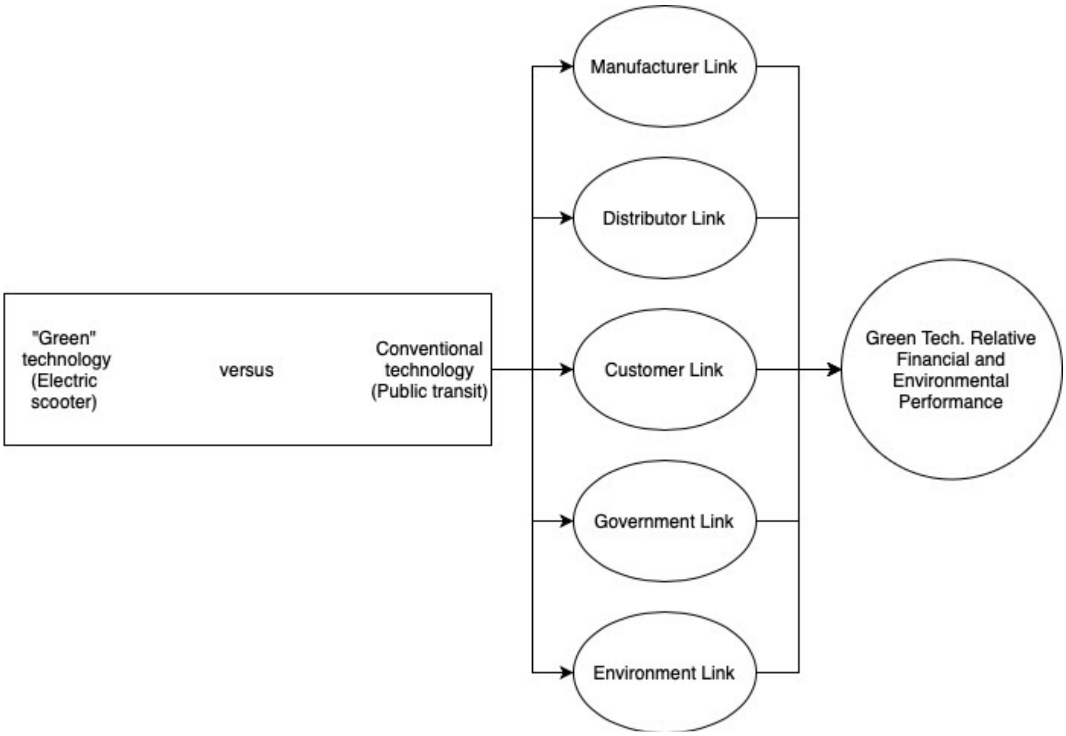


Figure 1: Green Innovation Value Chain

3. Methodology

This thesis applies the Green Innovation Value Chain using secondary data. Google Scholar was used to find relevant scientific articles about e-scooters. However, since e-scooters are a new phenomenon, the literature that has been peer-reviewed is very limited. Therefore, most of the research and information referred to in this thesis is based on reports, media and other non-scientific articles. Additionally, the walk-through method was applied in order to get a better understanding of how the riders can use the e-scooters and to gather information about how the providers have priced their services and which areas the e-scooters can be used. The walkthrough method can be defined as “a way of engaging directly with an app's interface to examine its technological mechanisms and embedded cultural references to understand how it guides users and shapes their experiences" (Light, Burgess & Duguay, 2018, p. 882).

Previous GIVC analyses have compared a green alternative with a non-green one, and in the case with e-scooters it would be relevant to compare with cars as they are less environmentally friendly. However, since the use of e-scooters only replace eight percent of car use, we chose to compare e-scooters with public transit because 23% of the trips with e-scooters are replacing the use of public transit in Oslo (Fearnley et al., 2020). Walking was the most cited transportation method replaced by e-scooters, but it is obvious that e-scooters are worse in all the links.

The GIVC analysis includes five different stakeholders, all which are affected by and affecting the overall attractiveness of both forms of transportation. In the manufacturer link, the comparison will calculate the profit the manufacturer makes for both forms of transportation, based on price, targeted lifespan and profit margin. In the distributor link, the calculation will include the profit the distributors make, based on the price and cost of using their products. For the customer link, the costs of usage will include both the actual price of the product as well as the costs of reduced life quality due to injuries. In the governmental link, as mentioned, the costs will include governmental subsidies, but additionally, the costs of injuries as medical treatment is covered by the taxpayers. Lastly, in the environmental link, the numbers presented are emissions caused by producing each product. In all the calculations, the final numbers will be presented in Norwegian Kroner (NOK) per person kilometer.

3.1 Manufacturer link

For manufacturers, both the price and life span of the various forms of transportation are distinctly different, especially, in comparison to e-scooters. Shared e-scooter has been under scrutiny for its short-lived life. A regular estimation suggests that an e-scooter lasts between one and two years, however, some shared e-scooters last as short as 29 days (Griswold, 2019). The manufacturing process between e-scooters and public transit-vehicles is severely different, where e-scooter are often produced in masses at manufacturers in China

(Hollingsworth et al., 2019). For public transit-vehicles, they require higher quality of engineering and manufacturing, hence they are often produced by quality-proven automobile manufacturers such as Siemens. Thus, in the calculation, the expected lifespan varies from one year (e-scooters) to as long as 40 years (subway) (Moreau et al., 2020; UITP, 2012).

3.1.1 E-scooters

E-scooter are mass produced, usually in China (Hollingsworth et al., 2019), and thus the price means more than quality for the buyer. The e-scooters are made of an aluminum frame, steel parts, a lithium ion battery, an electric motor, and tires with tubing (Hollingsworth et al., 2019). Further, some of the materials that are used to produce the e-scooters are recycled material (Moreau et al., 2020). The estimated price for each commercialized scooter varies from $360 (Heineke et al., 2019) and can get up to $550 (Efrati & Weinberg, 2018). However, the average price is estimated around 5000 NOK (~$500). In addition to the price varying amongst the different manufacturers, so thus the lifespan. The target lifespan is estimated to be one year (Moreau et al., 2020), whilst others in reality reports lower numbers from three months (Schellong et al., 2019) to 29 days (Griswold, 2019). Moreover, the usage of each e-scooter is an average of seven trips a day in Oslo (Fearnley et al., 2020). Thus, given the estimated trip to last one person kilometers (Fearnley et al., 2020), we assume one e-scooter moves 1900 person kilometers during its lifespan (nine operating months in Norway due to weather). Thus, the manufacturer's profit margin, assuming an 15% profit margin for manufacturers, based on average industry indexes, is estimated to be 0,3945 per person kilometers.

3.1.2 Public transit

In Oslo, the commuters have several options in forms of transportation on the same public transit ticket: buses, trams, subways and even ferries. This paper will focus on the first three, given the restrictions of e-scooters as it does not move well on water. In terms of subways, Ruter made a major purchase in 2012 with 32 new subway cars from Siemens, each with three sets of wagons, for NOK 1,4 billion (Valmot, 2012). This gives a price of just under 44 million NOK per subway car. Given the price, the subway cars subsequently are expected to last for a longer period. In Europe, the target life cycle is set at 40 years, and with good maintenance can last one or two decades longer (UITP, 2012). In New York, the life expectancy is at around 20 years (Dague, 2018). For the purpose of the calculation, we use the European estimation, as this is reflected in the high price of subway cars and high-quality manufacturers. Thus, per year, the price of a subway car is at 1,1 million NOK. Moreover, in 2019, the subway transported commuters in total 717 million person kilometers (Ruter, 2020). Thus, the manufacturer price of subways is NOK 0,0015 per person kilometers.

In relation to trams, the price and life span is in close proximity to subways. Intuitively, the track-driven vehicles are made to last longer, as there is less maintenance and lower risk of damages than vehicles moving on roads such as buses. In 2019, Oslo introduced its new fleet of trams, with a total of 87 new tram cars being ordered for the price of NOK 4 billion (Berge, 2019). Thus, a price of NOK 46 million per tram car. In comparison to subways, trams have a shorter life cycle expectancy at 30 years (UITP, 2012). Thus, per year, trams prices are around NOK 1,53 million. In 2019, trams moved commuters a total of 169 million person kilometers (Ruter, 2020), giving the manufacturer price of trams at NOK 0,009 per person kilometers.

The life cycle expectancy and price of electric buses is shorter than trams and subways. The price of an electric bus varies around 6 million NOK (or $600 000), with a life expectancy of 10 years (Potkány, Hlatká, Debnár & Hanzl., 2018). In comparison to the vehicles moving on track, there is a higher frequency of maintenance related to buses. Moreover, as the buses travel in road traffic, it is prone to more accidents. Given the numbers, electric buses have a manufacturer price of 600 000 NOK per year. City buses moved commuters 554 million person kilometers in 2019, which says the manufacturing price of an electric bus is at NOK 0,001 per person kilometers.

Thus, by setting an average between the three different forms of public transit, we calculate that the manufacturer has a price around NOK 0,0038 per person kilometers. Assuming the same profit margin (15 %) as e-scooters, it provides the manufacturer a profit of 0,00057 NOK per person kilometers for public transit.

3.1.3 Comparison of e-scooters and public transit

Conclusively, the comparison between e-scooters and public transit is presented in table 1. Given the perimeter for NOK per person kilometers, and the short lifespan, e-scooters are providing a higher profit margin than public transit, and thus for manufacturers are considerably profitable.

Table 1
The average manufacturer profit for public transit and e-scooters

	Average manufacturer profit margin per person kilometer
E-scooter	0,3945 NOK
Public transit	0,00057 NOK

3.2 Distributor link

In the case of shared e-scooters, the providers of the service are the distributor. Ever since Bird launched their first shared e-scooter in September 2017 (Trivedi et al., 2019; Gössling, 2020), numerous providers have entered the market. Tier and Voi were the first to launch their fleet of e-scooters in Norway in March 2019 (Fearnley et al., 2020; Jansen, 2019). Since then, the competition has intensified and some of the competitors have already withdrawn their scooters (Bugge, 2020a). “In their bid for market share, e-scooter providers and their investors are willing to sacrifice early profitability to establish a foothold while pursuing efforts to fortify product durability” (Schellong et al., 2019, p. 4). There are currently six providers in Oslo; Tier, Voi, Lime, Bird, Bolt and Wind, operating over 10 000 e-scooters (NTB, 2020a). The distributor of public transit in Oslo, Ruter, is in charge of all acquisitions, maintenance and operations of their fleet. This umbrella administrative company is divided into several smaller companies.

3.2.1 E-scooters

Research has found that providers with bigger fleets of e-scooters placed in a city tend to have the scooters that are used the most. The battery level decreases more rapidly compared to providers with smaller fleets (Fearnley et al., 2020). This indicates a network effect because it is easier to find an e-scooter if the provider has a large fleet of vehicles. E-scooters can be perceived as a commodity, implying that the consumers will choose the e-scooter that is closest available, given that the consumers have downloaded all the apps (Schellong et al., 2019). Since there is little that differentiates the different providers from each other, as they all offer similar services to their customers, this can be an efficient way to stand out to the customers. However, acquiring a large fleet of e-scooters requires a more extensive investment. The acquisition cost per scooter is around 5000 NOK, which includes the cost of the scooter, cost of acquisition and installation of a GPS tracker in the scooters (Heineke et al., 2019). The newest provider in Oslo recently launched 2000 e-scooters, which implies that they spent 10 million NOK on their fleet (NTB, 2020a).

Another significant cost related to shared e-scooters is the charging, which also includes the collection and redistribution of the scooters. E-scooters with low battery (usually less than 16-20%) become available for collection because the e-scooters have a minicomputer installed which makes it easier to locate them (Yakowich, 2018). The employees do not follow a specified route or areas for pick-up for collecting the e-scooters. Further, they are transported to a warehouse where they get charged before they are distributed the next morning to strategic locations (Moreau et al., 2020; Fearnley et al., 2020; Schellong et al., 2019). Fearnley et al. (2020) observed that many of the providers consider public transport hubs and large stops as attractive locations for distribution of the e-scooters. This includes locations such as Oslo S, Aker Brygge and Nationaltheatret. In some cities such as Raleigh, North Carolina, it is forbidden to leave the scooters in the streets at night (Hollingsworth et al., 2019). However, in Oslo, the scooters can stay outside, which allows the shared scooter companies to only collect the scooters that need to be charged or repaired.

Additionally, the companies rely on independent contractors to charge their scooters in exchange for cash or free rides, which is referred to as “crowd-charging” (Schellong et al., 2019). Typically, these contractors drive their personal vehicles around the city to collect as many scooters as possible, charge them at their home before they return them the next day. Moreover, it is easy since they only need to fill out a form in order to get started as a freelance charger. The payment is usually 70 NOK for collecting, charging and distributing the scooters (Hagesæther, 2019).

Research has found that the average real lifespan of the e-scooters usually varies from one to six months (Breian, 2019) compared to the target lifespan of one year (Moreau et al., 2020). However, findings show that the lifetime could be as low as 29 days in some cities (Aker, 2020). Originally, the e-scooters were intended for private use and not for shared rental services. As a result, the durability of the e-scooters has decreased. According to Moreau et al. (2020), the lifetime is dependent on four factors; eco-design, usage, vandalism and maintenance. Firstly, many of the providers have now made adjustments to the scooters in order to create a scooter that is suitable for shared mobility. Secondly, researchers have found that the wrong usage, such as two people riding together, riding fast on pavements with holes and up edges of sidewalks can lead to faster deterioration of the scooters. Thirdly, even though improvements have been made, and the latest models are expected to last longer, the e-scooters are vulnerable to vandalism (Moreau et al., 2020; Temple, 2019). The scooters are frequently fished out of bodies of water, tossed from buildings, used in stunts, run over and set on fire (Temple, 2019). Recently, people have expressed their frustration in Oslo over the dockless parking by painting over the QR-code and using cable ties to push in the brakes. Both of these actions result in inoperable scooters (Løkken, 2020). This results in a higher cost related to maintenance and repurchase of new e-scooters, which leads to the fourth factor, maintenance. E-scooters that are no longer working are collected and stored in the warehouse of the provider. Further, the e-scooter is disassembled and components that are in a good condition are used to repair other e-scooters (Moreau et al., 2020). One of the providers have stated that 90% of their e-scooters are back in operation after two days, and the scooters that are impossible to repair are used as spare parts. Further, 70% of the parts can be reused, and the rest is recycled (Løkken, 2020).

All of the providers have priced their services by using the same model with two components; a price to unlock the scooter and a price per minute when driving. A comparison of the prices for the providers in Norway is found in table 2.

Table 2
Comparison of prices of the providers of e-scooters in Norway.

Provider	Price to unlock scooter	Price per minute
Tier	10 NOK	2,50 NOK
Voi	10 NOK	2,50 NOK
Bird	10 NOK	2,50 NOK
Lime	10 NOK	3 NOK
Bolt	5 NOK	2,50 NOK
Wind	10 NOK	2,50 NOK

On average, each journey of e-scooters lasts for 10 minutes and is approximately one kilometer long in linear distance (Fearnley et al., 2020), where others have reported 1,85 kilometers (PBOT, 2018a) and 1,5 kilometers (Denver public works, 2019). Here, we assume one kilometer to be equal to one-person kilometer. With a ten-minute journey, each ride costs, on average, NOK 35 per person kilometers. BCG analyzed the business model for a shared e-scooter company, and found a $0,65 contribution margin for each $3,5 worth of journey, taking account of all operation costs (tax/insurance, maintenance/repairs, operation/charging) (Schellong et al. 2019). Thus, in the calculation we assume a similar contribution margin of 18,5 %. Hence, for the average shared e-scooter business, they enjoy a contribution margin of 6,475 NOK per person kilometers for single journeys.

Recently, four of the providers have introduced either daily, weekly or monthly packages with a fixed price that riders that use the e-scooters frequently can choose instead of the regular unlocking fee and price per minute. The different packages are presented in table 3. It has been stated by Voi that the purpose behind the packages is to become more competitive in order to capture consumers that would have used public transit (Bugge, 2020b).

Table 3

Comparison of packages offered by the providers in Norway

Provider	24-hour pass	Weekly pass	Monthly pass
Tier			89 NOK* 60 minutes: 199 NOK* 120 minutes: 299 NOK*
Voi	139 NOK**		599 NOK**
Lime	100 NOK***	30 NOK*	5 trips for 125 NOK*** 10 trips for 200 NOK*** 25 trips for 400 NOK***
Bolt	99 NOK	139 NOK****	329 NOK****

* Unlimited unlocking

**Each ride can be a maximum of 45 minutes long.

*** Each ride can be a maximum of 30 minutes long.

**** Maximum 30 minutes each day

For the passes, we focus on monthly passes for e-scooter as this option is mostly used by public transit users. We assume those who purchase monthly passes use them twice a day, similar to public transit (to and from work), five working days a week for all the four weeks a month. Based on the restrictions and limitations, Voi's NOK 599 monthly pass is regarded as most attractive. Moreover, Voi also has one of the biggest fleets in Oslo, with over 2000 e-scooters, and therefore assumes that riders choose this operator. Based on the assumed usage, we estimate e-scooter riders to travel 40 person kilometers a month for NOK 599. Given the same contribution margin from BCG (Schellong et al., 2019), the calculations show a contribution margin for a monthly pass to be NOK 2,77 per person kilometers. The assumptions for the calculations may occur underestimated, but we believe it to be reasonable for riders in Oslo.

3.2.2 Public transit

A single ticket with Ruter in zone 1 costs 37 NOK for an adult, where the user can ride for one hour and switch between bus, tram, metro, boats and train.

Additionally, they offer a weekly pass for 310 NOK and a monthly pass for 770 NOK for adults. In the annual reports from Ruter, they provide information on the income and costs of public transit (2020). As the Norwegian government provides subsidies for public transit, this calculation is based on the profits without subsidies to understand the business case of Ruter, and naturally, they will have negative income without subsidies. Ruter reports an income of 9,5 NOK per journey with subways, trams and city buses (2020). Moreover, they report an average cost of 15,5 NOK per journey for urban transportation, which includes all costs related to maintaining and operating public transit. Thus, public transit in urban parts of Oslo have reported -6 NOK per journey. Furthermore, by taking the total number of journeys and dividing by the total number of person kilometers, and averaging between subways, trams and buses, we calculate that a journey for public transit is at 4,67 person kilometers. Hence, Ruter's contribution margin for public transit is at -1,28 NOK per person kilometers. Ruter does not specify whether this is just for single tickets or monthly passes, thus, we assume it is for all forms of tickets and passes.

3.2.3 Comparison of e-scooters and public transit

Based on the calculations for contribution margin for e-scooter and public transit, from the various tickets and passes, the results are presented in table 4. In Norway, given the seasonable weather (few to none drives in the rain, even during summer), we assume the e-scooter to be available three quarters of time compared to public transit. Thus, the total margin for e-scooter is shortened with 0,75. The results also include the costs per buying the vehicles per person kilometers from the manufacturers. As we can see, the business model for e-scooter is generating positive margins and profits, while, as mentioned, Ruter's margins are naturally negative. Given the subsidies from the Norwegian government, Ruter's contribution margin is reasonably low, with losing just over NOK 1, - per person kilometers.

Table 4

Comparing contribution margins for e-scooters and public transit per person kilometer

	Single Ticket	Monthly passes	Cost of vehicles	Total margin
E-scooter	4,8563 NOK*	2,0775 NOK*	-2,64 NOK	4,2938 NOK
Public transit	-	-	-0,0038 NOK	-1,2838 NOK

* Seasonal operation in Norway considered

Moreover, from the numbers provided, and an average of seven trips per day per e-scooter, and a price of 5000 NOK, the breakeven point is 166 days (5,5 months) for each e-scooter. In other words, if the real-life span of three months or 29 days is the real story for the scooters in Oslo, this business model is not viable for long.

3.3 Customer link

E-scooters have become increasingly popular among consumers. One of the providers, Voi, states that a third of the population in Oslo have used their e-scooters, and that Oslo is one of the cities in Europe where people use the e-scooters the most (NTBc, 2020). The e-scooters can be retrieved and parked anywhere within a predefined area and can therefore be considered as a flexible transportation method. They are promoted to solve the first- and last-mile problem, which refers to the gap between the home of the user or the final destination and public transit stops (James et al., 2019). Since e-scooters are a relatively new phenomenon to urban mobility, it is interesting to look at the consumer behavior and attitudes towards the e-scooters. Who are they? Why do they use the shared e-scooters? What type of transportation would they have used if the e-scooters were not available?

There is limited research describing the demographics of the e-scooter users in Oslo. In their early mapping of e-scooters in Oslo, Fearnley et al. (2020) surveyed a sample of 675 participants and found that 549 of them had used e-scooters. Further, they found that the majority of the users were men (70%). Additionally, young people were overrepresented in the sample, with 69 percent being under the age of 40 years. The majority of the electric scooter users were between 20 and 29 years old. Around 72% of the electric scooter users had higher education from a university, and three out of four were employed. Approximately half of the users have a gross income of more than 500 000 NOK (Fearnley et al., 2020).

Fearnley et al., (2020) asked their participants of what type of transportation they would have used if the e-scooters were not available. They found that e-scooters mainly replace walking and public transit in Oslo, and to a small extent car. The majority of the respondents (60%) would have walked, 23% would have used public transit, eight percent would have used their own car or a taxi, six percent would have used a privately own bicycle, or a shared city bike and two percent would have skipped the trip. The mostly cited reason for the purpose of the trip was travelling between the user's home and work/school (30%). In addition, nine percent use the e-scooters during work hours when travelling to meetings. Other reasons cited are leisure activities (19%), first- and last-mile travelling between public transport and the final destination (15%), running errands (12%), just for fun (11%) and other (3%) (Fearnley et al., 2020). Further, research shows that the consumers choose e-scooters because they are perceived as the fastest option, most flexible and fun. Only six percent consider the e-scooters to be the cheapest option (Fearnley et al., 2020). According to the CFO in Voi, the second largest operator of e-scooters in Europe, the demand for e-scooters have increased due to the ongoing coronavirus (Johannessen, 2020).

The researchers also found that e-scooters are a part of an intermodal transportation chain Fearnley et al., 2020). This refers to the combination of different types of transportation on a single trip (Oostendorp & Gebhardt, 2018). In Oslo, the e-scooter is mainly combined with walking and public transit (Fearnley et al., 2020). This is an interesting finding since this implies that the users need to pay for both the public transit and the electric scooter on the same trip (assuming that the user has a valid Ruter ticket).

Three of the providers in Oslo have recently launched monthly passes for those who use the e-scooters frequently, and they are all cheaper than a monthly pass with Ruter as an adult. Nevertheless, it is not likely that the users are able to cover all their trips with an e-scooter alone, thus, ending up buying an additional ticket with Ruter. Firstly, the e-scooters can only be used in designated areas, mainly in the city center of Oslo (Appendix 1). Due to this limitation, the users might need another transportation method in order to travel to areas that are outside the city center. Secondly, there is no space on the e-scooters to store luggage and shopping bags, and it can be difficult to balance bags on the handlebars when driving. Thirdly, the users might rather choose another form of transportation due to bad weather.

Table 5 presents two different scenarios regarding the prices per person kilometer. The first scenario is a comparison of e-scooters and public transit for both single tickets and monthly passes. The prices are the same as mentioned in the distributor link. The second scenario adds the cost of e-scooters to the cost of public transit. This is due to the fact that many users combine e-scooters with public transit, also called intermodality, and that eliminating public transit completely is not possible because of the limitations mentioned above. The calculations are based on the same assumptions as in the distributor link in terms of prices and how many kilometers driven.

Table 5

Prices per person kilometer.

	Scenario 1		Scenario 2
	E-scooters	Public transit	E-scooters + public transit
Single ticket	-35 NOK	-7,92 NOK	-42,92 NOK
Monthly pass	-14,975 NOK	- 4,139 NOK	-19,114 NOK

3.3.1 E-scooter injuries

The increasing number of e-scooters available for the users in the bigger cities caused another controversy; the spike of traffic injuries related to scooters. The health and traffic authorities saw a worrying trend in several cities such as Oslo (NKT-Traume, 2019), Austin, Texas (Austin Public Health, 2019) and Aukland, New Zealand (Mayhew & Bergin, 2019). Kobayashi et al. (2019) conducted a retrospective case series of patients operated for injuries related to e-scooters. In their studies, they found a full spectrum of severity of injuries, where extremity fractures were the most frequent injury (42%), followed by facial fractures (26%) and intracranial hemorrhage (18%). The results in terms of causes of the injuries are undeniable, as Kobayashi et al. (2019) points to riding under intoxicated condition and lack of helmet-use as the two main reasons. Trivedi et al. (2019)

also identifies underage drivers as indicated for accidents, amounting for 11.4 % of the accidents (age < 18).

In a newly published report by The International Transport Forum (ITF) (Santacreu, Yannis, de Saint Leon & Crist, 2020), the authors conducted a meta-analysis of all e-scooter injury studies. In addition to the abovementioned, they also found that the majority of injuries are related to male, as "*the proportion of male riders is consistently above 50% across all e-scooter injury studies*" (Santacreu et al., 2020, p. 25).

Due to the construction of the e-scooters, injuries are also caused by road surface condition. Around 50 % of patients reported road surface conditions as caused to their crash in Austin, Texas (Austin Public Health, 2019), and over half of the patients pointed to the same reason in St Louis, Missouri (Petrin, 2019). Around one quarter of the responders in France argued that bad weather conditions caused the incidents (6t-bureau de recherche, 2019). Thus, in overall terms, the severity of injuries and the causes of it appear devastating.

In general, with e-scooter related crashes, there is a lack of registered data, especially from official entities as policing reports, and thereby also in the literature. Austin Public Health (2019) reported one pedestrian injured amongst 192 e-scooter related injuries (191 were riding the e-scooters and one bicycle). In general, minor crashes between e-scooters and pedestrians tend not to be reported or are not treated within the scope of traditional traffic safety data (Bekhit, Le Fevre & Bergin, 2020). However, the City of Santa Monica (2019) reports 7% of shared micro mobility collisions involve pedestrians. While Santacreu et al. (2020) found that non-riders, mainly pedestrians, are involved in an average 4% of e-scooter related injuries found in their systematic review of studies revolving around e-scooter related injuries.

The small number of reports revolving e-scooter injuries, points to a lack of studies in this field. However, the Norwegian Government and Norwegian Public Roads Administration (Statens Vegvesen) ordered a report of e-scooter injuries from Oslo public emergency ward (Oslo skadelegevakt) (Melhuus, Sivert and

Enger, 2020). The provisional report states the following: there have been 815 registered injuries reported to the Emergency ward during a one-year period (from 1th of April 2019 to 31th of March 2020). Furthermore, the report confirms what prior studies have found, as a large number (41%) were intoxicated, and less than 5% were using helmets.

These injuries in Oslo are mostly regarded as light and moderate, with a few numbers of severe cases. However, the difference is that the popular e-scooter season in Oslo are mostly in spring, summer, and early autumn, and only in drivable weather. There were few who travelled by shared e-scooter in the winter months. Moreover, there is no data suggesting how many person kilometers is travelled by e-scooters in the same period. Thus, it is difficult to estimate the number of injuries by using the data by Melhuus et al. (2020).

Austin public health (2018) studied injuries occurring from e-scooter accidents in a three-month period. From their findings, there were approximately 136 injuries per million person kilometers. In their reporting, they found similar data to Melhuus et al. (2020), that most (over 95 %) of the injuries were light or moderate. With their calculation, that accounts for 0,000136 injuries per person kilometers. Simultaneously, in Portland, Oregon, (PBOT, 2018b) initiated a grand pilot study on the emergence of e-scooters in their city. In their findings, in terms of injuries, there were around 130 injuries per million person kilometers. In other words, quite similar to the findings in Austin (2018). That equals 0,00013 injuries per person kilometers ridden on e-scooters. In Norway, Fearnely et al. (2020), made estimations that there were occurring 89 injuries per million person kilometers. However, this number is based on an uncertain number of person kilometers driven as well as injuries data only collected by the media.

Thus, in our calculations, we are making an estimation based on the data from Austin, Portland, and Norway. Given the more thorough calculation from Austin Public Health (2018) and Portland Bureau of Transportation (2018b), we assume that in Norway, within a year, there will be around 100 injuries per person kilometers. We believe this to be an underestimation, based on the high number of injuries and the shorter riding seasons in Norway. However, this estimation is based on real data collection. Thus, in Norway, there is estimated to be 0,0001 injuries per person kilometers ridden on e-scooters.

3.3.2 Public transit injuries

In comparison, there are only 40 injuries a year in relation to public transit in Oslo (Assum, 1995). As the findings are more than 20 years old, there is no indication of an increase in risk in the later years, as the traffic of public transit has increased in the later years. Bjørnskau (2018) argues for the risk of injuries by using public transit in Oslo to decrease, by calculating the risk development for public transit in Oslo from 2009 to 2016 measured in the number of accidents and serious incidents per million vehicle-kilometers.

To estimate the number of injuries related to public transit is difficult due to lack of information. There is no annual reporting of the number of injuries related to public transit. Sagberg and Sætermo (1997) calculated the risk of falling while inside of trams as 0,26 per million person kilometers while the risk for accidents related to boarding and disembarking as 0,71 per million travel for trams. In relation to subways, Assum (1998) calculated the risk for injuries or fatalities to be 0,06 per million person kilometers between 1987-1996. For trains the risk is at 0,009 per million person kilometers. However, there are levels of uncertainty for whether the data includes accidents outside the carriage, such as accidents on the tracks. Nevertheless, from the data, we see that there is a higher risk of accidents for trams and subways, compared to trains, which is intuitive due to the higher numbers of departures and travelers using urban transport (trams and subway compared to regional transport (trains).

For buses, there is a lack of newer data. Sagberg and Sætermo (1997) conducted a thorough study on accidents related to buses. They found that the risk of falling while inside the bus to be 0,22 per million person kilometers, and the risk of accidents when boarding or disembarking the bus to be 0,27 per million person kilometers. In other words, according to Sagberg and Sætermo (1997), there is a higher risk of injuries when travelling with trams compared to buses. This is not intuitive, as buses have a freer flexibility of moving, while trams are restricted by the tracks it can travel on. Furthermore, Elvik (2004) used police reported traffic accidents to calculate the risk of injuries related to bus-travels and found that the risk was as low as 0,042 per person kilometers. However, as this data is purely based on police reported accidents, the numbers cannot be regarded as accurate data. There are accidents occurring without the police involvement, often related to abrupt braking or while boarding and disembarking the buses. Bjørnskau (2018) also collected data from one of the bus companies, Nettbuss, which reported a risk of injuries to be approximately 0,04 per person kilometer. The low risk may be due to its regional travels, as Nettbuss do not travel in urban areas, but more in regional areas. The traffic onboard a bus in urban areas are prone to high risk, as more people are standing and there is a higher frequency of boarding and disembarking compared to regional journeys.

The only recent information on injuries related to public transit are statements from the annual report from Ruter, as the executive board writes: "*2019 was a pioneering year for public transport. No one lost their lives or were reported as seriously injured in accidents involving Ruter.*" (Ruter, 2020). However, there is no mention of lighter or moderate injuries.

In his report, Bjørnskau used the data from previous years to make current estimates on the risk of injuries related to public transport. Based on the data from Sagberg and Sætermo (1997), Bjørnskau assumes the risk of injuries related to trams to be reduced the later years, as the traffic of trams have increased in the later years parallelly to the Government focus on increasing public transport (and reducing car traffic) in urban areas according to the zero growth target. Thus, he estimates the risk of injuries related to trams to be 0,1 per person kilometers. For subways, Bjørnskau also reduces Assum's (1998) numbers and estimates a risk of injuries to be 0,03 per person kilometers. In relation to bus journeys, he estimates similar risk of injuries as trams at 0,1 per person kilometers. For all forms of transportation, Bjørnskau assumes one out of ten injuries to be severe, while the rest to be light injuries.

Thus, in our calculation on the number, and consequently the cost, of injuries related to public transit, we use Bjørnskau's updated estimates and combine this with Ruter's (2020) data from their annual report to estimate the data. Ruter announced that their subway facilitated the travels of 717 million person kilometers in 2019. Moreover, commuters travelled 169 million person kilometers with trams. With city buses, commuters travelled 554 million person kilometers. By combining these numbers with Bjørnskau's (2018) estimates of injuries, we can estimate a total number of injuries in 2019 to be 94. According to Ruter's board of executives (2019), there were no fatalities or severe injuries in 2019, and hence, we can exclude Bjørnskau's (2019) assumption of one out of ten injuries to be severe. Given the estimates, there should have occurred 94 injuries related to public transit in Oslo's urban area. However, this number is assumed to be lower as the local media reported zero to few incidents related to public transit. Nevertheless, 94 injuries per million person kilometer (0,000000065 injuries per person kilometers) will be the number used in the comparison to e-scooters.

3.3.3 Comparison of e-scooters and public transit

For the travelers, this data tells a story of higher risk of travelling with e-scooters compared to public transit. For the customers themselves, it does not cost much to be injured as the Norwegian government pays employees from the first day one person is absent from work due to illness or injuries. However, becoming injured has a negative effect on the life quality (welfare effect), according to surveys from Veisten et al. (2007). Thus, the costs on injuries for customers are costs of life quality. Hence, by using the numbers of injuries per person kilometers calculated previously and multiplying with the costs in life quality from Veisten et al. (2007), based on the percentage of severity of injury, we get the numbers shown in table 6.

Table 6

The costs of lost life quality due to injuries for e-scooters and public transit

	Injuries per person kilometers	Welfare affect (in NOK): Small injury: 24 380 Medium injury: 654 118 Severe injury: 3 215 742
E-scooter	0,0001	-43,1 NOK per person kilometers
Public transit	0,000000065	-0,0139 NOK per person kilometers

Hence, based on the number of the price of using e-scooter and public transit and the cost of reduced life quality (Veisten et al., 2007) (numbers seen in table 8), the total cost of the different forms of transportation for commuters is in Table 7.

Table 7

Comparison of e-scooters and public transit for the customer link.

	Cost of use (single ticket + monthly pass). *	Cost of reduced life quality. *	Total cost for customer. *
E-scooter	-49,975 NOK	-43,1 NOK	-93,075 NOK
Public transit	-12,059 NOK	-0,0139 NOK	-12,0729 NOK

* per person kilometer

3.4 Government link

When calculating the governmental link, Olson (2013b) excludes governmental subsidies to understand the viability of the business side of green technology. In his comparison on hybrid versus conventional cars, the Hybrid side is supported by governmental subsidies to be perceived as attractive by the consumers. In our example, public transit is the one that is receiving subsidies from the government. Nevertheless, as mentioned, we will calculate with governmental subsidies in our paper. As Norway has a state-funded health system, any accident resulting in injury will be a burden on the taxpayers as much as the governmental subsidies. Thus, to understand the burden for the taxpayers, this paper will calculate the cost of both governmental subsidies and injuries to grasp a wholesome understanding on which form of transportation is more attractive for the government.

In Norway, the number of traffic-related accidents leading to fatality or severe injuries have been gradually declining over the past decades, and in 2019 there was reported 108 fatalities and 565 severely injured (SSB, 2019). Norway is regarded to have the safest roads in the world, according to the International Traffic Forum (ITF) (2019). However, the Norwegian government is still focused on improving further, to achieve their zero-vision from 2002: to have zero fatalities or severe injuries in Norwegian traffic (Statens vegvesen, 2018).

Most of the fatal accidents are related to cars, both driver and passengers, and motorcycles. They account for over 80 % of fatalities and severe injuries (SSB, 2019). Regarding public transit and e-scooters, most injuries are considered as light or moderate injuries. Bjørnskau (2018) discusses the effect of moving commuters from cars to other forms of transportation in Norway. He finds that there is a spike in the amount of injuries, but the injuries are less serious. This movement of commuters is a part of a zero-growth target in urban areas set by the Norwegian government, where the goal is for all transportation growth in urban areas to relate to public transit, walking or micro mobility:

> "*The zero growth target was set by the Parliament in the Climate Agreement in 2012, and means that the growth in passenger transport in urban areas must be taken into account with public transport, cycling and walking. The goal was then used as a basis in the National Transport Plan 2014-2023 and 2018-2029*". (Regjeringen, 2020)

Thus, in the perspective of cars and injuries, both public transit and e-scooters should be preferable forms of transportation for the Norwegian government. However, between public transit and e-scooter, there is a noteworthy difference where e-scooter causes a significantly higher amount of injuries.

3.4.1 Cost of medical treatment

The Norwegian social welfare system is regarded as one of the best in the world. The most fundamental part of this system is public funded hospitals and where medical treatment is free. Thus, when accidents occur, the taxpayers cover the costs of the incidents and the injuries. In the calculations of the cost of injuries, there are different reports on what the total welfare cost is based on the severity of the traffic incidents.

In one report, Veisten, Flügel and Elvik (2010) conducted a valuation study on the total cost per injury at the various degrees of severity. This cost includes the real economic components; such as (1) medical costs, which are all costs related to medical treatment of traffic injuries, including costs for transport from the scene of the injury to the place of treatment, (2) material costs, which are costs of repairing material damage caused by accidents, possibly replacing vehicles that cannot be repaired, (3) administrative costs, which are all additional resources used for administration due to accidents. this includes both public and private administration, and (4) loss of production and productive capacity, which is the value of lost production or productive capacity as a result of people leaving the workforce permanently or temporarily (Veisten et al., 2010). In addition, the authors also include the *welfare effect* or quality of life in their calculations, which is the value of statistic lives/limbs and is based on expressed preference from surveys. Thus, in their calculation, Veisten et al. (2010) claims the total cost of per injury is 614 000 NOK for lighter injuries. The costs increase based on severity up to fatality, which is estimated to cost 30 million NOK. The numbers are based on general traffic accidents, from trail truck to bicycle incidents. Hence, these numbers may be regarded as artificially higher than what is realistic for this paper.

Furthermore, Veisten et al. (2007) made suggestions for the cost of injuries by the severity of the injury related to bicycling accidents. Their estimations are modest compared to Veisten, et al. (2010), and the cost of a small bicycle injury is estimated to be at 43 000 NOK, while fatality is estimated at over 21 million NOK. Table 8 shows the difference in costs between the different levels of severity of bicycle accidents.

As seen, there is a noteworthy difference between a small and moderate injury. What defines small and moderate injuries, is not clear in Veisten et al. (2007) report. However, the separation of small, moderate, and severe injuries is also present in Melhuus et al. (2020) report on injuries in Oslo. Hence, we assume the papers have the same definition of each level of severity. Therefore, given the closeness of e-scooter and bicycles, the paper will use Veisten et al. (2007) calculation estimates of governmental costs. Moreover, this paper will not include the cost of welfare effect or quality of life, but purely focus on the real economic components, as these are the ones affecting the government.

Table 8

Governmental costs of injuries, based on severity, in NOK (Veisten et al. (2007))

Cost components	Small	Moderate	Severe	Very severe	Fatality
- Medical	4 176	57 002	211 596	246 870	9 822
- Production cost	5 186	68 082	1 116 867	2 363 651	5 650 246
- Material	3 563	3 563	4 875	4 875	5 813
- Administrative	5 454	76 798	79 847	91 920	68 756
- Traffic delays	232	4 978	5 989	5 253	8 185
- Welfare effect	24 380	654 118	1 769 569	3 692 548	15 584 627
Total	42 990	864 541	3 215 742	6 405 116	21 327 449
Total*	18 610	210 423	1 446 173	2 712 568	5 742 822

* (without welfare effect)

Based on the data of the risk of injuries per person kilometers and the governmental cost of injury, we can calculate how much the injuries cost the government per person kilometer for e-scooters and public transit. For e-scooters, we calculated that risk of injury to be 0,0001 per person kilometers. Moreover, from Melhuus et al. (2020), we know how the severity of injuries is ranged; small injury (68 %), moderate injury (24 %) and severe injury (8 %). For all public transit, the calculation estimated the risk of injury to be 0,000000065 per person kilometers. There was reported no severe injury according to Ruter (2020). Without any numbers on the degree of small or moderate injury, we assume similar differentiation as for e-scooters with 70 % of injuries to be small injuries, and 30 % to be moderate injuries. We calculate the following governmental cost of injuries per person kilometers in Table 9.

Table 9

Governmental cost of injuries for e-scooters and public transit, in NOK

	Risk of injury	Cost of Small injury	Cost of moderate injury	Cost of severe injury	Total cost*
E-scooter	0,0001	1,26548	5,050152	11,569384	17,885016
Public transit	0,000000065	0,00084676	0,00410325	0	0,00495

* per person kilometer

3.4.2 Subsidies

Ruter receives subsidies from the Norwegian government, as it is in the government's interest to move commuters to public transit in urban areas, according to the zero-growth target (Regjeringen, 2020). The shared e-scooter companies do not receive any subsidies. However, in addition to the costs for e-scooters themselves, as mentioned, 23% of riders in Oslo would choose public transit if the e-scooter was not available (Fearnley et al., 2020). Thus, e-scooter reduces the load factor on public transit and, as the public transit still runs whether there are one or a hundred passengers, the profitability for public transit per person kilometers. Hence, the reduced load factor for public transit is regarded as a negative effect of e-scooters, and thus, the lost income of 0,4678 NOK per person kilometers for public transit, where 0,3667 % is covered from average subsidies (Ruter, 2020), is added as extra cost for e-scooters. Thus, e-scooters have a negative effect of 0,1715 NOK per person kilometers on subsidies.

For public transit, Ruter reports the number for economic subsidies received annually for every form of transportation. In 2019, the trams received 438 million NOK in subsidies from the government, subways received 469 million NOK, while city buses received 581 million NOK. Therefore, by dividing these numbers with the numbers of total person kilometers travelled with each form of transportation, and taking the average, the calculation shows that public transport cost 1,43 NOK per person kilometers in subsidies.

3.4.3 Comparison of e-scooters and public transit

Hence, for the total calculation of governmental cost of e-scooters and public transit, we combine the cost of injury and subsidies received. From Table 10, we can therefore conclude that the governmental cost of e-scooter and public transit per person kilometers as following; for e-scooter NOK 17,89 per person kilometers and for public transit NOK 1,47 per person kilometers.

Table 10

Cost comparison between e-scooters and public transit for government link.

	Governmental cost of injuries*	Cost of subsidies received from the government*	Total cost for the government*
E-scooter	-17,885016 NOK	- 0,1715 NOK	-18,06 NOK
Public transit	-0,00495 NOK	-1,43 NOK	-1,47 NOK

* per person kilometer

3.5 Environment link

E-scooters are often promoted as an environmentally friendly means of transport (Hollingsworth et al., 2019; Moreau et al., 2020). One of the providers, Tier, thanks their customers for riding with them after finishing a trip, stating that “With us, you are riding climate-neutral” (Appendix 2). However, it has been questioned by researchers whether the e-scooters are as environmentally friendly as the providers promote.

3.5.1 Life-cycle assessment

Even though there are no tailpipe emissions during the trips since the motor is electric, it is important to consider the environmental impact of the entire life cycle (Hollingsworth et al., 2019; Moreau et al., 2020). This includes how the vehicles are made, what type of transportation they are replacing and the lifetime of the scooters (Hollingsworth et al., 2019). Due to the fact that the shared e-scooters are fairly new to the market, evidence on the life-cycle impact is limited. Researchers at The North Carolina University were the first to look at the full life-cycle emissions including production, shipping, charging, collecting and disposing of the e-scooters (Hollingsworth et al., 2019).

Research has found that the manufacturing phase is one of the biggest contributors to emissions related to e-scooters. Hollingsworth et al. (2019) disassembled an e-scooter (model Xiaomi M365) that is representative of the model the pioneer Bird deployed in their fleet. They conducted a Monte Carlo analysis, where they investigated several scenarios. In their base case, they found that the materials and manufacturing phase accounts for 50% of the total global warming impact from the e-scooters. Furthermore, aluminum, which constitutes for almost 50% of the total weight of the scooter, is the main driver (Moreau et al., 2020). The e-scooters and the battery are assembled in China and need to be transported to Oslo. However, the transportation from the manufacturer is found to be non-significant in the case from Raleigh, North Carolina (Hollingsworth et al., 2019).

The environmental impacts of the use phase are influenced by the distance each scooter travels each day, the method for collecting, charging and redistributing the scooters, and the frequency of charging (Hollingsworth et al., 2019). The distance traveled for collecting and distributing e-scooters ranges from 1 to 4 kilometers per scooter in Raleigh, North Carolina (Hollingsworth et al., 2019). In the base case, collection and distribution accounts for 43% of the total global warming impact. The electricity used for charging the e-scooters only contributes with 4,7% of the total impact (Hollingsworth et al., 2019). The researchers suggest that alternative methods for collection and distribution have the potential to reduce the environmental impact significantly. By reducing the average distance driven to collect and distribute to 1 kilometer per scooter, the average impact can be reduced by 27%. Moreover, by only using fuel efficient vehicles the impacts can be reduced with 12% (Hollingsworth et al., 2019).

As earlier mentioned, the e-scooters do not last long (Hollingsworth et al., 2019). Maintenance is an important tool in order to extend the lifetime of the scooters, and the parts that are in a good condition are dismantled from broken scooters by a mechanic and used to repair other e-scooters (Moreau et al., 2020). According to Hollingsworth et al. (2019), the total global warming impacts could be reduced to

90 gram CO_2 per passenger kilometer if the lifetime of the e-scooters were increased to two years which is the warranty of the scooters.

3.5.2 Comparison of e-scooters and public transit

In a comparison of average carbon emission by transport mode conducted by Lufthansa Innovation Hub, dockless e-scooters were ranked as 14th (Lewin, 2019). Results show that the shared e-scooters are more environmentally friendly than hybrid, diesel and gasoline cars, gasoline driven motorbikes, autobuses and ferries. Further, it is found that e-scooters are less environmentally friendly than bicycles (both regular and electric), electric and plug-in hybrid cars, public transit such as buses, trams and trains and of course walking. This is consistent with the findings by Hollingsworth et al. (2019) where the global warming impact of e-scooters are more than two and a half times as high as for buses. A comparison of the global warming impact of e-scooters and public transit is presented in Table 11. It should be noted that the comparison does not include subways, since they were not included in the reported findings. However, we assume subways to be equal, or close, to trams due to the similarities between them.

Table 11

Life cycle global warming impacts (CO_2 per passenger kilometer) (Hollingsworth et al., 2019; Lewin, 2019).

Shared e-scooters	Bus	Electric bus	Tram
126 grams	52 grams	25 grams	37 grams

As earlier mentioned, the e-scooters are mostly replacing walking (60%) and public transport (23%) in Oslo. Only 8% replaces the use of personal cars and taxis (Fearnley et al., 2020). In addition, they found that the e-scooters are a part of an intermodal chain where the riders combine their trips with other types of transportation, such as public transit and walking (Fearnley et al., 2020). The findings from Oslo shows that there are a significantly lower percentage that displaces cars compared to other cities. In the study conducted in Raleigh, North Carolina, the researchers found that 34% would have used a personal car or ride-share service instead of the electric scooter, approximately 50% would have used a bicycle or walked instead, 11% would have taken public transit and 7% would have skipped the trip completely (Hollingsworth et al., 2019). Moreover, in Brussels, Belgium they found that 26,7% would have used a car, 29,2% public transit, 26,1% would have walked, 15,7% would have used an electric or regular bicycle and 2,3% another type of transportation (Moreau et al., 2020). These results indicate that there are differences in the use of e-scooters across different cities and countries.

In addition to the emissions caused throughout the life cycle of the transportation-vehicles, the e-scooter, as mentioned, caused a reduced load factor on public transit as they 'steal' passengers from them. Therefore, e-scooter has an added load factor related emission of 8,74 CO_2 per passenger kilometer, based on numbers from Fearnley et al. (2020) and Ruter (2020). In table 12, the added emission of load factor is added for e-scooter.

Table 12

Life cycle global warming impacts (CO_2 per passenger kilometer) with added load factor

Shared e-scooters	Bus	Electric bus	Tram
134,74 grams	52 grams	25 grams	37 grams

3.5.3 Greenwashing

Due to the fact that e-scooters often replace alternatives that are more environmentally friendly, it can be argued that the e-scooters are not as green as the companies' state. Hence, the e-scooter providers might be greenwashing when claiming that their service is climate-neutral. Greenwashing has been defined in several ways, but one of the most used definitions states that greenwashing is "the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service" (Delmas & Burbano, 2011; Rahman, Park & Chi, 2015; Lyon & Maxwell, 2011). According to Delmas and Burbano (2011), companies who greenwash are engaging in two types of behavior; poor environmental performance and communication that is positive about the company's environmental performance.

Several researchers have highlighted the negative effects of greenwashing. It leads to confusion of the consumers, as they perceive it as difficult to identify legitimate green products (Johnstone & Tan, 2015; Pomering & Johnson, 2009; Furlow, 2010). Studies have shown that trust in green products are negatively influenced by greenwashing (Chen & Chang, 2013). Further, consumers react with skepticism and become more cynical towards companies that claim that their products are environmentally friendly (Crane, 2000). This can also negatively affect companies that are not greenwashing, because the consumers are in general skeptical towards products that are promoted as environmentally friendly (Borin, Cerf & Krishnan, 2011). Therefore, the market for green products in general can be severely damaged by greenwashing.

4. Results

The results from the Green Innovation Value Chain analysis presented in table 13 suggests that the e-scooters are not exceeding the financial performance for the customers or the government compared to public transit. Additionally, with the short lifespan and manufacturing process of the e-scooters, the environmental impact is higher in comparison to public transit. On the other hand, the e-scooters pose as financially attractive for the manufacturers and the distributors. It should be noted that since e-scooters are still a new phenomenon, there is potential for efficiency and higher profitability.

Nevertheless, for the distributors there are some reports that provide examples of how e-scooters are not sustainable in the long-term. In BCG's calculations, they provide dark numbers for e-scooter, estimating a three months lifespan, while calculating the break-even time period to be 3,8 months (Schellong et al, 2018), where we found the breakeven point to be 5,5 months, largely influenced by the seasonal weather. This proves the inefficiencies new green products experiences, and why the need for subsidies is sufficient. In addition, the need for strong market penetration of their products to become profitable (Olson, 2014).

Table 13:

E-scooters Green Innovation Value Chain results per person kilometer

		E-scooter	Public transit	E-scooter vs public transit
Manufacturer link	profit	0,75*	0,00057*	0,75*
Distributor link	profit	4,2938*	-1,2838*	5,58*
Customer link	costs	-93,075*	-12,0729*	-81,00*
Government link	costs	-18,06*	-1,47*	-16,59*
Environmental link	emission	134,74 grams	52 grams	-82,74 grams
All links	profit	-100,97*	-14,8223*	-91,26*

* in NOK.

5. Discussion and conclusion

To sum up, shared e-scooters have become a popular method of transportation and represent a solution to problems related to urban congestion and the first- and last-mile problem. Nevertheless, there are several challenges that need to be faced. Firstly, since e-scooter trips often replace more environmentally friendly alternatives, one can argue that the total emissions related to transportation has increased. Furthermore, the environmental results of e-scooters would be even worse compared to walking, which is the transportation method that is replaced the most by the e-scooter. Therefore, other factors should be highlighted when promoting e-scooters, such as the convenience and fun. However, this might be seen as problematic since the taxpayers have to pay for the medical expenses related to injuries. Secondly, the providers are facing an uncertain future even though the scooter-sharing market in Oslo is big. The demand for regulations has escalated, and the government has stated that they will enforce new restrictions within the summer of 2021. This could for example include a reduction in the total number of e-scooters allowed in Oslo, which might affect the profitability of the providers. Thirdly, the number of injuries related to e-scooters have been a central issue, and several alternatives for improvement have been proposed. For example, making it impossible to ride the e-scooters at night will most likely lead to a reduced number of injuries, since more than half of the injuries in Oslo occur at night. However, this may have consequences for the environmental link if all the e-scooters are collected from the streets each night.

Another subject that has been discussed related to the injuries is that less than 5% of the people who were injured wore a helmet. If helmet use became mandatory it would reduce the severity of the injuries, but make it less convenient for the customer since they have to carry a helmet. This is especially related to situations where the customers have not necessarily planned to ride an e-scooters in advance. One of the providers, Tier have announced that they will launch a foldable helmet that can be found in a box on the e-scooter (Bugge, 2020c). This reduces the possible inconvenience of helmet use and is not causing the customer an additional cost. Furthermore, Tier states that they will perform a quality control for every fifth use as well as disinfection.

This GIVC analysis also raises questions of new innovations and business models considered green. The new wave of green sharing business models is often perceived as environmentally ‘better’ than the conventional alternative. However, in the comparison of two perceivable green options, this paper suggests that the conventional, pre-existing alternative performs better than the new disruptor. In addition, it is noteworthy to mention that public transit will continue to run, whether it is one passenger or one hundred passengers. Thus, each customer choosing e-scooter over public transit affects the revenues of public transit due to lost income while maintaining the same cost, as well as the extra contribution to pollution with increased emission from e-scooters, as proven in the results.

In addition, this GIVC analysis also proves its importance for government and policy makers. As e-scooters do fit well with the Norwegian government’s zero growth target (Regjeringen, 2020), the cost of increased total emission (though the emission is mostly affected abroad, due to the manufacturing process) and especially the cost of injuries is forcing policy makers to rethink their decision. Thus, the importance of undergoing GIVC analysis could provide useful guidance.

There are limitations related to this analysis. Especially in terms of the usage of this tool, where pressure to greenwash (or demonize) new innovations may cause inaccurate calculations of its financial and environmental attractiveness. Examples of inaccurate calculations may be to over- or underestimate the lifespan, profit margins, emissions, societal effect or other forms of data to confirm their argument. Additionally, since the providers of the e-scooters are constantly adjusting their scooters as an effort to extend the lifespan, the environmental impact might have improved.

Moreover, when analyzing new innovations, there are limitations of gathered data and reporting. Most reports and analysis of e-scooter has occurred the last three years, and there are constantly new articles occurring with newer and more accurate perspectives. Thus, this paper is limited by the collected secondary data as Olson (2014) argues: "Unrealistic GIVC link assumptions are likely to be most problematic when dealing with totally new green technologies that do not have well-established performance and cost data available." (Olson, 2014, p. 79). However, the GIVC analysis provides a clear distinction between the two forms of transportation, enough for each stakeholder to rethink their decisions in the long-term.

References

6t-bureau de recherche (2019, June 6), Usages et usagers de services de trottinettes électriques en freefloating en France. *6-T*. Retrieved from: https://www.ademe.fr/usages-usagers-trottinettes-electriques-freefloating-france.

Aker, S. N. (2020, July 22). Elsparkesyklene lever ikke lenger enn 29 dager - Nå tar aktørene grep. *Finansavisen.* Retrieved from https://finansavisen.no/nyheter/transport/2020/07/22/7549497/elsparkesykler-lever-ikke-lenger-enn-29-dager-na-vil-aktorene-gjore-noe-med-det

Ambec, S., & Lanoie, P. (2008). Does it pay to be green? A systematic overview. *The Academy of Management Perspectives*, 45-62.

Assum, T. (1995). Døds-og personskaderisiko i persontransport. Accident analysis and Prevention, 27(4), 503-521.

Austin Public Health (2019, April). Dockless electric scooter-related injuries study. *City of Austin*. Retrieved from: https://www.austintexas.gov/sites/default/files/files/Health/Epidemiology/APH_Dockless_Electric_Scooter_Study_5-2-19.pdf

Ayres, R. U. (1995). Life cycle analysis: A critique. *Resources, Conservation and Recycling*, 14(3-4), 199-223.

Bardhi, F., & Eckhardt, G. M. (2012). Access-based consumption: The case of car sharing. *Journal of Consumer Research*, *39*(4), 881-898.

Baumann, H., Boons, F., & Bragd, A. (2002). Mapping the green product development field: engineering, policy and business perspectives. *Journal of cleaner production*, 10(5), 409-425.

Bekhit, M. N. Z., Le Fevre, J., & Bergin, C. J. (2020). Regional healthcare costs and burden of injury associated with electric scooters. *Injury*, 51(2), 271-277.

Belk, R. (2007). Why not share rather than own?. *The Annals of the American Academy of Political and Social Science*, *611*(1), 126-140.

Berge, J (2019, August 28). Her blir Oslos nye trikk avslørt. *Nettavisen*. Retrived from: https://www.nettavisen.no/nyheter/her-blir-oslos-nye-trikk-avslort/3423836537.html

Bjørnskau, T. (2018). Flere trafikkskader av nullvekstmålet. Effekter av å flytte framtidige reiser fra bil til andre transportmidler. TØI rapport, 1631, 2018.

Bocken, N. M., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, 42-56.

Borin, N., Cerf, D. C., & Krishnan, R. (2011). Consumer effects of environmental impact in product labeling. *Journal of Consumer Marketing*.

Botsman, R., & Rogers, R. (2010). What's mine is yours. *The Rise of Collaborative Consumption*.

Breian, Å (2019, April 25). Elsparkesyklene varer fra rundt en til rundt seks måneder. *Aftenposten.* Retrieved from https://www.aftenposten.no/norge/i/2GVPER/elsparkesyklene-varer-fra-rundt-en-til-rundt-seks-maaneder

Bugge, T. N (2020a, June 25). Leie elsparkesykkel? Dette selskapet er best og billigst. *Tek.no.* Retrieved from https:/www.tek.no/nyheter/guide/i/XgPoLm/leie-sparkesykkel-dette-selskapet-er-best-og-billigst

Bugge, T. N. (2020b, July 3). *Voi følger Lime - lanserer månedskort på elsparkesykkel.*Retrieved from https://www.tek.no/nyheter/nyhet/i/na8Pdd/voi-flger-lime-lanserer-manedskort-pa-elsparkesykkel

Bugge, T. N. (2020c, May 22). Tier lanserer sammenleggbar hjelm. *Tek.no.* Retrieved from https://www.tek.no/nyheter/nyhet/i/LAwmO4/tier-lanserer-sammenleggbar-hjelm

Caspi, O., Smart, M. J., & Noland, R. B. (2020). Spatial associations of dockless shared e-scooter usage. *Transportation Research Part D: Transport and Environment*, *86*, 102396.

Chen, Y. S., & Chang, C. H. (2013). Greenwash and green trust: The mediation effects of green consumer confusion and green perceived risk. *Journal of Business Ethics*, *114*(3), 489-500.

City of Santa Monica (2019). Shared mobility pilot program summary report. City of Santa Monica. Retrieved from: https://www.smgov.net/uploadedFiles/Departments/PCD/Transportation/SantaMonicaSharedMobilityEvaluation_Final_110419.pdf

Cooney, G., Hawkins, T. R., & Marriott, J. (2013). Life cycle assessment of diesel and electric public transportation buses. *Journal of Industrial Ecology*, *17*(5), 689-699.

Crane, A. (2000). Facing the backlash: green marketing and strategic reorientation in the 1990s. *Journal of Strategic Marketing*, *8*(3), 277-296.

Dacko, S. G., & Spalteholz, C. (2014). Upgrading the city: Enabling intermodal travel behaviour. *Technological Forecasting and Social Change*, *89*, 222-235.

Dague, J (2018). Getting back on track: replacing and repairing subway cars will be expensive and take more than a decade. Citizen Budget Commission. Retrieved from: https://cbcny.org/sites/default/files/media/files/REPORT_MTASubwayCars_07182018_1.pdf

Delmas, M. A., & Burbano, V. C. (2011). The drivers of greenwashing. *California management review*, *54*(1), 64-87.

Denver Public Works (2019). Denver Dockless Mobility Program Pilot Interim Report – February 2019. *Denver Public.* Retrieved from: https://www.denvergov.org/content/dam/denvergov/Portals/705/documents/permit s/Denver-dockless-mobility-pilot-update-Feb2019.pdf

Efrati, A. & Weinberg, C. (2018, October 23). Inside Bird's Scooter Economics. *The Information*. Retrieved from: https://www.theinformation.com/articles/inside-birds-scooter-economics

Elvik, R. (2004). Transportarbeid og risiko for ulike trafikantgrupper. *Transportøkonomisk institutt*. 1607.

Endr. i forskrift om krav til sykkel (2018). Forskrift om endring i forskrift om krav til sykkel (FOR-2018-04-09-545). Retrieved from https://lovdata.no/dokument/LTI/forskrift/2018-04-09-545

Eccarius, T., & Lu, C. C. (2020). Adoption intentions for micro-mobility–Insights from electric scooter sharing in Taiwan. *Transportation Research Part D: Transport and Environment*, *84*.

Fang, K., Agrawal, A. W., Steele, J., Hunter, J. J., & Hooper, A. M. (2018). Where Do Riders Park Dockless, Shared Electric Scooters? Findings from San Jose, California. *San Jose State University*.

Fearnley, N., Berge, S. H., & Johnsson, E. (2020). Delte elsparkesykler i Oslo. Transportøkonomisk institutt. https://www.toi.no/getfile.php/1352254-1581347359/Publikasjoner/T%C3%98I%20rapporter/2020/1748-2020/1748-2020-elektronisk.pdf

Finnveden, G. (2000). On the limitations of life cycle assessment and environmental systems analysis tools in general. *The International Journal of Life Cycle Assessment*, 5(4), 229.

Frenken, K. (2017). Sustainability perspectives on the sharing economy. *Environmental Innovation and Societal Transitions*, *100*(23), 1-2.

Furlow, N. E. (2010). Greenwashing in the new millennium. *The Journal of Applied Business and Economics*, *10*(6), 22.

Gjerde, R. (2020, February 6). Oslo-byrådet varsler strengere regulering av el-sparkesykler. *Aftenposten.* Retrieved from https://www.aftenposten.no/osloby/i/kJG7bL/oslo-byraadet-varsler-strengere-regulering-av-elsparkesykler

Gössling, S. (2020). Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change. *Transportation Research Part D: Transport and Environment*, *79*, 102230.

Griswold, A (2019, March 1). Shared scooters don't last long. Quartz. Retrieved from https://qz.com/1561654/how-long-does-a-scooter-last-less-than-a-month-louisville-data-suggests/

Hagesæther, P. V. (2019, August 9). Da jeg var hunter, rider og street crew. *Aftenposten*. Retrieved from https://www.aftenposten.no/a-magasinet/i/K3lMWo/da-jeg-var-hunter-rider-og-street-crew

Harnes, M. P. (2020, July 28). Regjeringen: Nytt regelverk for el-sparkesykler før neste sommer. *Shifter*. Retrieved from https://shifter.no/nyheter/regjeringen-nytt-regelverk-for-el-sparkesykler-for-neste-sommer/188234

Heineke, K., Kloss, B., Scurtu, D., & Weig, F. (2019). Micromobility's 15,000-mile checkup. *McKinsey & Company Automotive & Assembly. Retrieved from: https://www. mckinsey. com/industries/automotive-andassembly/our-insights/micromobilitys-15000-mile-checkup*.

Hess, D. B., & Lombardi, P. A. (2005). Governmental subsidies for public transit: History, current issues, and recent evidence. *Public works management & policy*, *10*(2), 138-156.

Hollingsworth, J., Copeland, B., & Johnson, J. X. (2019). Are e-scooters polluters? The environmental impacts of shared dockless electric scooters. *Environmental Research Letters*, 14(8).

ISO (International Organization for Standardization). (2006). *Environmental Management: Life Cycle Assessment; Principles and Framework* (No. 2006). ISO.

ITF (2019). Road Safety Annual Report 2019. Retrieved from: https://www.itf-oecd.org/sites/default/files/docs/irtad-road-safety-annual-report-2019.pdf

James, O., Swiderski, J. I., Hicks, J., Teoman, D., & Buehler, R. (2019). Pedestrians and e-scooters: An initial look at e-scooter parking and perceptions by riders and non-riders. *Sustainability*, *11*(20), 5591.

Jansen, V. (2019, March 31). Tier og Voi – To forskjellige utleietjenester for elektriske sparkesykler. *Tek.no*. Retrieved from https://www.tek.no/nyheter/nyhet/i/dOjgOJ/tier-og-voi-to-forskjellige-utleietjenester-for-elektriske-sparkesyk

Johannessen, E. B. (2020, July 16). Voi tapte 715 mill. kroner i fjor - tror på lønnsomhet i 2021. *Dagens Næringsliv.* Retrieved from https://www.dn.no/samferdsel/voi/elsparkesykler/elektriske-sparkesykler/voi-tapte-715-mill-kroner-i-fjor-tror-pa-lonnsomhet-i-2021/2-1-843802

Johnstone, M. L., & Tan, L. P. (2015). An exploration of environmentally-conscious consumers and the reasons why they do not buy green products. *Marketing Intelligence & Planning*.

Kobayashi, L. M., Williams, E., Brown, C. V., Emigh, B. J., Bansal, V., Badiee, J., ... & Doucet, J. (2019). The e-merging e-pidemic of e-scooters. *Trauma surgery & acute care open*, 4(1), e000337.

Lewin, A (2019, December 11). Electric scooters: not so "green" after all. *Sifted backed by Financial Times.* Retrieved from https://sifted.eu/articles/electric-scooters-green-comparison/

Light, B., Burgess, J., & Duguay, S. (2018). The walkthrough method: An approach to the study of apps. *New media & society*, *20*(3), 881-900.

Lyon, T. P., & Maxwell, J. W. (2011). Greenwash: Corporate environmental disclosure under threat of audit. *Journal of Economics & Management Strategy*, *20*(1), 3-41.

Løkken, N. (2020, August 1). Sabotasje mot en rekke elsparkesykler – maler over QR-kodene. *TV2.* Retrieved from *https://www.tv2.no/nyheter/11563822/*

Mayhew, L. J., & Bergin, C. (2019). Impact of e-scooter injuries on Emergency Department imaging. Journal of medical imaging and radiation oncology, 63(4), 461-466.

McKenzie, G. (2020). Urban mobility in the sharing economy: A spatiotemporal comparison of shared mobility services. *Computers, Environment and Urban Systems*, *79*, 101418.

Melhuus, K., Siverts, H., & Enger, M. (2020, June 25). El-sparkesykkelskader i Oslo. *Oslo Univeristetssykehus*. Retrieved from https://oslo-universitetssykehus.no/seksjon/nyheter/Documents/Sparkesykkelskader%202019.pdf

Moreau, H., de Jamblinne de Meux, L., Zeller, V., D'Ans, P., Ruwet, C., & Achten, W. M. (2020). Dockless E-Scooter: A Green Solution for Mobility? Comparative Case Study between Dockless E-Scooters, Displaced Transport, and Personal E-Scooters. *Sustainability*, *12*(5), 1803.

Møller, T. H. & Simlett, J. (2020, April 14). Micromobility: moving cities into a sustainable future. EY. Retrieved from https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/automotive-and-transportation/automotive-transportation-pdfs/ey-micromobility-moving-cities-into-a-sustainable-future.pdf

NKT-Traume (2019, Nov 21) Elsparkesykler og skader – hva vet vi så langt? *NKT-Traume.* Retrieved from: https://nkt-traume.no/2019/11/elsparkesykler-og-skader-hva-vet-vi-sa-langt/

Norris, G. A. (2001). Integrating life cycle cost analysis and LCA. *The International Journal of Life Cycle Assessment*, *6*(2), 118-120.

NTB (2020a, July 27). Oslo får 2.000 nye elsparkesykler. *E24*. Retrieved from https://e24.no/i/0nMrr2/oslo-faar-2000-nye-elsparkesykler

NTB (2020b, July 31). Legevakten i Oslo ber om elsparkesykkel-stand om natten. Vg. Retrieved from https://www.vg.no/nyheter/innenriks/i/wP7kxG/legevakten-i-oslo-ber-om-elsparkesykkel-stans-om-natten

NTB (2020c, March 5). Året vi startet å voie. *NTB Kommunikasjon. Retrieved From https://kommunikasjon.ntb.no/pressemelding/aret-vi-startet-a-voie?publisherId=17847264&releaseId=17880861*

Olson, E. L. (2013a). Perspective: the green innovation value chain: a tool for evaluating the diffusion prospects of green products. *Journal of Product Innovation Management*, 30(4), 782-793.

Olson, E.L., (2013b). It's not easy being green: the effects of attribute tradeoffs on green product preference and choice. *Journal of the Academy of Marketing Science* 41 (2), 171-184.

Olson, E. L. (2014). Green innovation value chain analysis of PV solar power. *Journal of Cleaner Production*, 64, 73-80.

Oostendorp, R., & Gebhardt, L. (2018). Combining means of transport as a users' strategy to optimize traveling in an urban context: empirical results on intermodal travel behavior from a survey in Berlin. *Journal of Transport Geography*, *71*, 72-83.

PBOT (2018a). 2018 E-Scooter Findings Report. Portland Bureau of Transportation. https://www.portlandoregon.gov/transportation/article/709719

PBOT (2018b). 2018 E-Scooter Pilot User Survey Results. Portland Bureau of Transportation. www.portlandoregon.gov/transportation/article/700916.

Petrin, K. (2019). St. Louis begins rolling out safety updates for Bird, Spin and Lime scooters. *St. Louis Public Radio*. Retrieved from: https://news.stlpublicradio.org/post/st-louis-begins-rolling-out-safety-updates-bird-spinand-lime-scooters#stream/0

Pomering, A. A., & Johnson, L. W. (2009). Advertising corporate social responsibility initiatives to communicate corporate image: Inhibiting scepticism to enhance persuasion. *Corporate Communications: An International Journal*, *14*(4), 420.

Porter, M. E., & Reinhardt, F. L. (2007). A strategic approach to climate. *Harvard Business Review*, *85*(10).

Potkány, M., Hlatká, M., Debnár, M., & Hanzl, J. (2018). Comparison of the lifecycle cost structure of electric and diesel buses. NAŠE MORE: znanstveno-stručni časopis za more i pomorstvo, 65(4), 270-275.

Rahman, I., Park, J., & Chi, C. G. Q. (2015). Consequences of "greenwashing". *International Journal of Contemporary Hospitality Management*.

Regjeringen (2020). Belønningsordningen, bymiljøavtaler og byvekst avtaler. https://www.regjeringen.no/no/tema/transport-og-kommunikasjon/kollektivtransport/belonningsordningen-bymiljoavtaler-og-byvekstavtaler/id2571977/

Ruter (2018). Utslippsfri kollektivtransport i Oslo og Akershus. Retrieved from https://ruter.no/contentassets/e7bd74c5a3724b2789c874e97ae0427b/rapport-utslippsfri-kollektivtransport-i-oslo-og-akershus.pdf

Ruter (2020) Årsrapport 2019. Retrieved from https://aarsrapport2019.ruter.no/no/

Sagberg, F., & Sætermo, I. A. (1997). Trafikksikkerhet for sporvogn i Oslo. *TØI*. 367.

Santacreu, A., Yannis, G., de Saint Leon, O., & Crist, P. (2020). Safe micromobility. *International Traffic Forum*. Retrieved from: https://www.itf-oecd.org/safe-micromobility

Schellong, D., Sadek, P., Schaetzberger, C., & Barrack, T. (2019). The promise and pitfalls of e-scooter sharing. *Europe*, *12*, 15.

Shaheen, S., & Cohen, A. (2019). Shared Micromoblity Policy Toolkit: Docked and Dockless Bike and Scooter Sharing. *UC Berkeley*.

Sikka, N., Vila, C., Stratton, M., Ghassemi, M., & Pourmand, A. (2019). Sharing the sidewalk: A case of e-scooter related pedestrian injury. *The American Journal of Emergency Medicine*, *37*(9).

SSB (2019) Trafikkulykker med personskade. *Statistisk sentralbyrå*. Retrieved from: https://www.ssb.no/transport-og-reiseliv/statistikker/vtu/aar

Stabell, C. B., & Fjeldstad, Ø. D. (1998). Configuring value for competitive advantage: on chains, shops, and networks. *Strategic Management Journal*, *19*(5), 413-437.

Statens vegvesen (2018, December 12). Nullvisjonen. Retreived from: https://www.vegvesen.no/fag/fokusomrader/trafikksikkerhet/nullvisjonen

Strømme, S. H. (2019, July 10). Dette er reglene for bruk av elsparkesykkel. *Aftenposten.* Retrieved from: https://www.aftenposten.no/osloby/i/Opa4VV/dette-er-reglene-for-bruk-av-elsparkesykkel

Temple, J. (2019, August 2). Sorry, scooters aren't so climate friendly after all. *MIT Technology review*. Retrieved from https://www.technologyreview.com/2019/08/02/646/electric-scooters-arent-so-climate-friendly-after-all-lime-bird/

Trivedi, T. K., Liu, C., Antonio, A. L. M., Wheaton, N., Kreger, V., Yap, A., ... & Elmore, J. G. (2019). Injuries associated with standing electric scooter use. *JAMA network open*, *2*(1), e187381-e187381.

UITP (2012) Metro, light rail and tram systems in Europe. *UITP*. Retrieved from: https://www.uitp.org/sites/default/files/cck-focus-papers-files/errac_metrolr_tramsystemsineurope.pdf

Valmot, O. D. (2012, October 24). Oslo får 100 nye t-banevogner. *TU*. Retrieved from https://www.tu.no/artikler/oslo-far-100-nye-t-banevogner/245305

Veisten, K., Flügel, S., & Elvik, R. (2010). Den norske verdsettingsstudien, Ulykker–Verdien av statistiske liv og beregning av ulykkenes samfunnskostnader. *Transportøkonomisk institutt*. 1053.

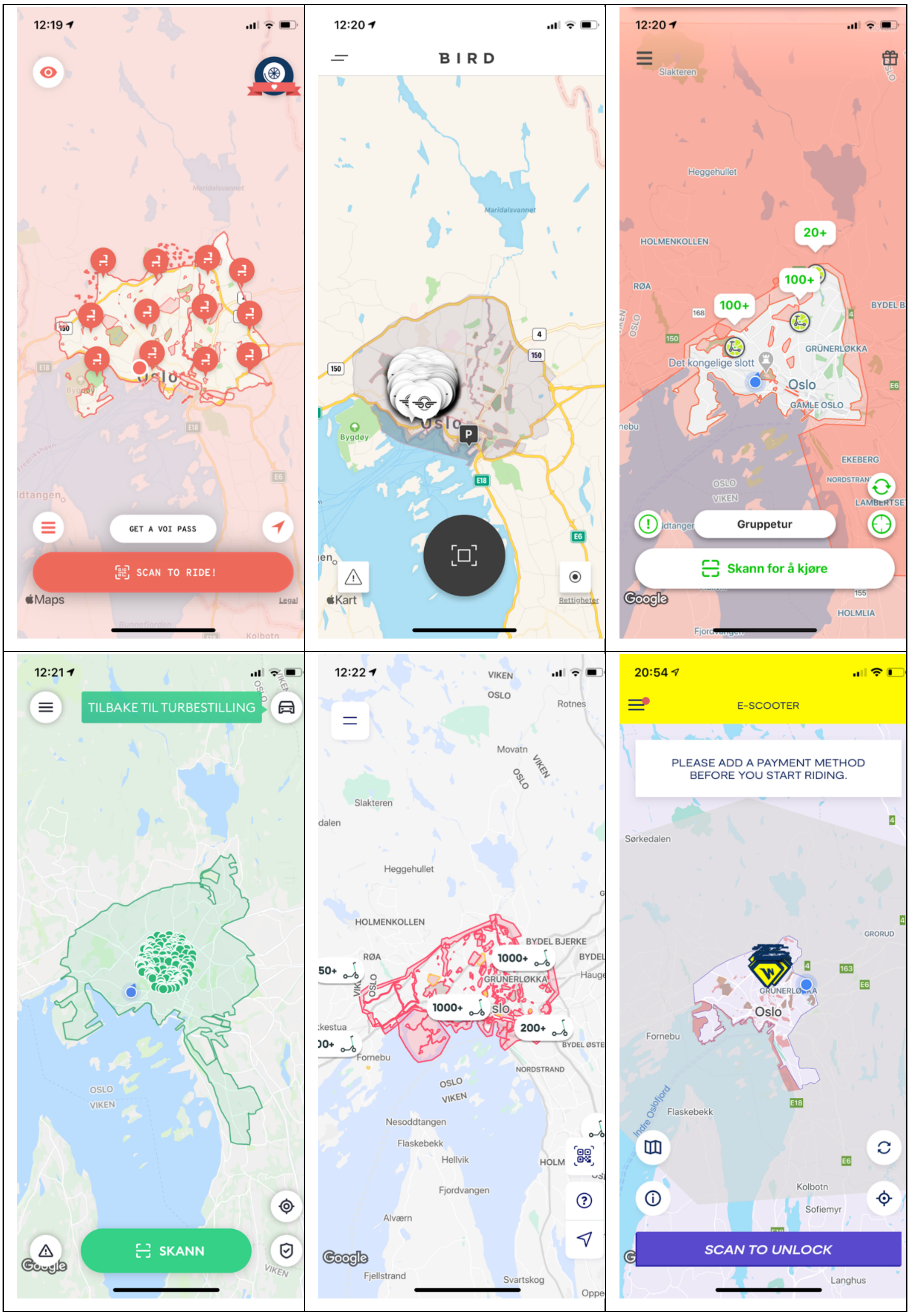
Veisten, K., Sælensminde, K., Alvær, K., Bjørnskau, T., Elvik, R., Schistad, T., & Ytterstad, B. (2007). Total costs of bicycle injuries in Norway: Correcting injury figures and indicating data needs. *Accident Analysis & Prevention*, *39*(6), 1162-1169.

Vestrum, A. (2020, February 27). 74 millioner i støtte til elektriske busser i Oslo. *Dagsavisen.* Retrieved from https://www.dagsavisen.no/oslo/74-millioner-i-stotte-til-elektriske-busser-i-oslo-1.1671979

Yakowich, W. (2018). 14 months, 120 cities, $2 billion: There's never been a company like Bird. Is the world ready? *Inc Magazine.* Retrieved from https://www.inc.com/magazine/201902/will-yakowicz/bird-electric-scooter-travis-vanderzanden-2018-company-of-the-year.html

Appendix

1: Area defined by the providers where the electric scooters can be used



2: Receipt from Tier

TIER CHANGE MOBILITY FOR GO

THANKS FOR CHOOSING TIER

With us, you are riding climate-neutral!

THANK YOU FOR RIDING WITH TIER!

We hope you had a good time on your way to change mobility for good. Here are some facts about your latest ride with TIER:

TOTAL

27.50 NKR

Travel time

7 minutes