Standing E-scooters, what to expect:

micro-mobility with micro effects?

Explorative research into the expected effects and policy implications of the introduction of e-scooters in the Dutch traffic system

By

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Preface

This report is the result of my graduation internship at AT Osborne, which is the final step to complete the Delft University of Technology master program Transport, Infrastructure and Logistics.

First of all I would like to thank AT Osborne, Erik, Puck and the other colleagues for the opportunity to finish my studies at AT Osborne. Unfortunately I could be at the AT Osborne office for one month only, due to COVID-19, but I still got a taste of the consultancy profession at AT Osborne. Besides this valuable experience, I would like to thank Erik and Puck for making the time to help me in the process, your insights and structured way of thinking helped a lot!

Secondly, I would like to thank my TU Delft daily supervisors Jan Anne and Niels for guiding me in this interesting experience of qualitative research and of course for the comments relating to the content of this thesis. Besides Jan Anne and Niels I Would like to thank the chair of my assessment committee, Bert, for his very detailed comments on my work during the official meetings.

At last I would like to thank my friends, family and girlfriend for reading my work and making critical comments and of course for the moral support.

I learned a lot and can’t wait till we can finally drive around legally on e-scooters in The Netherlands!

Gijs Alberts
The Hague (Netherlands), March 2021

Executive summary

Situation

Standing e-scooters, both as an option for the first- and last-mile as for individual trips through the city, are a promising mode of transport. They are electrically powered, light, easy to handle, and fit into the dense urban landscape due to their size. Besides that, they are generally faster than the bicycle and require no physical effort to go around (Smith & Schwieterman, 2018; Oeschger, Carroll, & Caulifield, 2020; Ewert, Brost, & Schmid, 2019). Shared e-scooter providers claim that e-scooters are part of the solution for a sustainable and liveable city (Voi, n.d.; Lime, n.d.).
E-scooters are currently prohibited in the Netherlands, but the ministry is working on an authorization framework (Hulshof, 2021). However, little is known about the impact of these vehicles on travel behaviour and society, which can be expected when e-scooters are launched in the Netherlands. Insight into the impact of e-scooters is required to make reasoned considerations about regulations at present time and in the future.

Gap

Literature into e-scooters, in general, is scarce. Being a relatively new and upcoming sub-field of urban transportation research (McKenzie, 2020), the available literature is almost exclusively about research done in countries where e-scooters are currently legal, like France, the USA and Norway.
The research results have certain similarities but also certain differences. For example, multiple studies found a positive attitude towards e-scooters during or after a shared e-scooter pilot (Portland Bureau of Transportation [PBT], 2018; Clewlow, Foti, & Shepard-Ohta, 2018; Eccarius & Lu, 2018). There is also a consensus in the literature on one an afternoon peak in the distribution of use over the day (McKenzie, 2020; Liu, Seeder, & Li, 2019; Civity Management Consultant [CMC], 2019). Differences are, for example, found in the dominant travel purpose (leisure or commuting) and the modal shift effects of e-scooters (Transportøkonomisk institutt [TØI], 2020; PBT, 2018; Bortoli & Christoforou, 2020; Hollingsworth, Copeland, & Johnson, 2019).
To the best of the authors knowledge, there are currently no peer-reviewed scientific papers about e-scooters that focus on the Netherlands. However, there are some industry reports includingL **i)** A research about 'experiences abroad' by TNO (2020) with an overview of the e-scooter situation in cities throughout the world. **ii)** A qualitative research with users and non-users of E-scooters by MetrixLab (2020) about opinions regarding the transport potential and safety of E-scooters. **iii)** A research by Goudappel Coffeng (2020) about the opinion of different stakeholders (private and public) concerning safety aspects, other conditions terms and the role of the government regarding the allowance of e-scooters on Dutch roads. Thus far, no research has been conducted into the expected impact on travel behaviour and society when shared and private e-scooters are introduced in the Netherlands.

Research goal and questions

This research tried to reduce that gap with an explorative study into the expected effects of e-scooters when introduced in the Netherlands. Besides that, insight into possible policy strategies and instruments that can be used to regulate the impact of e-scooters was provided. The following research question was addressed:

What relevant effects are to be expected when e-scooters are (legally) introduced in the Netherlands, and what are the potential policy implications?

To answer this research question, three sub-questions were formulated: **1)** What are the expected travel behaviour effects when e-scooters are introduced in The Netherlands? **2)** What relevant societal effects can be expected from these travel behaviour effects in the Netherlands? **3)** Which e-scooter related policy instruments and strategies can the Dutch government use, to maximize desirable outputs of these societal effects? Being of an explorative nature, it was not the intention to provide conclusive evidence on the impact of e-scooters. The purpose was to provide the academic world and policymakers with a better understanding of the high-level situation.

Research method

A qualitative research method was used to answer the research question. A causal diagram (referred to as the system diagram) was made of the introduction of e-scooters and their impact. The diagram conceptually represents the expected impacts on travel behaviour and society of e-scooters. The effect estimations in the diagram were gathered through interviews with mobility experts and compared to foreign research outcomes based on a literature study and conference notes. Consequently, interviews with policy officials of three municipalities and a focus group session with mobility experts were organised to gain insights into policy instruments.

A qualitative content analysis was used to analyse the data retrieved in the interviews and focus group session. The results were presented based on frequency and interpretation by the author of other meaningful results. These 'meaningful outcomes' have also been mentioned because this is an is an exploratory study on a new topic. Therefore, something mentioned by only a single expert may also be of great value (Dorussen, Lenz, & Blavoukos, 2005).

System diagram on a aggregated level

Employing a literature study, factors and relationships of the urban transportation system and travel behaviour were identified. These factors and relationships were consequently demarcated, which led to the creating of the system diagram on a aggregated level (Figure 0-1). The system diagram analyses the system with the introduction of e-scooters as a starting point. It follows from the literature that, due to a changing transport supply, travel resistances, needs and desires change. From this follow travel behaviour effects, leading to traffic volumes and resulting societal effects; on the environment, public health, traffic safety, liveability and accessibility and inclusivity. There are also feedback loops in the system. The system diagram was validated by consulting eleven mobility experts.

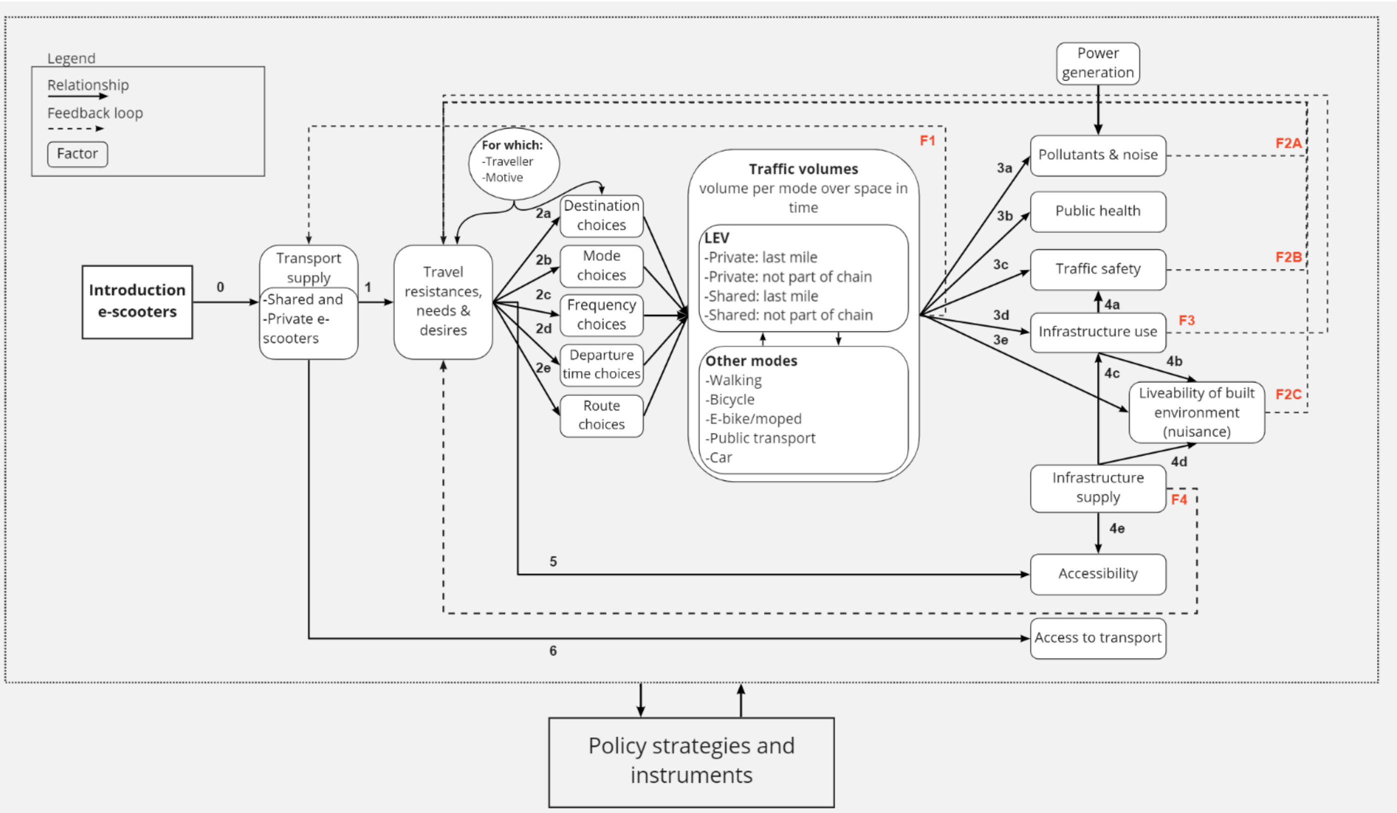


Figure 0-1: The system diagram on a aggregated level

Effect estimations

Eleven mobility experts were interviewed in a semi-structured manner; for each block and arrow in the system diagram, they were asked about their opinion on the most important underlying factors and expected effects. Experts from various institutes have been interviewed, including academia, policymakers, consultants and other researchers, all with an expertise in (urban) mobility.

The majority of the experts think the factors 'comfort aspects', 'price', 'lifestyle aspects', 'availability of shared e-scooters' and 'precise set-up of a shared e-scooter system' will influence the travel resistances, needs and desires. E-scooters are not expected to affect travel patterns substantially.
The majority of the experts believe that shared e-scooters will have a higher usage potential than private e-scooters. E-scooters are to be expected to be used in multimodal trips more than in unimodal trips. The largest shift is expected from active modes and bus, tram and metro. There are different expectations among the experts about the degree (or presence of) the modal shift from the car, the potential for using e-scooters for commuting trips and the share of private e-scooter users.
Consequently, there are different expectations of the effect of e-scooters on the environment and public health, ranging from negative to slightly positive in time. Regarding the effect of e-scooters on traffic safety, there were two prevailing views: i) e-scooters are not a risk to traffic safety because of the Dutch cycling culture ii) e-scooters are harmful to traffic safety because the Dutch bicycle paths are already busy. For the effect of e-scooters on the liveability, the experts assent that this depends mostly on the rules regarding the use of public space, such as parking areas. The impact can be large if not well regulated. Lastly, the experts agreed that the positive accessibility effects of e-scooters are most relevant for the small group of non-cyclist and at improving public transportation networks.

Policy implications

From the effect estimations, it was learned that there are uncertainties in the effect estimates with possible negative outcomes, where regulation is (possibly) required. Moreover, little information is available about e-scooter policies abroad and how these translate to the Netherlands. Therefore, insights into policy in the Dutch context are required. Three mobility policy officials of three municipalities (Amsterdam, Utrecht and Eindhoven) were interviewed to gain insight in desirable outcomes of the mobility system and policy strategies currently used for other forms of micro-mobility. Besides that, a focus group session was organised with seven mobility experts to gain insight into e-scooter related policy instruments. In the focus group, a case of a fictive city was provided, in which the focus was on only one societal effect for each discussion point.

Policy strategies and instruments

From the policymaker interviews, it was ascertained that all societal effects (environment, safety, liveability, inclusivity, accessibility, health) are desirable and must be pursued. However, the focus on these effects differs per municipality and per area in the municipality.
The policy instruments and strategies that were identified in the interviews and focus group session are shown in Table 0-1. There are options to set requirements in the tender for shared providers, organise the transportation system, set requirements for users, and setting driving rules. The policy options are classified according to the societal effect to which they contribute. Some policy options contribute to multiple societal effects and some contribute to one societal effect while being negative for another. In the policymaker interviews, it was mentioned several time that policy should be adaptive to deal with uncertainties in effects.

Type	Strategy or instrument	Contributing to societal effects
Setting requirements in the tender for shared e-scooter suppliers (local) or the admission framework (nationally)	Requirements for recharging (with green energy)	Environment
	Requirements for the production process of e-scooters	Environment
	Requirements for safety design of e-scooters: reflectors, lights, maximum speed, license plate	Traffic safety
	Requirements for the production process of e-scooters	Environment
	Requirements for the number of vehicles using smart scaling	Liveability
	Service requirements for certain areas	Accessibility and inclusivity
	Requirements for the maximum cost of use	Accessibility and inclusivity

Organise the transportation system	Connect e-scooters to public transportation and the car by means of hubs	Environment, accessibility
	Place enough charging points and make sure charging points can be used by all electric modalities	Environment, liveability
	Allow e-scooters to be parked everywhere or ensure enough parking places	Accessibility
	Use geofencing to avoid dumping, driving in restricted areas and parking in restricted areas	Environment, liveability, traffic safety
Set requirements for e-scooter users	Minimum age, (car) driving license, helmet use	Safety
Driving rules (local or national)	Only allow usage on bicycle infrastructure	Traffic Safety
	Don't allow riding next to each other	Traffic safety
Other	Organise an information campaign	Liveability, traffic safety, public health
	Skip certain bus tram or metro stops to make them faster and connect e-scooters to serve the skipped stops	Accessibility
	Don't allow e-scooters if the major shift is from active modes	Environment, public health

Table 0-1: results of expert interviews and the focus group regarding policy instruments

Conclusions

Figure 0-2 shows the conclusion on all factors, effects and policy strategies and instruments added to the system diagram. The most important conclusions are provided here. This research shows with the system diagram, a literature review, expert interviews and a focus group session that the e-scooter situation is complex with different factors, relationships and effects: If just allowed, and minimally regulated (both shared and private), e-scooters can have a large an possibly negative impact on society, however there are uncertainties in the effects:

E-scooters are not expected to substantially change travel patterns regarding destination, frequency, route, and departure time choices, but an increase in trip frequency could occur. Shared e-scooters have the highest usage potential; only a niche market of private users is expected. E-scooters will mostly replace trips previously made by foot, bicycle and public transportation. Only a minimal shift from the car is expected.

Therefore the impact on the environment is expected to be negative (since cycling and walking are more beneficial to the environment), but the impact can be reduced by improving certain parameters. E-scooters are expected to negatively impact public health since they are not an active travel mode, and they will replace mostly active travel modes. No profound estimations can be made (yet) about the impact of e-scooters on traffic safety; there are two prevailing views: e-scooters are not a risk to traffic safety, because of the Dutch cycling culture ii) e-scooters are harmful to traffic safety because the Dutch bicycle paths are already busy. The effect of e-scooters on the liveability of public space can be large: mainly due to space occupancy and cluttering of shared e-scooters. E-scooters have the potential to increase the accessibility, but only for a small group of people (non-cyclists) and the public transportation network. E-scooter prices can be high compared to other transportation modes, and the vehicles are not accessible for the disabled, which is not beneficial for the inclusivity of the transportation system.

To ensure a contribution of e-scooters to desirable outcomes of the transportation system, regulations can be made to achieve a better impact on the environment by: connecting e-scooters to public transportation points and park and rides (to achieve a shift from the car) and setting environmental requirements regarding recharging and vehicles in tenders or the admission framework. To ensure traffic safety, requirements can be set for users (age, helmet use or driving licenses), vehicles (safety standards in the admission framework),and the infrastructure (only allow on bicycle paths and or sperate traffic flows. Furthermore, a

safety campaign could help to inform users and non-users about this new transport mode. The impact on the liveability could be improved by setting rules for parking (designated parking zones, enforce by ticketing and/or geofencing), cluttering (fold an stack e-scooters while not in use), and driving (designate areas where e-scooters are not allowed). Finally, to ensure the contribution to the accessibility and inclusivity, the connection of e-scooters to other modalities should be ensured (with hubs at public transportation stations and park and rides), there should be enough parking options, and service requirements for certain areas are needed. At last, pricing requirements and low-income plans can be included in the permit for shared e-scooter suppliers.
In general, policy should be adaptive to account for uncertainties in the effects. If well-regulated, this research shows that e-scooters have the potential to contribute to the environment, the impact on the liveability of public space can be moderate, and e-scooters can contribute to the accessibility of a large group of people and areas, including transportation poverty places.

Reflection & recommendations

Generalizability of research results

E-scooters have certain characteristics regarding their size, weight, propulsion technique and operating speed. There are more micro-mobility vehicles with similar characteristics like hoverboards, monowheels and electrical skateboards. The author believes that if these vehicles have the same supply, demand and ease of use as e-scooters, the results are also applicable for these kinds of vehicles. The same holds for other locations: this research focusses on the Dutch context; however, the effect estimations can also be applicable for other countries/cities where e-scooters are not introduced yet. Important contextual variables to consider while transferring these research outputs to other locations are the modal split situation, the available e-scooter infrastructure (quality and quantity), the electricity carbon intensity, and public space density. If these factors are comparable to those of the urban environment of the Netherlands, the results are better applicable, then if these factors differ significantly.

Limitations of the research

Biases

The results of this research have been acquired with a qualitative methodology mix. Although attempts have been made to minimize these in advance, there may be biases in research and, therefore, results. The interviews and the focus group session were held with a limited number of experts (eleven and seven, respectively). Therefore, one person's statements and opinions have had a relatively large influence on the research results. To minimize this potential for bias, experts have been selected from a range of institutions, and also, meaningful, less mentioned results have been reported.
In the author's moderating role during the interviews and the focus group, bias could also occur. The author has tried to minimize this by following semi-structured interviews with the system diagram as a guideline, and in the focus group, a discussion guide was made and followed. However, arranging an external moderator would have been better to minimize the author's role on bias in the results.
Lastly, the content analysis results are processed on the base of frequency, but also less frequent factors are presented if considered as 'meaningful results' by the author. The author's bias may have influenced the presentation of these results, and a different author could have selected different results. To minimize this bias, external expert(s) could have been used to (help) identify these 'meaningful results'.

Complex system with a simple system diagram

The urban transport system is a complex system with a seemingly endless amount of factors and relationships. It has not been possible to capture all these factors in one system diagram. Hence, it was simplified to an aggregated level and assumptions were made on the most important factors. Therefore, some factors were left out of scope. Although elven mobility experts validated the system, it is possible that that different results could be obtained with another (more detailed) diagram. On the other hand, it can be argued that, given the exploratory nature of the research in which expectations are central, it is not useful to go into more detail and thus create 'apparent certainties'. Moreover, the system diagram does not (explicitly) take into account that e-scooters, in addition to the effects on society mentioned, can also simply 'be fun' and contribute to 'the freedom of choice' and thereby contribute (positively) to society. If this had been included, the conclusions might have been more positive towards the impact of e-scooters.

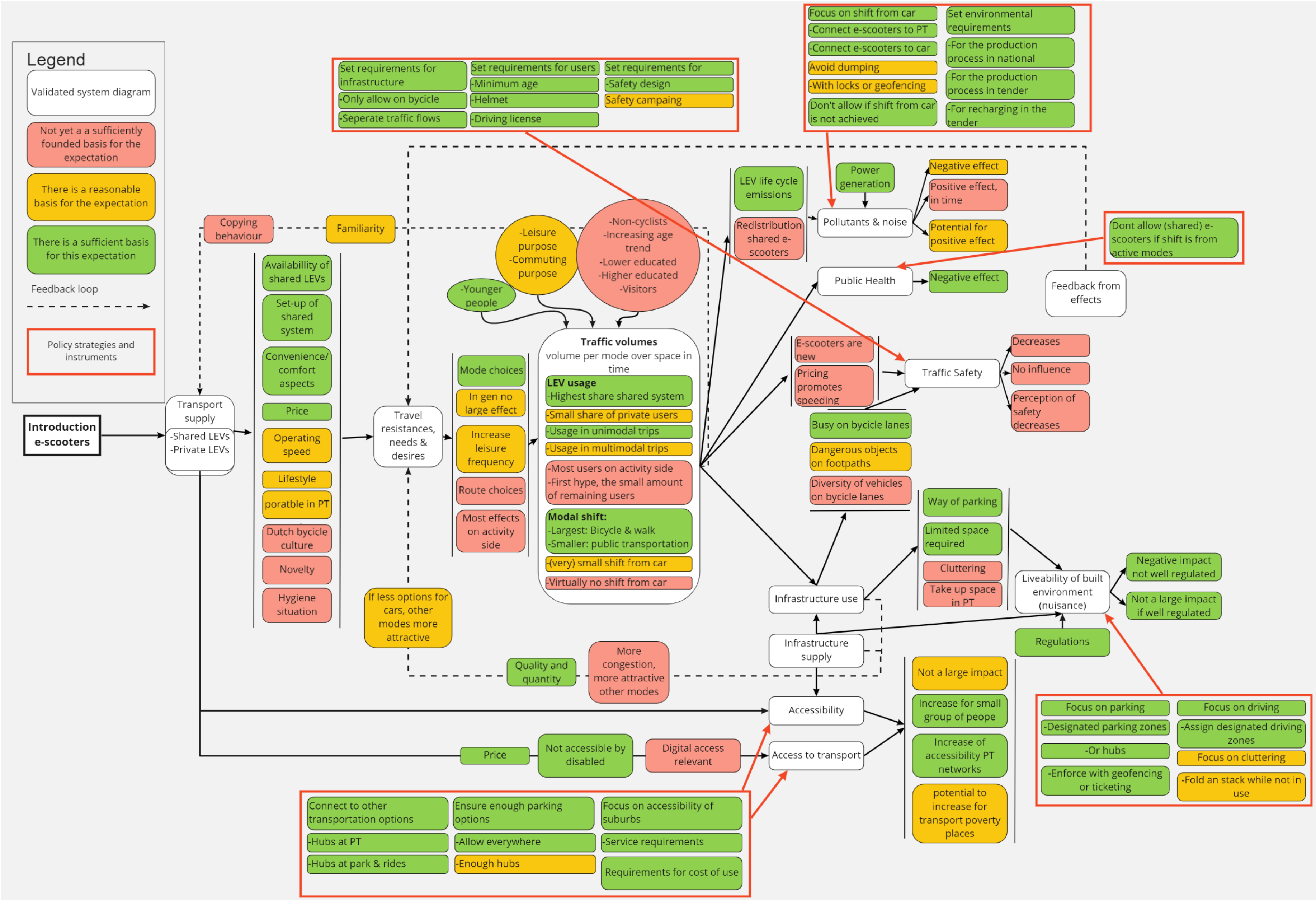


Figure 0-2: Conclusion on effect estimations and policy implications in the system diagram

Recommendations – research

Effect estimates

For a range of effects, not a clear picture of the estimate did emerge from this study. More detailed (quantitative) insights into the usage potential and modal shift effects of e-scooters could be retrieved by first doing a stated preference study. The utilities that emerge from this stated preference study could subsequently be applied in utility-based transportation models. In this way, quantitative estimates can be made of the effects of e-scooters

If the admission framework is completed and e-scooters are allowed on the Dutch roads, there is also a possibility to collect empirical data, as pilots can be started to investigate the effects on the travel behaviour of e-scooter users. Pilots come in many forms, with both shared e-scooters and private e-scooters. These pilots could be supplemented with travel surveys to gain further insights into e-scooter travel behaviour (changes).

Policy implications

Currently, to the best of the author's knowledge, there is not any peer-reviewed scientific literature on the performance and the effectiveness of e-scooter related policy instruments. Insights in these instruments could be retrieved with a qualitative research design in which policymakers and other mobility experts are asked about the policy instruments used and their opinion on their effectiveness. Or a quantitative approach could be used, in which data from (shared) e-scooters is used to analyse whether and what influence certain policy instruments have had on travel behaviour and thus society.

Recommendations – public entities

This is research showed that, if regulated well, e-scooters can positively contribute to the transportation system. **On the national level,** there are options to add requirements to the admission framework:

- Safety standards for e-scooters, including reflectors, lights and a maximum speed
- Require a license plate
- Designate cycle paths as a place on the road

On the municipal level, since only a niche market for private LEV users is expected, it is advised to focus policy at first on shared e-scooters. Furthermore, it is advised to ensure that policy is adaptive to deal with unexpected effects. Policymakers can set certain requirements in the tender for shared e-scooter providers:

- Service requirements for areas (outside the city centre) and maximum pricing requirements.
- Require shared e-scooter providers to charge e-scooter only with green energy and service them with green vehicles
- Require providers to apply smart scaling and ensure broken vehicles are removed from the streets.
- Required the use of geofencing to prevent usage and parking of e-scooters in restricted areas

Policymakers can organize the transportation system in the municipality by:

- Creating hubs or assign other designated parking spaces
- Connect the different transportation options to each other through e-scooter hubs at public transportation stations and park and ride locations
- Investigate if certain bus tram or metro stops can be skipped to make them faster, if these transportation modes are well connected to other modes like e-scooters.
- Ensure business districts, universities and suburbs are connected to e-scooters (and other transportation alternatives) to stimulate people not to commute by car and thereby improve the environment.

If the impact of e-scooters on society is not desirable, the choice can be made not to allow shared e-scooters. Nevertheless, a choice can also be made in the case e-scooters may not add something in a positive sense to the social effects that are central to this report (environment, public health, traffic safety, liveability, accessibility and inclusivity), but do contribute positively to choice freedom and pleasure.

Contents

1 Introduction

1.1 Motivation

In 2019, the Dutch government published the `Klimaatakkoord`, which states that increasing the accessibility of urban areas while realising a modal shift away from the car is essential to achieve the goals of the Paris Climate Agreement (Rijksoverheid, 2019). These claims are based on the need to reduce the number of greenhouse gases while at the same time, there is an ongoing trend of urbanisation. In 2015, 48% of the population of the OECD countries lived in urban areas and the trend is continuing upwards (OECD/European Commission, 2020).
On top of that, about 70% of every kilometre travelled in the Netherlands by persons is done in a car (Centraal Bureau voor de Statistiek [CBS], 2019). Similar numbers are seen in other European countries (Eurostat, 2019). Due to this reliance on cars, three main car-related problems arise in urban centres: Urban cities encounter noise and air pollution problems (Stanton et al., 2013), the reliance on cars reduces the liveability of cities by claiming a large share of public space for car infrastructure (Shelat, Huisman, & van Oort, 2018; Ewert, Brost, & Schmid, 2019).) and cities already encounter capacity issues, which will only grow in the future due to the previously mentioned trend of urbanisation (Stanton et al., 2013).

These three car-related problems combined (pollution, public space and network capacity) highlight the need for a `mobility transition`, from the current mobility system towards a more sustainable one. This encompasses a broad range of measurements, of which a modal shift from the car to other modalities is one.
E-scooter companies claim that e-scooters are part of the mobility transition and a solution for a sustainable and liveable city (Voi, nd; Lime, nd). E-scooters are a promising mode of transport, both for the first and last-mile, as individual trips through the city (Gössling, 2020; Tuncer & Brown, 2020). They are electrical powered, light, easy to handle and fit in the dense urban landscape due to their size. Besides that, they are in generally faster than the bicycle and require no physical effort to go around. As will be elaborated on in the literature review (Chapter 3), e-scooters, both in combination with and without public, can offer a potential alternative to the journey by car, for car-users who were not yet convinced by other micro-mobility options too (Smith & Schwieterman, 2018; Oeschger, Carroll, & Caulifield, 2020; Ewert et al., 2019).

In the Netherlands, there is currently not an admission framework for e-scooters. As a consequence, e-scooters are covered by existing regulations. In practice, this means that most models are illegal on public roads (RDW, 2019; ANWB, n.d.). The ministry is working on an authorisation framework (Hulshof, 2021). However, little is known about the expected impact of these vehicles when launched in the Netherlands.

1.2 Knowledge gap

Literature into e-scooters, in general, is scarce. Being a relatively new and upcoming sub-field of urban transportation research (McKenzie, 2020) the available literature is almost exclusively about research done in countries where e-scooters are currently legal, like France, the USA and Norway. The research results are usually based on surveys (e.g., 6t-bureau de recherche, 2019; Hollingsworth, Copeland, & Johnson, 2019; TØI, 2020; Portland Bureau of Transportation [PBT], 2018) and / or data from shared e-scooter providers (McKenzie, 2020; TØI, 2020; Civity Management Consultant [CMC], 2019; Liu, Seeder, & Li, 2019).

The findings of the available studies have certain similarities but also certain differences. For example, multiple studies found a positive attitude towards e-scooters after or during a shared e-scooter pilot (PBT, 2018; Clewlow, Foti, & Shepard-Ohta, 2018; Eccarius & Lu, 2018). A clear picture can also be seen in several studies of an afternoon peak in the distribution of use over the day (McKenzie, 2020; Liu et al., 2019; CMC, 2019). Differences are, for example, found in the dominant travel purpose (leisure or commuting) and the modal shift effects of e-scooters (Transportøkonomisk institutt [TØI], 2020; PBT, 2018; Bortoli & Christoforou, 2020; Hollingsworth et al., 2019). Chapter 3 elaborates more on e-scooter literature.

The literature is found using the keywords and databases that are mentioned in Chapter 2. To the best of the authors knowledge, there are currently no peer-reviewed scientific papers about e-scooters that focus on the Netherlands. However, some industry reports include **i)** A research about 'experiences abroad' by TNO (2020) with an overview of the e-scooter situation in cities throughout the world. **ii)** A qualitative research with users and non-users of E-scooters by MetrixLab (2020) about opinions regarding the transport potential and safety of E-scooters. **iii)** A research by Goudappel Coffeng (2020) about the opinion of different stakeholders (private and public) about safety aspects, other conditions terms and the role of the government regarding the allowance of e-scooters on the Dutch roads. Thus far, no research has been conducted into the impacts on travel behaviour and society expected to occur when shared and private e-scooters are introduced in the Netherlands. Insights into the impact of e-scooters is required to make reasoned considerations about regulations at present times and in the future.

1.3 Research goal and research questions

This research tries to reduce that gap, with an explorative study into the expected effects of e-scooters, when introduced in the Netherlands. Besides that, insight into possible policy strategies and instruments that can be used in relation to e-scooters is provided as well. The following research question is addressed:

What relevant effects can be expected when e-scooters are (legally) introduced in the Netherlands, and what are the potential policy implications of these effects?

The following sub-questions help to answer the research question:

1. *What are the expected travel behaviour effects when e-scooters are introduced in The Netherlands?*
2. *What relevant societal effects can be expected from these travel behaviour effects in The Netherlands?*
3. *Which e-scooter related policy instruments and strategies can the Dutch government use, to maximize desirable outputs of these societal effects?*

- Sub-question 1 is used to gain insight into travel behaviour and how this is achieved. With this information, estimates can be made of the effect of e-scooters on travel behaviour.
- Sub-question 2 gains insight into the transportation system societal effects are linked to travel behaviour. With this information, estimations can be made of the influence of e-scooters on these societal effects.
- Sub-question 3 investigates the policy implications of the expected impact of e-scooters. Desirable outputs of the transportation system are retrieved, and insights into e-scooter related policy strategies and instruments that can be used to influence the effect of e-scooters on society.

This research is of an explorative nature. It is not intended to provide conclusive evidence on the impact of e-scooters. The purpose is to provide the academic world and policymakers with a better understanding of the factors and relationships that are relevant to the impact of e-scooters. Thus through this understanding, reasoned considerations can be made about further research and regulations. Although the focus of this research is on the Netherlands, the outcomes are also useful to other cities and countries that consider the introduction of e-scooters, depending on the specific context.

1.4 Scope and definitions

What are e-scooters: There are different e-scooters available with different configurations, e.g.; two or three wheels, kick-support or full electric propulsion, self-driving, with/without luggage capacity, with/without saddle (TNO, 2020). This research focuses on e-scooters that fall within the following characteristics:

- Fully electric propulsion, meaning that no physical effort is required to drive.
- Foldable, without a saddle, with a steering wheel.
- Weight: <25 KG, this is the maximum portable weight a person is able to carry according the EN 1005-2 & ISO 11228-1 norm. Being able to carry an e-scooter, in combination with the foldability, is an important feature in combination with public transportation (eg: Tuncer & Brown, 2020. p. 6).
- Maximum operating speed between 15 km/hr and 25 km/hr, meaning e-scooters can go faster then on average on a bicycle.

This demarcation has been chosen because the author expects that e-scooters with these characteristics differ from (e-) bicycles and mopeds to such an extent that the user experience and, therefore, the use and effects are different.

Vehicle 1, an e-scooter or e-step, <u>within</u> scope of this research

Vehicle 2, an e-moped or e-scooter, <u>not within</u> the scope of this research

Figure 1-1: e-scooters and e-mopeds

Confusing term 'scooter'

The term 'scooter' is confusing. Scooter can refer to a smaller vehicle where you stand on (vehicle 1 in Figure 1-1) or a larger and heavier vehicle where you sit on (vehicle 2 in Figure 1-1). In the Netherlands vehicle 1 is called a 'step' and vehicle 2 is called a scooter. Simultaneously, in many English speaking countries, vehicle 2 is called a 'moped', but sometimes also a scooter.
The terms are sometimes also confused in literature: McKenzie (2020) refers to Hardt and Bogenberger (2019) as if they did research into vehicle type 1, but in reality their research is about vehicle type 2. In some literature it is unclear if the authors are talking about vehicle types 1 or type 2, or both. This highlights the need for an official taxonomy. In this report the term e-scooter refers to vehicle 1, the term moped refers to vehicle 2.

Focus on personal mobility

This research focusses on the transport of persons. Cargo transport with e-scooters is left out scope. Therefore 'the transportation system' refers to the transportation system for persons and not for goods.

Urban context

This study focusses on the five biggest urban centres of the Netherlands; Amsterdam, Rotterdam, Den Haag, Utrecht and Eindhoven. The reason for this being **i)** Almost all the available literature studies took place in larger urban areas, with characteristics similar to the biggest cities of the Netherlands **ii)** The e-scooters potential is highest in urban areas, especially if a sharing system is considered (Tuncker & Brown, 2020; Tice, 2019; TNO, 2020).

Current state of affairs of e-scooters worldwide

E-scooters are currently road legal and available in a shared system in various countries throughout the world. Figure 1-2 shows the presence of e-scooters as of November 2019. Mobility Foresights (2020) estimates the e-scooter market in Europe and the US at a total value of $743 Million in 2019, growing with about 25% each year till 2025. How and where the e-scooters are placed in the existing traffic system differs per country. In some countries, e-scooters are categorized within the bicycle category; in others, within the moped category.

Alternatively, Some countries created a new vehicle classification for e-scooters (TNO, 2020).

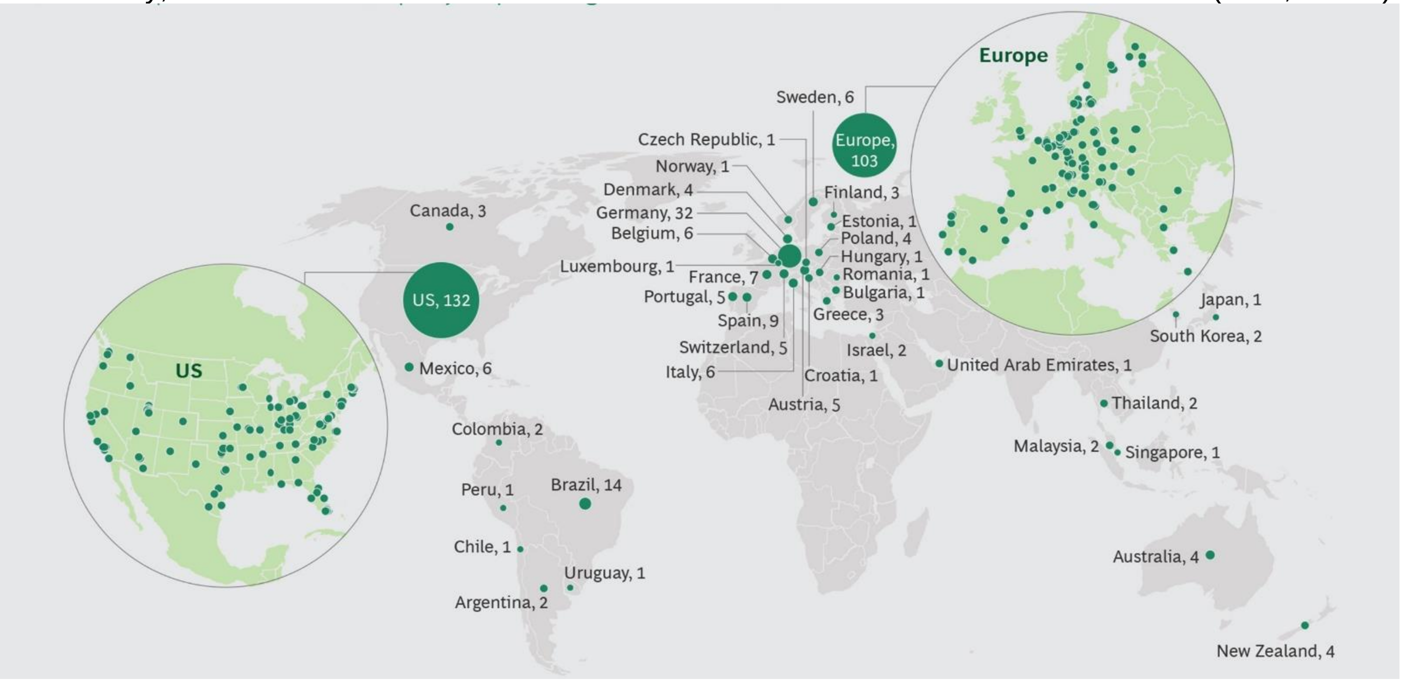


Figure 1-2: presence of e-scooters in cities worldwide as of November 2019 (Boston Consultancy Group [BCG], 2020)

1.5 Structure of this report

The structure of this report is visualised in Figure 1-3. In Chapter 2 the applied methodology is explained. Chapter 3 provides an overview of the existing base of knowledge, retrieved from literature and congresses. In Chapter 4 the system diagram on an aggregated level is presented. Chapter 5 and 6 elaborate on the expected effects of e-scooters in the Netherlands and the policy implications. In Chapter 7, the conclusions of the research are formulated. Lastly, in Chapter 8 a reflection on the research is provided, and recommendations for further research and policy are formulated.

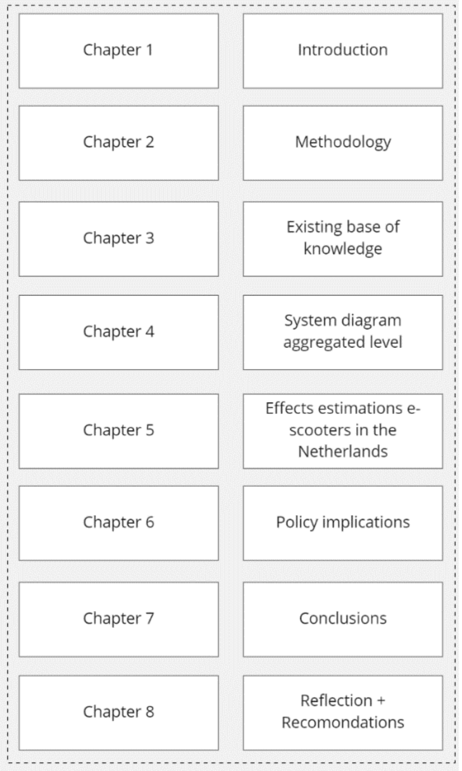


Figure 1-3: structure of the report

2 Methodology

This chapter elaborates on the applied research structure and used methodology to answer the research questions. An explorative, qualitative research design is used to answer the research questions. A conceptual model is created, representing the introduction of e-scooters and the impact in the Netherlands referred to as the system diagram. The effect estimations in the diagram are gathered through mobility expert interviews and compared to known effects in countries where e-scooters are currently available from a literature study. Consequently, a focus group session with mobility experts is organised to gain insights into policy strategies and instruments. Figure 2-1 visualises the applied research structure and methodology mix. The research consists of five consecutive research steps, which are explained below the figure.

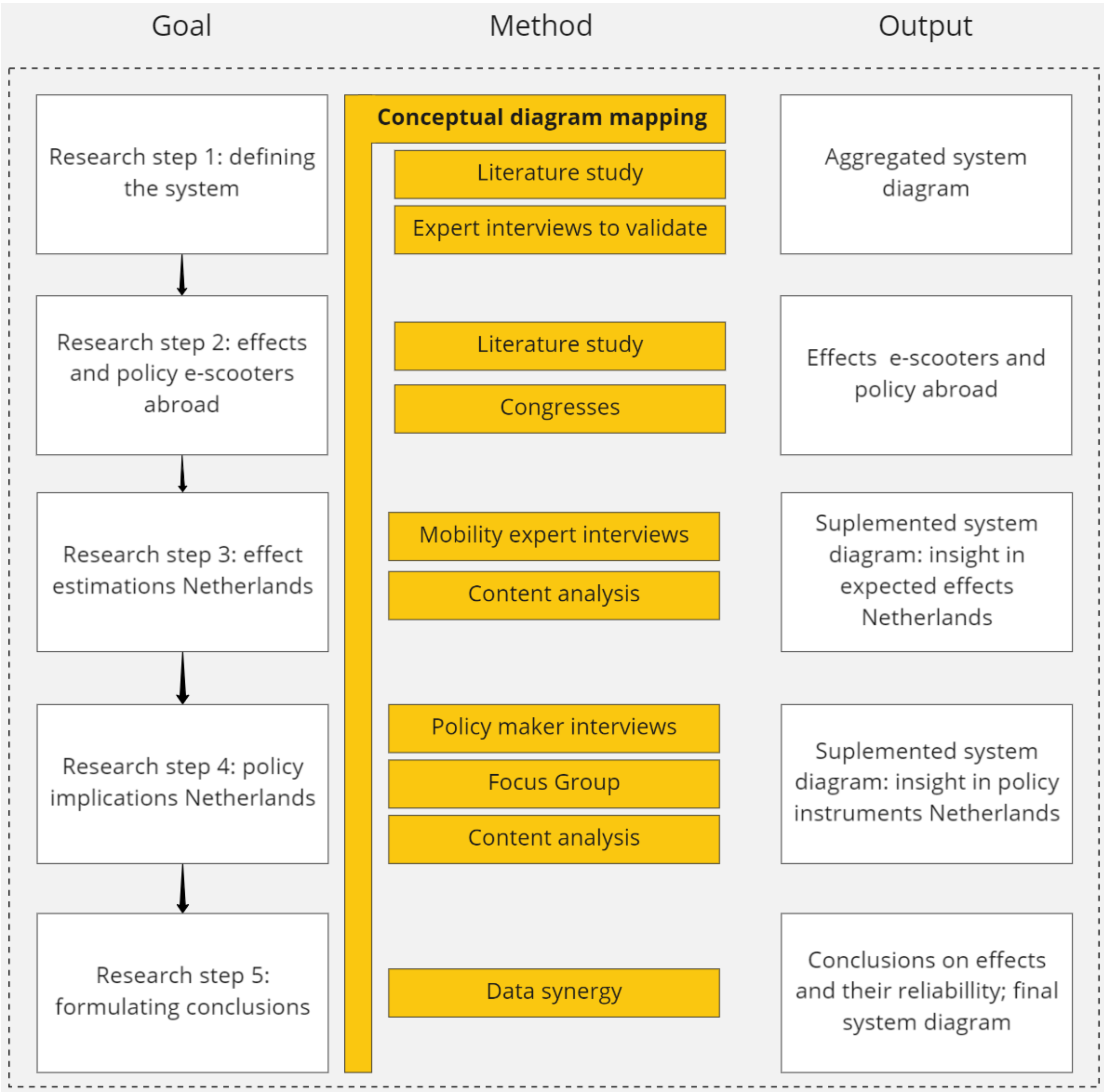


Figure 2-1: the five consecutive research steps

- In **Research Step 1,** the first aggregated version of the system diagram is created, using the conceptual diagram mapping technique and a literature study into travel behaviour and the transportation system. The aggregated version of the system diagram is validated with mobility experts interviews.

- In **Research Step 2,** insights into the effects and policy implications of e-scooters abroad are gathered by a literature study and visiting conferences. The effects of e-scooters abroad are used in research step 5 to formulate final conclusions and construct the final system diagram.
- With **Research Step 3,** the system diagram on an aggregated level is supplemented with expectations and underlying factors of the effects of e-scooters in the Netherlands. The effect estimations are gathered by interviewing mobility experts and the data is analysed using a qualitative content analysis.
- Due to uncertainties and possible negative impacts, regulation on e-scooters is (possibly) required. Therefore, in **Research Step 4,** insights in policy instruments and desirable outputs of the transportation system in municipalities are retrieved. This is done by interviewing policymakers of municipalities and a focus group session.
- Finally, in **Research Step 5,** the data retrieved in the different research steps are compared and synchronised. Conclusions on the expected effects are formulated, including a statement on the reliability of the expectations. Besides, conclusions on policy implications are formulated and added to the system diagram, creating the final system diagram.

The contents of each reaseach steps is explained in more detail in the following sections (Section 2.1-2.5). Finally, alternative methodologies that could have been used and the motivation for the applied methodology is provided in the last section (Section 2.6).

2.1 Research step 1: defining the system

In research step 1 the conceptual model of the system, on an aggregate level, is created; the system diagram on a aggregated level. This first version of the system diagram is created with the use of the conceptual diagram mapping technique. The factors and relationships in the system diagram are obtained by performing a literature study on the urban transportation system. The system diagram on an aggregated level is validated by means of questioning mobility experts.

Conceptual diagram mapping: system diagram

To answer the research question, a methodology was sought to provide insights into the complex relations between the introduction of e-scooters, behavioural changes and resulting societal effects. At the same time, the methodology should be able to deal with uncertainty and unknown data. And it should be possible to provide insight in certain policy measures. Furthermore, it should be available and fit the time constraints of this research. The chosen approach is to make a conceptual diagram of the situation; referred to as the system diagram. A conceptual framework or model is a tool that makes an abstraction of reality to help us better understand real-world systems. It is also used to facilitate communication and integrate knowledge across disciplines (Heemskerk, Wilson, & Pavao-Zuckerman, 2003). Section 2.6 discusses alternative methods that could also have been used to answer the research question.

Creation of the system diagram
The system diagram on an aggregated level is created in different stages. This method is based on the system dynamics causal diagram mapping method. According to this method, a causal diagram consists of factors and relations between factors. These factors and relations can be retrieved with different strategies (Pruyt, 2013; Sterman, 2002):

- A literature study;
- Own insights;
- Expert interviews;
- Group sessions.

A combination of these strategies is applied. Chosen is to retrieve the factors of the system diagram on an aggregated level with the use of a literature study, as there is already a vast amount of literature on factors of the urban transportation system and travel behaviour. Thereafter the factors on a more detailed level are retrieved by interviewing experts because this concerns e-scooters specific factors for which less literature is available. The following procedure is used to create the system diagram on an aggregated level:

- Factors and relationships of travel behaviour and the urban transport system are identified using a literature study.
- Because the urban transportation system depends on a seemingly infinite amount of factors and corresponding relations, a selection of the most important factors and relationships is made. This is done based on the interpretation of the author, using the scope of the project and the communication purposes of the diagram as a guideline. The result is a system diagram on an aggregated level.
- The system diagram on an aggregated level is validated by questioning mobility experts.

Literature study

To identify the factors of the system diagram on a aggregated level, a literature study is performed on the urban transportation system and theories on travel behaviour. The literature study is explained in more detail in the next section.

Expert interviews

The hypothesis of the system diagram is validated by interviewing eleven mobility experts. Section 2.3 elaborates more on the expert interviews.

Output research step 1

The output of research step 1 is the validated system diagram on an aggregated level. The system diagram will be supplemented with factors and effects on a more detailed level in the coming research steps.

2.2 Research step 2: effects and policy of/on e-scooters abroad

In research step 2 effects of e-scooters abroad and e-scooter related policy strategies and instruments are retrieved by performing a literature study and visiting congresses. These insights are compared to the mobility experts' expectations of the of the situation to formulate the final conclusions.

Literature study

A literature study is applied to gain state of the art knowledge about the relevant themes in this research. The main researched topics are: e-scooters, light electric vehicles, travel behaviour and societal effects relating to transport. The retrieved knowledge into these topics is used to:

- Identify the research gap;
- Gain insights into the effects of e-scooters in countries where they are already available;
- Identify policy instruments that are used abroad;
- Identify the main factors and relations of the urban transport system.

How applied

A systematic literature review is performed. For each main topic, key words are identified. These key words are consequently used as input the literature databases Google Scholar and Scopus. Besides that, Google is used to find 'grey literature' about the topics. Combinations of the following keywords are applied:

- **Topic e-scooters:** "standing e-scooters" "e-scooters" "electrical scooters" "Light Electric Vehicle", "Micro mobility ", "Small Electric Vehicle" and "Micro Electric Vehicle", ".
- **Topic societal effects:** "Societal effects", "Transport", "Mobility", "Transport Externalities" "Transport safety" "Environmental impact", "public land use", "built environment" and "Accessibility".
- **Topic policy:** "policy", "instruments", "regulating", "laws", "Rules", "planners" and "regulations".
- **Topic travel behaviour:** "Travel behaviour", "Travel behaviour", "Determinants", "Mode choice" and "modal shift".
- **Topic urban transportation system:** "transportation", "system" and "factors".

These keywords are also combined cross-topic, eg: "transport safety of micro mobility". The keywords are also used translated in Dutch, eg: "Veiligheid van licht elektrische voertuigen". In addition, the forward and backward snowballing technique is applied to find more articles.

Congresses

Due to the research subject's novelty and the lack of literature, especially related to the Dutch context, congresses have been participated in. The author perceives the congresses as a valuable source of information where many stakeholders are brought together, providing a good opportunity to gain state of the art knowledge that has not been published yet. Two congresses have been participated in; one organised by CROW and one organised by VOI.

CROW: CROW, a non-profit technology platform for transport, infrastructure and public space, connecting governments and businesses, organised a micro-mobility webinar in November 2020.
The subject of this congress was 'The impact of micro-mobility. Thus the scope of the congress was broader than the scope of this research (E-scooters are a subcategory of micro-mobility).
Around 200 participants with a diverse selection of stakeholders from the Netherlands participated in this congress; micro-mobility suppliers, policymakers, consultants, road authorities, vehicle authorities etc. The webinar started with two plenary sessions on the regulatory framework for diverse micro-mobility vehicles, followed by breakout sessions with the following specific subjects:

- Sustainabillity
- Data
- Traffic safety
- Data
- Liveability of public space

Voi: Voi, a Sweden based e-scooter company, organised a webinar on micro-mobility in December 2020. The subject of the congress was ‘Micro-mobility as part of the sustainable mobility transition in cycling country the Netherlands’. Although organised by a shared e-scooters supplier, the congress and information institutions presented at the congress was not a ‘sales pitch’. The congress contained:

- An introduction on Voi and its experience with e-scooter pilots in the UK
- A contribution of CoMuUk, an organisation that informs on shared mobility in the UK, on how to successfully implement e-scooters in cities
- A contribution of the Berliner Verkersbetriebe and Jelbi (MaaS application in Berlin) on how they set up the successful integration of different modalities in one application and hubs in Berlin.

Due to covid-19 restrictions, the congresses were held in the form of a webinair. The CROW webinar was more in the form of presentations form, with less time for discussion. The VOI webinar was with an interactive set up. The following structure is followed in order to obtain useful information for this research from the attended congresses:

- Participated in the congresses, attended the interactive sessions and break-out rooms;
- Made personal notes;
- Watched recordings of parts that could not be participated in;
- The notes and reports of the conference components (if available) are combined in one report (See Appendix 6 and Appendix 7.

Output research step 2:

With research step 2, insights in the effects of e-scooters abroad and e-scooter policy are retrieved. Which is further used in research step 5 to formulate final conclusions.

2.3 Research step 3: effect estimations e-scooters in The Netherlands

In research step 3 the system diagram is supplemented with expectations on the effects of e-scooters in the Netherlands and the underlying factors. These effect estimations are obtained by means of expert interviews with eleven mobility experts.

Mobility Expert interviews

As stated in Chapter 1, e-scooters are a relatively new subject; therefore, there is a limited data and literature available. Especially not related to, or considering, the situation in the Netherlands. On top of that, this research is of a broad and explorative nature. Expert interviews are suitable to provide an in-depth understanding of a social phenomena and are appropriate where little is known about the study subject (Gill et al., 2008). For those reasons, expert interviews are a suitable method to retrieve data and are used in this research as one of the main data retrieving methodologies. Besides data retrieving purposes, expert interviews are used to validate the system diagram on an aggregated level. The interviews with the mobility experts are used to:

- Validate the system diagram on a aggregated level (Research step 1);
- Find the most important underlying factors and relationships of the diagram, and make estimations of the impact of e-scooters in the Dutch context.

Semi-structured interviews are conducted. Semi-structured interviews offer some benefits compared to surveys/structured interviews. The method allows for open-ended responses from participants, providing more in-depth information. It encourages two-way communication and provides an opportunity for interviewers to learn and understand answers to questions and their reasoning. Disadvantages are that interviews are time-consuming and preferably multiple experts are interviewed to draw valid conclusions (Newcomer et al., 2015).

Expert selection

The expert selection represents the view of the academic world, policymakers, mobility consultants, institutions on mobility and companies involved in e-scooters. Experts from a range of institutions are selected because these experts have multiple interests and therefore less bias is expected in the results.
Due to the subject's novelty, the author didn't consider it feasible to find only experts with specifically e-scooters as their area of expertise. Therefore a the following selection criteria are applied: Experts should have the expertise and / or (research/project)experience with at least one of the following topics:

- Travel behaviour;
- Societal effects (regarding safety, accessibility, public land use and the environment) of urban transport;
- Transport Policy;
- (Shared) Urban mobility;
- Mobility/traffic regulations;
- Micro mobility;
- First / last mile mobility.

The interviewed experts are shown in Table 2-1. See Appendix 2 for an elaboration of the function and expertise per expert. Numbers are used to refer to the experts, because of privacy reasons.

Company/organistation	Expert
Accademia (TU Delft, International Transport Forum)	(1), (2), (3)
Policymakers (Ministery of Infrastructure and Water Management, municipality)	(4), (5)
Consultancy firms (Studio Bereikbaar, AT Osborne)	(6), (7), (8), (9)
Others (TNO, PBL/Dutch Cycling Ambassy)	(10), (11)

Table 2-1: interviewed experts

Interview structure

The interviews to validate and the mobility expert interviews were combined in one interview. The same topics were discussed in each interview and the same structure was maintained:

- **Demarcation**: In this phase the scope and the terminology of the research are explained to the interviewee.
- **Explanation of the System diagram**: In this phase the system diagram is explained to the interviewee.
- **Validation of the system diagram**: In this phase the interviewee is asked if he/she agrees with the made visualisation of the system, whether the most important factors and relations are incorporated in the diagram.
- **Expert's expectation of effects and underlying factors**: In this phase each factor and relation of the system diagram is discussed with the expert. The experts are asked about their opinion on expected effects and the underlying factors and relationships.

Qualitative content analysis

Qualitative data is retrieved during the interviews and the focus group session (see next research step). Processing of the policymaker interviews' is done in a straight forward way; a report is made and the outputs of those interviews are then used in the text. For the validating interviews, the mobility expert interviews and the focus group a content analysis is carried-out, where the data is first processed and thereafter interpreted.

Content analysis

The data is processed following the principles of content analysis (Elo & Kyngäs, 2008). The followed procedure is visualised in Figure 2-2. All interviews are recorded and the records are transcribed using Trint[1] software (The transcripts can be requested from the author). This software automatically makes transcriptions of audio files. The interview transcriptions are consequently checked for the largest errors and thereafter coded; statements made by the expert are coded in keywords. Next, the codes of all the interviews are grouped; similar keywords are grouped into the same categories based on the author's interpretation. Lastly, these grouped codes are counted and interpreted, as will be elaborated on in the next paragraph.

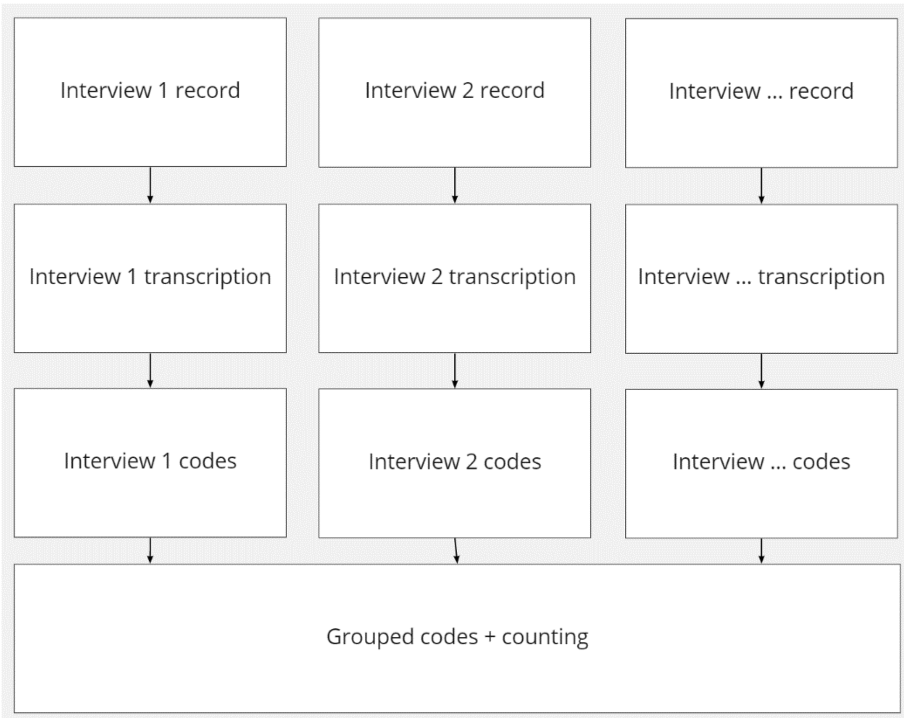


Figure 2-2: applied content analysis

[1] https://trint.com/

Interpreting the data

The data retrieved in the interviews is qualitative. The statements made by the experts at arrows in the diagram are dependent on the statements made by the same expert in previous steps of the diagram. This has implications for the data processing and interpreting the data.
This is easiest explained by using an example: If three experts are interviewed on the expected magnitude of an arrow, and two state they expect a large effect and one states he/she expects a small effect, it would not be correct to conclude an 'above medium' effect (e.g. the average of the answers). This would assume a level of certainty that cannot be retrieved from the data. A correct interpretation would be: 2 out of 3 questioned experts expect a high effect, and 1 expert expects a small effect. Or: the majority of experts expect a high effect but there is also a minority that expects a small effect.
If multiple experts named a factor, this is an indication of the importance of that factor. However, this does not necessarily mean that factors named by only a few or only one expert(s) are off less importance. Considering the novelty of the subject and the fact that e-scooters are not yet introduced in the Netherlands, one expert may see something that other experts have not yet thought of (Dorussen, Lenz, & Blavoukos, 2005). Therefore, these factors are also considered and mentioned if considered a meaningful result based on the author's interpretation.

Outputs research step 3

The results of research step 3 is an further expanded system diagram with factors on a more detailed level and estimations on the impact of e-scooters in the Dutch context, which will be compared to the known effects of e-scooters abroad to formulate final conclusions. This is done in research step 5.

2.4 Research step 4: policy implications of e-scooters in The Netherlands

In research step 4, insights in policy strategies and instruments and desirable outputs of the transportation system in municipalities is retrieved. This is done by interviewing policy officials of municipalities and a focus group session. This research step is added because that there are uncertainties in the effect estimates with possible negative outcomes, where regulation is (possibly) required.

Policymaker interviews

To gain insights in the desirable outcomes of the transportation system and possible policy strategies in the larger cities of the Netherlands, three interviews are conducted with mobility policy officials of three cities: Amsterdam, Utrecht and Eindhoven.

Municipality	Expert initials
Eindhoven	12
Utrecht	13
Amsterdam	14

Table 2-2: interviewed mobility policy officials

Interview structure

Semi-structured interviews are conducted with the following structure, for each interview:

- Explanation of the scope and research terminology;
- Explanation of the results so far;
- Questions on the current goal/objective and desirable outputs of the mobility policy in the municipality;
- Questions on how the municipality is trying to reach that;
- Questions on e-scooters policy strategies and instruments.

Focus group

A method was sought to interview several experts with the same expertise in a structured manner, with room for discussion. Therefore a focus group session is organised to gain insight into e-scooter related policy instruments that can be used if the aim is to stimulate one effect on society by the transportation system. A focus group is a qualitative research methodology in which a group of people is asked about their opinions and thoughts on a certain topic (Morgan, 1996). There are also other methods to question a group of experts, for example, the Delphi method and a 'normal' group meeting discussion (Gordon, 1994). What differs between the methodology of a focus group and the Delphi method is that, in a focus group, there is room for interaction and discussion (Morgan, 1996). What differs between a focus group and a 'normal' discussion between a group of people is (Larson, Grudens-Schuck, & Allen, 2004) **i)** a clear plan and controlled process. **ii)** structured plan to collect and process data **iii)** participants based on characters they share, instead of differences between them. Most focus groups consist of 6-10 participants; however, the ideal group size depends on the topic (Morgan, 1996). In homogenous groups, discussions may flow more smoothly (Morgan, 1996). Simultaneously, participants from different organisations and with different views can ensure 'rich' discussions (Kitzinger, 1994).

Execution

The focus group session is held digitally. All interviewed experts within the mobility expert interviews are invited for the focus group session. A total of 7 experts participated in the session (expert 1, 4, 6, 7, 8, 9 and 11). All participants are working in or have a background in mobility and at least some experience with the e-scooter topic. This helped to ensure a smooth discussion. On the other hand, the participants were selected from different organisations with different goals to ensure a 'rich' discussion.

The focus group is held with the following structure; the focus group's attendees are transport policymakers in the fictive city 'Lutjedam'. The goal of the policymaker is to focus solely on the corresponding goal of their job. E.g., the policymaker environment has only one goal - to ensure the transportation system in Lutjedam is as beneficial to the environment as possible. For each discussion point, the focus of the policymaker changes: e.g.: 'policymaker environment' or 'policymaker traffic safety'. In this way, policy strategies and instruments emerge when the focus is on one social effect. A full report with all discussion points and an explanation of the case of the focus group is provided in Appendix 9. The focus group session is recorded and a transcription is made. The data is processed and interpreted in the same way as the mobility expert interviews, which is explained in the previous section.

Outputs research step 4:

The result of research step 4 is an further expanded system diagram, with insights in policy strategies and instruments. These insights will be expanded with the insights on policy instruments from literature to formulate final conclusions in the next research step.

2.5 Research step 5: formulating conclusions

In this last research step, the information retrieved in the different research steps is synchronised. In the synchronising step, final conclusions are formulated and a judgment is made about the reliability of the estimate.

Data synergy

The conclusions are formulated by comparing expert interviews and focus group results to the existing base of knowledge from literature and congresses. Based on this comparison an indication of the reliability of the estimate is provided. For the effects and factors the following rules are followed, as designed by the author:

- If the mobility expert's expectations align with existing base of knowledge from literature and congresses, the conclusion is made that there is a *sufficient basis* for the expected effect.
- If the sources are similar but not entirely, or a factor has been mentioned by a majority of experts but not yet studied in the literature, the conclusion is made that there is a *reasonable basis* for the expectation, but more research would provide a stronger basis.
- If the information sources don't agree, the conclusion is made that there is there is *not yet a sufficiently founded basis* for this expectation, and the factor or effect must be further investigated to make substantiated estimations.

Because there is limit literature on e-scooter policy available, a different rule to indicate the reliability of the policy implications is used. Please note that the labels are no indication of the performance or effectiveness of the policy strategies or instruments.

- If an strategy / instrument is named by a majority or minority and named in literature or the congresses, the conclusion is made that there is *sufficient* basis to conclude that the policy strategy or instrument can contribute positively to the societal effect.
- If an strategy / instrument is named by mobility experts but not mentioned anywhere in literature or vice versa, concluded is that there is a *reasonable* basis to conclude that the policy strategy or instrument can contribute positively to a societal effect.

It was decided to apply these labels of reliability, not to nullify the results of the research, but to emphasize that it is about expectations. Similar that a sensitivity analysis would be performed in a quantitative model study.

2.6 Alternative methodologies

Other methodologies could have been used to research the expected impact of e-scooters on travel behaviour and society in The Netherlands. An option is to analyse empirical usage data and draw conclusions from that data. However, this is not possible as e-scooters are currently not legal on Dutch roads, and therefore no usage data is available. Moreover, in the literature that uses data, it can be seen that this almost exclusively concerns data from providers of shared e-scooters. Therefore certain insights that do emerge in this study, such as multimodal use and use of private e-scooters, would not be retrieved by examining the data of shared e-scooter providers.
Another possibility would have been to apply transportation models to estimate effects in the Netherlands. In that case, assuming a utility-based transportation model is applied; first, insight into the utility of e-scooter trips would be required. A stated-preference study would be a suitable method to retrieve those utilities. However, it is not feasible to capture both methods in one graduation project due to time constraints. It would also have been possible to apply a transport model, making assumptions for the e-scooter parameters. In this way, quantitative estimates could have been made of the effects. However, these would then be based on assumptions and would therefore also be sensitive to errors in those assumptions, thus lurking the risk of 'false certainty'. The aim of this research is to give only a first 'indication' of the effects, therefore the qualitative research design, as discussed in the previous sections, has been chosen.

3 The existing base of knowledge

This chapter elaborates on the existing base of literature on e-scooters. The insights gathered in this chapter are applied in Chapter 7 to formulate conclusions along with the results of the interviews and focus group session. Besides that they are used to identify the research gap. Therefore this chapter contributes to sub-questions 1, 2 and 3.
E-scooters are a new and upcoming sub-field of urban transportation research. Therefore the state of literature about the subject is still in its infancy (McKenzie, 2020). This chapter is, therefore, supplemented with un-peer reviewed knowledge retrieved in visited conferences and consultancy reports. If this is the case, this is mentioned in the text.
The literature discussed in this chapter is mainly carried out to-and-in cities where there are shared e-scooters available. Travel behaviour patterns cannot be easily translated to other countries. For example, Buehler (2011) showed that, while controlling for different socio-economic and physical context variables, travel patterns differ between Germany and the US. A possible explanation for this is cultural and policy differences, the researchers state. This does not mean that the information presented in this chapter has no value. However, it is important to take this into account when interpreting this information.

Section 1 discusses what is already known about the impact of e-scooters on travel behaviour. Section 2 elaborates on the effects of e-scooters on society. In the last section, Section 3, information on policy instruments as used abroad is provided.

3.1 Effects of e-scooters on travel behaviour

In this section the impact of e-scooters on travel behaviour is discussed. First some aspects of e-scooters that influence the travel experience, that lead to impact on travel behaviour are highlighted. Thereafter trip characteristics and modal shift effects are elaborated on.

How E-scooters (potentially) influence the travel experience

E-scooters offer some distinctive characteristics. If these characteristics are taken into account, placement of e-scooters and the e-scooter-transit combination in comparison to speed and accessibility of other modalities could be as show in figure 4-1. E-scooters are placed above (on the y-axis) bicycles since the operating speed of e-scooters is faster. Regarding the accessibility, the bandwidth of e-scooters is broader than that of the bicycle. For shared e-scooters, this is dependent of parking restrictions and the precise interpretation of the shared system. For private e-scooters this will be similar as that of the bicycle. However one could argue that the accessibility bandwidth of the bicycle should then also be broader if different set-ups of shared bicycle systems are taken into account. This figure is adapted from Kager, Bertolini and Te Brömmelstroet (2016) based on the authors interpretation and functions as an indication of the potential of e-scooters based on its

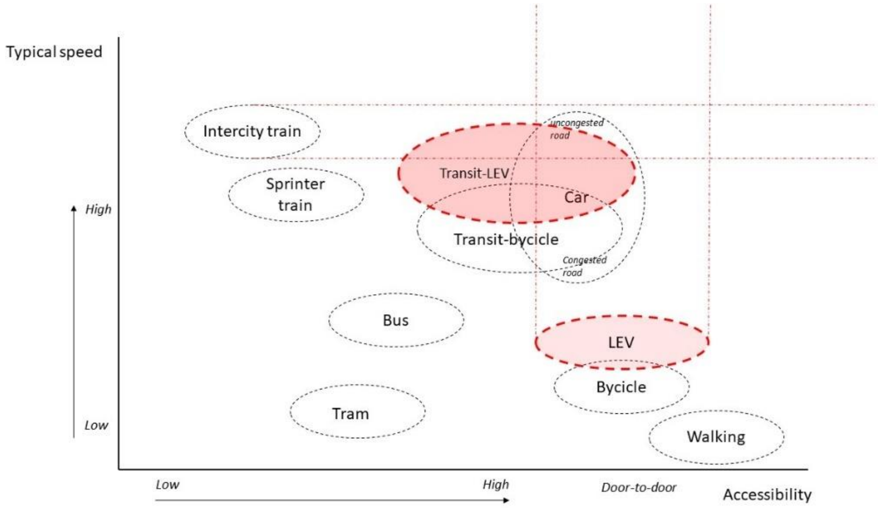


Figure 3-1 potential benefits of e-scooters and the e-scooter-transit combination regarding accessibility and speed (schematically visualized), adapted from Kager et al., 2016.

characteristics. The next paragraphs elaborate on the literature about the influence of e-scooters on the travel experience.

E-scooters as independent mode of transport

E-scooters have certain properties that are different than other, more common forms of micromobility, like (e-) bicycles and mopeds. Users (are expected to-) like the effortless, travel time savings, playfulness and low entrance barrier (Tuncer & Brown, 2020; Christoforou et al., 2021; Sipe & Pojani, 2018; McKenzie, 2020). For shared e-scooters, the vehicle density is an important determinant for mode choice and research results indicate that docked shared modes are preferred for commuting trips over dockless shared modes (Reck et al., 2021). Lastly, E-scooters can be a alternative for urban car travel as well (McKenzie, 2020; Smith & Schieterman, 2018).

Tuncer and Brown (2020) questioned e-scooter users in Paris. They found that people like the effortless of e-scooters. As compared to bicycles they are more suitable to commute, interviewees stated that they are suitable to ride with office dress. This is in line with the expectations of the participants of congress 1 (Appendix 4, not peer reviewed), they expect that the ease of use of e-scooters is a benefit over other modalities. Also two urban planning and transport professor argue in a (non-peer-reviewed) article that e-scooters are more suitable to drive on with office dress. Besides, they state that manoeuvring along narrow paths is more easy (Sipe & Pojani, 2018). Moreover, Christoforou et al., (2021) performed a survey with e-scooter users in Paris: Their main motivation is travel time savings followed by playfulness and money savings.
McKenzie (2020) compared the data of different micromobility providers in Washington (US). The data suggest that e-bicycles as compared to e-scooter have a higher entrance barrier: “it is still necessary to pedal the bike in order for it to operate. This is a significant barrier to entry for some users, limiting the target user base to those willing to exert some degree of physical effort” (p. 12). Reck al al. (2021) carried out a comparative study of different shared micromobility providers as well. They investigated the usage patterns and competition of different shared mobility modes (dockless e-scooters, docked bikes and docked e-bikes) in Zurich (Swiss). Using vehicle location data from four micromobility companies they estimated a mode choice model that is able to predict a micromobility mode choice based on certain parameters (vehicle density, distance to vehicle, etc.).
Results show that vehicle density has a strong relationship with mode choice, up to a certain ‘plateau effect’. Besides, that users prefer the docked (e-)bike options during rush hours and dockless e-scooters outside of the rush hours. Indicating that the docked (e-)bikes are more attractive for commuting. The researchers provide a possible explanation for this: docked modes have, among other things, a higher certainty of availability and therefore fit better into habitual travel patterns (such as commutes). It would be interesting to compare docked e-bikes with docked e-scooters and dockless bikes with docked e-scooters, to see if this relationship also holds the other way around.
At last, there are also indications found in literature that e-scooters can compete with the car in certain circumstances: McKenzie (2020) conclude in their data analysis (see above) that, only during rush hour, e-scooters are faster then car transport in the urban area of Washington. This last conclusion is in line with trip simulations in Chicago done by Smith and Schieterman (2018). They found that the e-scooter option appears to provide a clear niche between bicycling, walking, and transit. Especially in car-constrained environments, on trips between 1-3 km, the e-scooter can be a strong alternative as compared to private automobiles. It has to be said however, the researchers excluded private bicycles from this conclusion. And the research was paid for party by the e-scooter company Bird.

E-scooters in combination with public transport

As stated in the introduction (Chapter 1), a modal shift away from the car is desired. Public transport and micromobility can be a substitute for car usage. However, public transport on its own doesn’t provide door-to-door transport and micromobility lacks radius (Kager et al., 2016). Combining private transport and public transport in a truly multimodal transport system offers opportunities to capitalise on the strengths of the various systems while avoiding their weaknesses (Van Nes, 2002). Combining modes helps to increase the destination density while reducing travel times (Sinha, 2003).

There hasn’t been any peer-reviewed research yet to the e-scooter-transit multimodality. Gössling (2020) states that the last-mile potential of e-scooters are a prominent reason of shared e-scooter introduction in cities by policymakers. However this claim is not supported by anything else then the authors interpretation of E-scooters. Also Baartman (2020, Appendix 4, not peer-reviewed) sees a potential for the use of private e-scooters combined with public transport. Arendensen (2020) investigated the willingness to use shared mobility modes as last mile in multimodal public transport trips. Despite the unfamiliarity with e-scooters for most people. There is already an early adapter group seriously considering the mode in their choice set. In 5% of all choices, respondents preferred the e-scooter as last mile solution for trips of 1-2 km. Familiarity with a mode is an important determinant in the choice of a mode (see; Appendix 3). Considering that 47% of respondents never heard of the e-scooter and 51% heard of the e-scooter but never used it, this small number of 5% nevertheless shows an indication of the potential of this mode of transport for last mile transport in combination with the train.

The bicycle-transit multimodality has gained great interest in research on the other hand (Kager et al., 2016; Shelat et al., 2018; Van Mil et al., 2020). Keeping in mind the differences in characteristics, some findings of the bicycle-transit combination are applicable to the e-scooter-transit combination as well. For example, Kager et al. (2016) researched the synergy of the train-bicycle multimodality in a case study in Amsterdam. He states: “When the transfer is organised well, bicycles offer a substantial increase in door-to-door accessibility compared to train trips. The bicycle adds a fine-grained spatial distribution of origins and destinations that the train system alone can never achieve. Likewise, trains offer a substantial increase in speed and likewise to the spatial reach of the bicycle system. The resulting synergy of high speed (and thus spatial reach) of the train with the door-to-door accessibility of the bicycle give the system unique speed and accessibility characteristics, making it potentially competitive with the characteristics of personal motorised transport” (pp. 211) .

Trip characteristics

This section elaborates on the literature on e-scooter trip characteristics. Besides, the effects of e-scooter on travel behaviour that have occurred or stated by (prospective) users is discussed.

Users

Users of e-scooters are mostly men, between 18 and 35 years of age and higher educated in places where user surveys have been carried out (Christoforou et al., 2021; Laa & Leth, 2020;) An upwards age trend is observed when e-scooters are available in a city for a while (Hunternilsson, 2020, Appendix 4)

Christoforou et al. (2021) performed a survey with e-scooter users in Paris. Both users of shared e-scooters as owners of e-scooters were questioned. They found that 2/3 of the respondents were men, 1/3 women, while stating that the Parisian population is gender-balanced. The highest percentage of user groups are between 18 and 29. As compared to the Parisian population, people under 24 were over represented. One third of the respondents holds a MSc degree or higher. This is line with the findings of Laa and Leth (2020) who questioned e-scooter users in Vienna (Austria). They found e-scooter users to be young, male and highly educated: about 80% of the users were men and more then 60% of users were bellow 35. More then 60% of the respondents were educated on a university level.
Although, e-scooter supplier Voi sees an upward trend regarding the age of e-scooter users in Sweden trend (Hunternilsson, 2020, Appendix 4, not peer-reviewed). At first older people are hesitant to use the vehicles, but after a while they start using the vehicles.
Furthermore, (Knoester & Hunternilsson, 2020 appendix 4) state (a non peer-reviewed statement) that they experience that early adapters are most of the time cyclist. People have to get used to micromobility, and product gets more attractive with more users. Supply has to grow till also car users are convinced. In Sweden there is an upwards trend that more people switch from car to e-scooter. CoMuUK (2020, appendix 5, not peer-reviewed) agrees with this statement, he states that: “if you want to get people out of their cars, you need a range of options”. e-scooters are therefore part of the solution in his opinion. Furthermore he refers to research by Augustin Friedel (2020, not peer-reviewed), mobility expert at Volkswagen. Friedel claims that, on a global level, 25% of e-scooter trips would have been car trips.

Trip purpose:

Literature shows that e-scooters are used for both commuting (education and work) as leisure purposes. There is not a clear dominant purpose, however there are more studies that show a dominant leisure purpose (Christoforou, 2021; Eccarius and Lu, 2018; Ewert et al., 2019) than studies that show a dominance in commuting purpose (TØI, 2020; Hollingsworth et al., 2019).

Mathew et al.(2019) concludes that scooters are less being used as a "last-mile" weekday commute option, and more as a mode for running short-distance midday errands, traveling around a campus, and leisure (pp 46). Also Eccarius and Lu (2018) found a dominance for leisure purposes, they found stated preferences of trip purposes for e-scooters. Their results are: work/school (28%), shopping (19%) and tourism (16%) the rest of the purposes were also leisure related. Only 3% of the students intended to use e-scooters as firt/last mile mode. A similar picture emerged from the study of Christoforou et al., (2021). They found that e-scooters are mostly used for leisure trips. Commuting is a less frequent travel purpose. At last, the experts questioned by Ewert et al. (2019) foresee leisure trips (for tourists) as most promising trip purpose, thereafter commuting. However these are merely expectations and not observed trips or stated preferences by users.
On the other hand, TØI (2020) found that E-scooters are mostly used for education and work purposes. A similar picture emerged from the study by Hollingsworth et al. (2019). They did a survey with 61 e-scooter users and found that 67% used the e-scooter to reach a destination, and 32% used the e-scooter for recreation. The findings of the literature on trip purposes are summarized in Table 3-1.

Study	Study location	E-scooter situation in study location	Respondent types	Main findings regarding trip purpose
TØI, 2020	Norway	Shared E-scooters	User data	Most trips made for education or work purposes
Ewert et al., 2019	Europe	Diverse	Expert interviews	Most promising trip purpose is leisure for tourist, thereafter commuting.
Mathew et al., 2019	Indianapolis, US	Shared E-scooters	User data from shared e-scooter providers	Short-distance midday errands, and leisure
Eccarius & Lu, 2018	Taiwan	Shared e-scooters	Stated preference	Education/Work (28%), shopping (19%) and tourism (16%), rest are other leisure activities
Hollingsworth et al., 2019	North Carolina	Mostly shared	Users, survey (n=61)	67% education/work, 32% leisure
Christoforou et al., (2021)	Paris	Shared and private (90 vs 10%)	Users, survey, n=500	Mostly leisure, thereafter commuting

Table 3-1: findings on e-scooter trip purposes

Trip length

Literature finds that e-scooters are mostly used for shorter trips (1.8 – 4 km) (Reck et al., 2020; CMC, 2019; Christoforou et al., 2021)

Reck et al. (2020) found that dock less e-scooters are preferred for shorter trips then bicycles. CMC (2019) did a large (non peer-reviewed) research. They analysed the data of six large e-scooter rental providers in European cities and found a average trip length of ~1.8 km for trips on shared e-scooters, compared to an average distance of 0.9 for trips by foot and 3.4 km for trips by bicycle. Christoforou et al. (2021) found a slightly longer average trip length for e-scooter users in Paris. The results show that the average e-scooter trip last 15 minutes and are 4 kilometres long.

Time of Day:

In literature a clear afternoon peak is seen in the usage of e-scooters, based on data of shared e-scooter providers (Reck et al., 2020; Liu et al., 2019; McKenzie, 2020; CMC, 2019; Portland Bureau of Transportation, 2018) and users surveys (TØI, 2020).

TØI (2020) found, from their user data, that the e-scooters are mostly used between 16 and 17hr. Reck et al. (2020) analysed data from 5 shared mobility providers in Zurich. They found that dockless e-scooters don't have commuting patterns, indicating they are not widely used for commuting. Liu et al. (2019) analysed shared e-scooter trips in Indianapolis, US. They found that the e-scooters are mostly used between 16hr and 20hr as shown in Figure 3-2. The Portland E-scooter pilot revealed similar numbers: data showed a clear three-hours e-scooter evening commute peak (PBT, 2018).
McKenzie (2020) investigated the data over a four month period of five shared e-scooter companies in Washington DC, US. In total they investigated over 300.000 trips made on e-scooters. They found a clear PM rush hour peak in the usage, and to a lesser extend also in the morning peak as shown in Figure 3-3. Also CMC (2019) found a clear afternoon peak in the data of shared e-scooter companies in several cities throughout Europe.

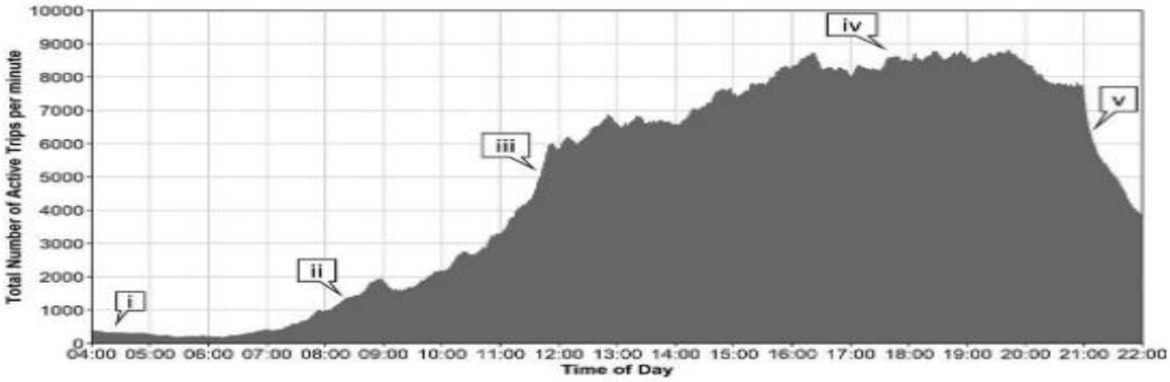


Figure 3-2: Time of day data of shared e-scooter trips in Indianlapolis (US) (Liu et al., 2019)

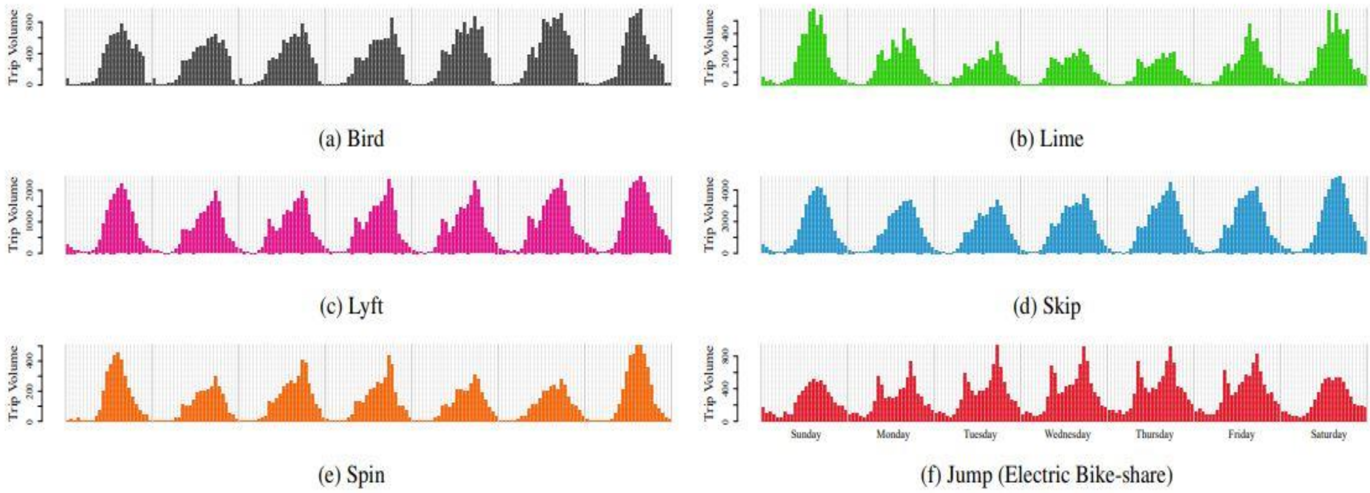


Figure 3-3: Time of day data from shared e-scooters in Washington (US) (McKenzie, 2020)

Modal Shift effects, multimodality and trip frequency

Literature shows that most trips made with e-scooters replace trips previously made with active travel modes. US-based studies show a relatively large shift from the car (PBT, 2018; Hollingsworth et al., 2019) as compared to EU based studies, which show a relatively large shift from public transportation (TØI, 2020; Bortoli & Christoforou, 2020; 6t-bureau de recherche, 2019; Laa & Leth, 2020). Not many studies touch upon multimodal trips with e-scooters, the studies that do, found that a large proportion of the trips were made in combination with another means of transport (TØI, 2020; 6t-bureau de recherche, 2019). Also not many studies investigated whether e-scooters cause an increase in travel movements, if this is done research found an increase of 8-20% (PBT, 2018; Hollingsworth et al., 2019). The only available study that compared the use of private and shared e-scooters found that owners of e-scooters replace more car trips and use e-scooters more often in combination with public transportation (Lee and Leth, 2020).

The modal split results of the e-scooter pilot in Portland (PBT, 2018) revealed the following modal shift results: 8% would not have taken the trip, 45% would have biked or walked, 36% would have used an automobile, and 10% would have used a bus or streetcar. Another US study by Hollingsworth et al. (2019) in North Carolina determined the modal shift effects of e-scooters based on a survey with 61 e-scooter users. She found a modal shift result of: walking 30%, Car 30%, bicycle 15%, bus 19%, taxi 6% and 19% would not have gone.

TØI (2020) found the following modal split results in Oslo (Norway), using a survey: 60% percent of shared E-scooter users shifted from walking, 23% from public transport, 9% from the bicycle and 8% from car. More than 50% of users use the e-scooter as part of an multimodal trip, most often in combination with public transportation. These modal shift effects are quite similar with two other EU based studies, both in Paris. Bortoli and Christoforou (2020) determined the modal shift effects of shared e-scooters in Paris through a survey. The previous used modes of transport were: Walking (35%), metro (23%) and the bus (12%), car (10%) and bicycle (8%). 26% of the trips were part of an intermodal chain: 26% with the bus, 32% with the metro, 11% with cars and the rest with other modes. 6t-bureau de recherche (2019) surveyed 4382 users of e-scooters in non peer-reviewed study. Regarding the modal shift effects the institute found that: 44% of users stated that the e-scooter trip replaced a trip on foot, 30% a trip by public transportations, 12% a trip by bike and around 10% a trip by car. 23% of the free floating e-scooters were used in combination with PT.

Furthermore Lime (2018) published an end of year report of their operations in Auckland, NZ. It states that 22% of riders switched from a car. However these numbers are not independently verified. Coming from the same database, about 78% Lime trips appeared to replace cycling or walking. Smith and Schieterman (2018) simulated the usage of e-scooters in Chigago, US. They found that on shorter trips (0.8 – 3.2 KM) e-scooters can be a strong alternative as compared to the car. Eccarius and Lu (2018) asked students, if they stated they would like to do a trip with an e-scooter, with what other mode the trip would have been previously taken.

The answers were: moped (39%), followed by public transport (31%) and walking/bicycling (20%), only 10% stated current car. At last, Fitt and Curl (2019) found a modal shift result of 57% from active modes, 28% of car. 7% were new trips.

There is currently only one study available that compared the usage of private and shared e-scooter users. Laa and Leth (2020) used a survey (n=166) and three field observations to gather data results. They found that, a considerable amount of e-scooter trips made by owners are replacing private car trips. However in both groups walking and public transport are the most used modes pre e-scooter. 41% of e-scooter owners indicated that they regularly take their e-scooter in PT, 39% sometimes and 20% not at all. Indicating a potential for multimodality. The study results as elaborated on in this paragraph are summarized in Table 3-2 on the next page.

Study	Study location	e-scooter situation in study location	Respondent types	Main findings regarding modal shift from:
TØI, 2020	Norway	Shared E-scooters	Survey	60% walking, 9% bicycle, 23% PT, 8% car. 50% as part of multimodal trip
Lime, 2018	Auckland, NZ	Shared E-scooters	User data	~78% walking/bicycle, 22% car
Smith & Schieterman, 2018	Chigago, US	Shared E-scooters	Simulation model	Strong alternative from car on 0.8-3.2 km trips
Eccarius & Lu, 2018	Taiwan	Shared e-scooters	Stated preference	20% walking/bicycle, 39% moped, 31% PT, 10% car
PBT, 2018	Portland (US)	120 day pilot	Citywide poll (n=4552)	45% walk/bicycle, 10% PT, 36% car, 8% new trip
Bortoli & Christoforou, 2020	Paris (France)	Mostly shared e-scooters	Survey	35% walk, 8% bicycle, 35% PT, 10% car
Hollingsworth et al., 2019	North Carolina	Shared e-scooters	Users, survey (n=61)	30% walk, 15% bicycle PT 19%, car 36%, new trip 19%
6t-bureau de recherche, 2019	Paris (France)	Mostly shared e-scooters	Users, survey (n=4382)	30% walk, 12% bicycle, 30% PT, 10% car. 23% part of multimodal trip
Laa & Leth, 2020	Vienna (AU)	Shared and private e-scooters	Users of shared E-scooters and owners of E-scooters	walk&bicycle most replaced. Owners also replace car trips. Owners: 41% regular use e-scooter with PT.
Fitt & Curl, 2019	New Zealand	Mostly shared e-scooters	User and non users survey (n=591)	57% active modes, 28% car, 7% new trips

Table 3-2: Modal shift effects of e-scooters from literature

3.2 Societal effects

This section describes literature on the impact on society that was noticed or is expected as a result of the introduction of e-scooters in urban environments.

Public opinion and perception of e-scooters

Gössling (2020) analysed 173 news items in ten cities (US, EU and Oceania) were e-scooters are recently introduced to asses public opinion. This qualitative analysis can is an indication of the effect on society of e-scooters. He analysed the news articles prior and after the introduction. He suggests that “public opinion is the most significant challenge for this transport mode” (pp3). The concerns addressed in those news articles are shown in Table 3-3. Gössling found that, however the public opinion about e-scooter related problems difference considerably between cities, the most dominant themes were safety and conflicts over space. He concludes by stating that many conflicts, regardless of city characteristics, can be avoided by restricting speed limits at around 25 km/u, to allow E-scooters only on bicycle infrastructure and to create designated parking spaces. Besides he devote the differences of the public opinion to the differences in cultural and social situation in cities.

Concerns over e-scooters prior to and after introduction.

Issue	Brisbane	Christchurch	Copenhagen	Dallas	Los Angeles[1)]	Málaga	Paris	Stockholm	Vienna	Zurich
Pre-introduction (in order or relevance)										
Safety*	x	x	x	x			x			x
Conflicts over space		x	x			x			x	
Legal speed limits	x			x		x				
Irresponsible riding**			x			x			x	
Cluttering***				x		x				
Vandalism		x					x			
Helmet requirement		x				x				
Post-introduction (in order of relevance)										
Irresponsible riding **	x	x	x		x	x	x		x	
Safety/Injuries	x	x		x	x		x		x	
Cluttering***			x	x	x	x				
Vandalism	x				x	x	x	x		
Conflicts over space						x	x		x	
Legal speed limits	x					x	x		x	
Environmental aspects****							x	x		x
Social division*****						x	x	x		
Riding without helmet	x								x	
Insurance issues	x									

Table 3-3: Concerns before and after introduction of e-scooters, as adressed in news articles (Gössling, 2020)

In addition to Gössling's research into media reports, there have been a number of studies on the perception of users and non-users of e-scooters in cities where e-scooters are currently driving. In cities where e-scooters are currently available, the majority of the people perceive e-scooters as a positive development and a potential valuable addition to the transport system (Clewlow et al., 2018; PBT, 2018; Matrixlab, 2020; Eccarius & Lu, 2018; Fitt & Curl, 2019).

Clewlow et al., (2018) found, in a non peer-reviewed study applying a survey conducted in eleven cities in the US, that the majority of people in urban areas perceive (70 percent) e-scooters positively as they expand transportation options and provide a convenient replacement for short trips in a personal vehicle or ride-hailing services. Eccarius and Lu (2018) administered a survey among students in Taiwan. The survey contained questions about the intentions, attitudes and perceptions of e-scooters. 58% of the students had e positive attitude regarding e-scooters. Students liked environmental benefits, money savings and the convenience of the e-scooters.
PBT (2018) did 120 day pilot period with e-scooters in the city. They analysed more then 700.000 trips and a citywide poll (n=4552), 62% of Portlanders viewed e-scooters positively at the end of the pilot. Metrixlab (2020) did a research into the opinions of users and non-users of E-scooters. Regarding E-scooters (as in this research) the conclusions are: Older respondents see them more as toys then as modes of transport (especially hoverboards and monowheels, e-scooters fall in between). Younger and inhabitants of cities see a transport function potential. 20% of respondents considers buying a e-scooter. Potential adapters see a

potential for short distances and the carry-on function in PT. The biggest concerns are safety risks due to speed and integration in traffic.
At last, Fitt and Curl (2019) did a survey with users and non-users about their perception on e-scooters in New Zealnd (n=591). Although the sample was not representative of the population, the results provides some insights. They found that younger males are the most likely to use an e-scooter. The biggest concerns regarding e-scooters are safety and costs. Table 3-4 on the next page summarizes the findings of attitudes and perception towards e-scooters from literature.

Study	Study location	e-scooter situation in study location	Respondent types	Main findings regarding attitudes & perceptions
Clewlow et al., 2018	11 cities in the US	Mostly shared e-scooters	Randomly selected users&non-users	70% positive attitude, 30% negative
Eccarius & Lu, 2018	Taiwan	Mostly shared e-scooters	Local and international students	53 – 58% positive attitude, 22% negative
PBT, 2018	Portland (US)	120 day pilot of shared e-scooters	Citywide poll (n=4552)	62% viewed E-scooters positive t end of the pilot
Metrixlab, 2020	Netherlands	Not legal	Random selection of respondents	Older respondents: "E-scooters are toys". Younger inhabitants of cities "E-scooters have transport potential".
Fitt & Curl, 2019	New Zealand	Mostly shared e-scooters	Users and non-users (n=591)	Younger males most likely to use e-scooters

Table 3-4: perceptions and attitudes of E-scooters, from literature.

Environment

Two quantitative studies have been published with regard to the effects on the environment of E-scooters (Bortoli & Christoforou, 2020; Hollingsworth et al., 2019). In both studies, similar, but not identical, life cycle assessment were carried out on shared free floating e-scooter systems. In a life cycle assessment, all the effects of the entire product chain are taken into consideration. What falls within this chain differs slightly in both studies. Both studies found that currently shared e-scooters are not beneficial for the environment.

Bortoli and Christoforou (2020) performed an analysis in Paris, France. They concludes that the introduction of the shared e-scooters in Paris led, very likely, to an overall increase in emissions. This is mainly due to the modal shift effects: 60% of users switched from metro & tram to E-scooters and 22% from active modes. The short average lifetime of the e-scooters (1 year) and the recharging service method contribute to the total life cycle emissions as well. Almost half of the carbon footprint is due to the recharge service with gas-powered vehicles.
Scenario analysis showed that increasing the lifetime of the e-scooters or making the recharge service more sustainable are both insufficient to obtain a positive balance. Only combining both leads to a positive effect of the e-scooter use on the climate. The found life cycle carbon footprint of the E-scooters and a comparison with other transport modes in Paris is shown in Figure 3-4.

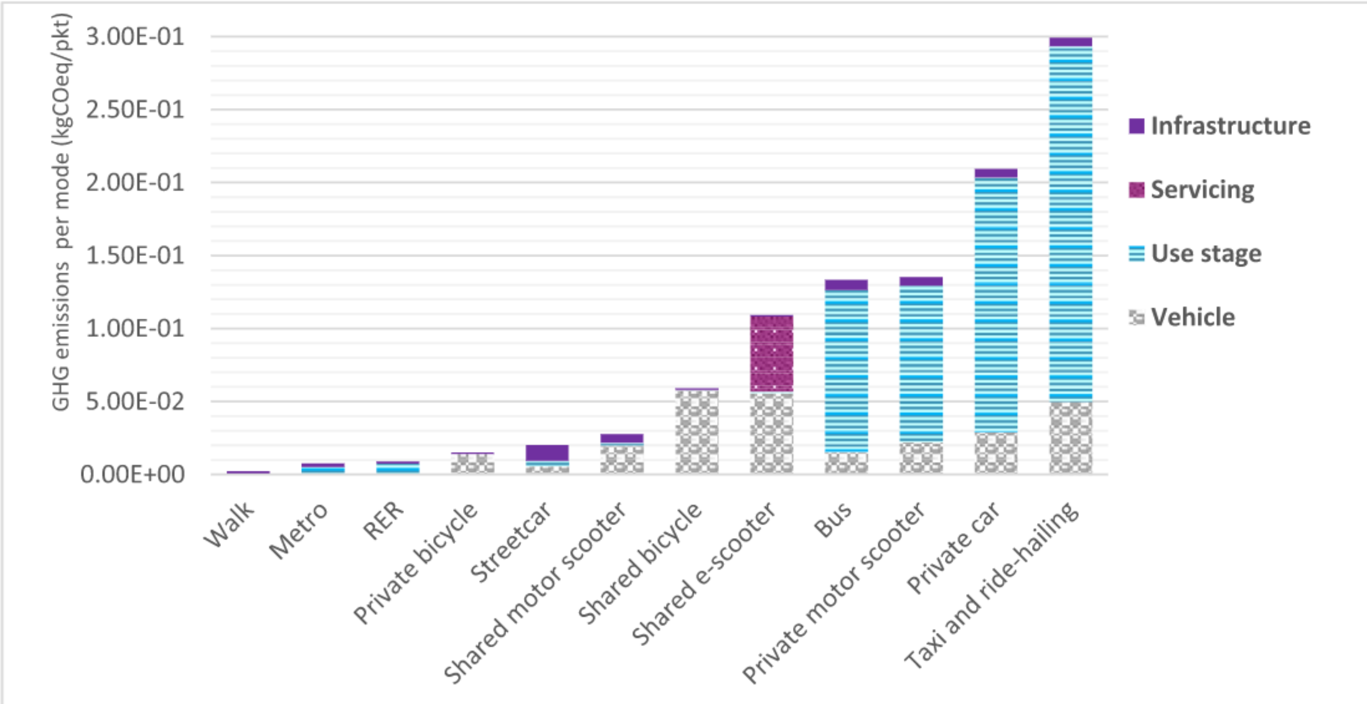


Figure 3-4: Life cycle carbon footprint of the main modes of transportation in Paris (Bortoli & Christoforou, 2020)

The ’electricity carbon intensity’ (a measure for the amount of carbon emitted per energy that is consumed) is also relevant. This is an location specific parameter, it depends on the way the electricity mix in a city is generated. In Paris 70% of the electricity comes from nuclear plants with a relatively low impact on the climate. Counter intuitively, a higher electricity carbon intensity leads to a better impact of E-scooters on the climate. This is also due to the found modal shift effects in this research: the high share of the switch from public transportation. The metro and tram run on electricity, a switch towards E-scooters means less electricity use but more emissions due to servicing and materials (considering the short lifetime).
However, a discussion point on this research is the fact that intermodal trips are not included in the life cycle assessment, these trips account for 26% of the total e-scooter use. It is hard to determine the effect of these multimodal trips on the life cycle emission, because trip data for the other modes is required.

Hollingsworth et al. (2019) performed the analysis in North Carolina (US). They also found that the impact of e-scooters on the environment is highly sensitive to the modal shift effect, the e-scooter lifetime and the charging service (accounting for 43% of total emissions in this research), moreover they identified the type of battery as an important aspect. Scenario analysis and simulation showed here, that increasing the average lifetime of e-scooters to two years highly decreases the impact on the environment: in 96% of trips the e-scooter is then a more sustainable mode then the replaced mode. A comparison with other transport modes is shown in Table 3-5 on the next page.

	Base case	Low collection distance	Battery depletion limit	High vehicle efficiency	High scooter lifetime
Personal automobile[a] (414 g CO_2/mi)	1.7%	0.3%	0.7%	1.0%	0.0%
Shared dockless bicycle[b] (190 g CO_2/mi)	33.2%	20.9%	23.6%	30.0%	0.0%
Benchmark Displacement[c] (150 g CO_2/mi)	65.0%	34.8%	39.9%	50.0%	4.0%
Electric moped[d] (119 gCO_2/mi)	100.0%	54.2%	66.9%	89.5%	100.0%
Bus with high ridership[e] (82 g CO_2/mi)	100.0%	99.6%	100.0%	100.0%	100.0%
Electric bicycle[d] (40 g CO_2/mi)	100.0%	100.0%	100.0%	100.0%	100.0%
Bicycle[d] (8 g CO_2/mi)	100.0%	100.0%	100.0%	100.0%	100.0%

Table 3-5: The likelihood that e-scooter life cycle impacts per passenger-mile traveled exceeds the impacts of alternative modes of transportation (Hollingsworth et al., 2020)

A discussion point regarding this study is, that the infrastructure demand is not taken into account. However Bortoli and Christoforou (2020) found, that this accounts only for 3% of the marginal emissions. This parameter is location specific though; it depends on the use of the infrastructure of all modes combined.

Besides these two quantitative researches, Ewert et al. (2019) analysed the environmental impacts qualitatively. He questioned 32 experts about their expectations or observations regarding the impact of E-scooters. The experts were mostly from Europe. Environmental effects like better air quality, noise reduction and CO2 reduction were considered as most important prospects for E-scooters in the city.

Lastly, Metz (2020, Appendix 6) investigated (with a non peer-reviewed study) the sustainability effects of -among other modes- shared e-scooters. He states that there are a lot of determinants and uncertainties that influence the effect of e-scoter on the environment. Important factors are: modal shift effects, redistribution of vehicles, the life cycle and battery changing systems. Furthermore he concludes that, on its own e-scooters probably won't have a large effect on the environment. But they can contribute to the freedom to choose multiple transport modes besides a car and therefore in the end contribute to a cleaner environment. The attendees responses on the question which factors influence the effect of e-scooters on the environment (if named by multiple attendees) were: circularity, laws and regulations, ease of use, life cycle, availability of LEVs (Appendix 6).

Traffic safety and health

There are three reports on e-scooter related injuries (PBT, 2018; Mayhew & Bergin, 2019; Blomberg et al., 2019). In all cases hospital data is compared with the situation before the introduction and after the introduction of e-scooters. All studies found an increase in e-scooter related injuries after the introduction of a shared e-scooter system. However, in none of these studies is analysed if injuries related to other modes of transport decreased/increased in the study period. In other words, there is no evidence of an increase or decrease of the total transportation related injuries.
In non injury data based studies, e-scooters are expected to have a similar risk profile as the bicycle (Bierbah et al., 2018; TNO, 2020;) Depending on modal shift effects, e-scooters have a negative influence on public health since no physicial effort is required to go around (Milakis et al., 2020).

Mayhew and Bergin (2019) reviewed hospital emissions of a 6 month period in Auckland (NZ). They report a "large number of serious related injuries" (p. 464). During the Portland e-scooter pilot, 5% of total traffic crash injury visits were e-scooter related (PBT, 2018). Blomberg et al. (2019) reviewed medical records of a 2.5 year period in Copenhagen. Besides accidents of users of e-scooters, they also report a large proportion (17%) of injuries of non-riders. These were mostly elderly people who tripped over e-scooters.
However, as stated, these studies don't provide evidence of an increase or decrease of total injruties related to transportation. This is also reflected in media reports on the safety of E-scooters: Gössling (2020), concludes on the matter that the media reports on safety are "one-sided" and do not take into account a shift of risks (injuries that had occurred should e-scooter riders have used other modes of transport). Furthermore De Goede (2020, Appendix 6) states that it would not be straightforward to compare data from abroad,

because of the bicycle culture in the Netherlands; people are used to riding a bicycle and chaotic bicycle paths. However this is based on his own statement an non peer-reviewed.
Next to these injury data bases studies, in Germany the 'Bundesantalt für strassenwesen' (Bierbag et al., 2018) researched the safety aspects of E-scooters, in preparation for the development of a classification system for the law. By doing 'dynamic driving tests' and 'technical specification research' the formulated some conclusions. They conclude that, if helmets are used and the maximum speed is 20km/hr , the safety aspects and risks of E-scooters are similar as that of the bicycle. This is in line with the conclusions of a research by TNO (2020) they conclude, after analysing the situation in a range of countries, that the risk for severe injuries is similar as that of the bicycle. They refer to research by (ITF-OECD, 2020) which report a ratio of 87 – 251 severe injuries per 1 million trips, for the bicycle this ratio is 110-180 per million trips.
Moreover, Hoek et al. (2019) see two problems regarding safety. If speed limit is low (10 km/hr) there is a safety risk for pedestrians. If speed limit is higher and allowed on bicycle lanes, there is a risk for other cyclist and automobiles. However they state that one could argue if these risks are due to e-scooters or due to cars.
At last the attendees responses in the congress (Appendix 6) on the question which factors influence the effect of LEVs on traffic safety (if named by multiple attendees): speed, mass (Weight), behaviour, place on the road, road layout, driver, width of the vehicle.

Next to traffic safety aspects, e-scooters could also influence health through physical activity. This depends on the modal shift effects of E-scooters. If mostly active modes are replaced by e-scooter trips, effects are negative. Since no physical activity is required to go around on e-scooters (Milakis et al., 2020).

Liveability of public space:

E-scooters compete over space with pedestrians, cyclist and motorized transport and they add complexity to the transport system (Gössling, 2020, p. 2). On the other hand, e-scooters can utilize space effectively, CROW (2020) states that about 20 e-scooters fit in one parking space for a car. However, Liu et al. (2019) found that only 15% of the shared e-scooters are used for more then 1hr a day. This implies that the e-scooters are parked most of the time.
The impact of e-scooters on public land depends for a part of the modal shift effects (Laa & Leth ,2020). If e-scooters mostly replace public transport and walking trips, the e-scooter users are additional users of cycle infrastructure. Also parking regulatons and places are important, in the examples abroad is seen that e-scooters are regularly parked on side walks (Fang et al., 2018; James et al., 2019; Zagorskas & Burinskiené, 2020). Baartman (2020, Appendix 6) states that LEVs can, however being rather small, have a large effect on the liveability of the built environment. However this statement is based on his own experience and not peer-reviewed. Participants of the CROW congress named the following factors on the question of determinants of the influence of light electric vehicles (including e-scooters) on the liveability: Ease of use of e-scooters, behaviour, safety, driving speed.

Accessibility & Inclusivity

E-scooters have the potential to increase the accessibility of places, however differences occur between areas depending on local situation (Smith & Schwieterman, 2018; PBT, 2018). Potential lies in the connection of e-scooters to public transportation networks (Milakis et al., 2020; Jelbi, 2020, Appendix 7) and also for short distance trips (Milakis et al., 2020; Van Dam et al., 2020, Appendix 6).

By adding a new mode of transport with its distinct characteristics, e-scooters could potentially change the accessibility of areas. Smith and Schwieterman (2018) acknowledge this, their simulation model of Chigago showed that 16% more jobs were reachable within a 30-minute radius as compared to the situation with just public transit and walking. They note that the effects on accessibility are markedly different between certain areas. However, as stated before, one has to keep in mind that their simulation model did not include the bicycle as mode of transport. The researchers of the Portland Pilot (PBT, 2018) also see a potential for the accessibility benefits of e-scooters. ""E-scooters have the potential to expand opportunity and access for underserved Portlanders, though barriers exist" (p. 34).

Milakis et al., (2020), researchers of the German Institute of Transport Research, analysed literature on the effects of micromobility (thus, a broader range of vehicles then in this report) on a range of effects; air pollution, safety, physical activity and subjective wellbeing. On accessibility they conclude that, regarding e-scooters:

e-scooters have the potential to improve the accessibility by “by enhancing first/last mile connectivity to public transport as well as by offering low-cost, seamless short distance trips” (p. 8). However, they state that the involved costs, required physical abilities and technical skills. They refer to the fact that from the first user surveys is noted that most users are higher educated and have a higher income, which leads to questions about the affordability of E-scooters.
Jelbi (2020, Appendix 7) thinks LEVs can contribute to accessibility of the city center and the outer city. The company claims (non peer-reviewed) that due to the Jelbi app and hubs (with among other vehicles, LEVs) 70.000 extra people in the outer city of Berlin have access to micromobility. This corresponds to 6% of the total population of Berlin. An important factor is the connection to public transport stations, activity locations and neighborhoods outside the city center. They try to accomplish this by placing hubs on strategic locations.
Van Dam, Zandstra & Jeroen (2020, Appendix 6) think LEVs have the potential to increase the accessibility of the transportation system in general. However this is based on their experience and non peer-reviewed. Regarding the accessibility of less dense areas the opinions differ: Some think that there are only opportunities for micro-mobility from nodes and centers, thus linked to public transport. Others see that micro-mobility (shared scooters) are useful in rural areas, especially for the last mile. Regarding inclusivity of the transportation system is noted that currently there are not many LEVs with a focus on access for disabled or elder persons. Also is noted that sidewalks should remain accessible, otherwise the accessibility of a city on foot decreases Van Dam, Zandstra & Jeroen (2020, Appendix 6, non peer-reviewed).

3.3 Policy options

In line with the novelty of the subject, there isn’t a large amount of literature available specifically on e-scooter related policy strategies and instruments and their performance (Gössling, 2020). In this paragraph an overview is provided of articles that elaborate on policy related to E-scooters.

Gössling (2020) made an overview of ex post policies that cities implemented to address shared e-scooter issues. He identified four categories; technology, infrastructure & e-scooter design, legalisation & management and behaviour. The policy instruments that can be used in the categories are shown in Table 3-6.

Category	Policy instruments and strategies
Technology	Geofencing (limiting speed)
	Smart scaling (monitor use to adjust available numbers)
	App to report broken/improperly parked e-scooters
Infrastructure & e-scooter design	Designated parking zones
	E-scooter design must include safety measures like light and reflectors
Legislation & management	Differentiated speed limits
	Max speed 25 km/h
	Riding on sidewalks prohibited
	Use limited to bicycle infrastructure
	Helmets for riders below age of 12
	Helmets for all riders
	Minimum riding age 18
	Recharging only with renewable energy
	Limiting number of E-scooters
	Limiting number of operators
Behaviour	Safety campaign
	Awareness campaign regarding e-scooter rules
	Maximum of one rider per e-scooter
	No use of phones while riding
	Maximum blood alcohol concentration
	No doubling up (riding next to each other)

Table 3-6: Policy instruments implemented by cities, adapted from Gössling (2020)

Gössling (2020, pp 9) concludes his article with a suggestion for policy measures, irrespective of city size or structure: “In order to minimize the conflicts created by e-scooter introductions, it is prudent for cities to pre-emptively introduce legislation. … This should include , as a minimum, (differential) speed limits, restrictions to only use bicycle infrastructure, and the designation of parking (rental/return) areas. Behavioural campaigns, perhaps along with fines, are needed to limit negative outcomes of e-scooter use. To limit the number of operators will reduce complexity”
This is the same advise as provided in two other studies: TNO (2020) analysed the experiences with e-scooters in countries outside the Netherlands. They state that it is important to make policy on the rules & regulations before e-scooters are introduced in a city. Besides that policy should be adaptive; to respond to unexpected effects. Relating to micromobility policy, thus a broader range of vehicles then in this report, DuPuis, Griess and Klein (2019) advise to formulate rules and regulations before the introduction. They also suggest to focus on safety and equity aspects. Both studies expand their advise and add that e-scooter pilots on which base policy can be adjusted is a good way to make adaptive policy. Furthermore TNO (2020) advices to make policy on three subjects: **i)** The vehicle itself; for example regarding size, speed and lights. **ii)** The user; for example regarding minimum driving age, driving ability requirements and personal protection. **iii)** The surroundings of E-scooters; for example the place on the road and parking policy.

At last, two interesting things are mentioned that were not mentioned in other studies: Schellong et al. (2019) adds an interesting point, they states that it is important to sort liability issues of users before introducing e-scooters by implementing a liability claim system. Riggs & Kawashima (2020) evaluated e-scooter policies in the US, they also found policy instruments targeting e-scooter equity: distribution requirements and low income plans.

3.4 Conclusion literature review

In this chapter, the available literature on e-scooter is discussed. E-scooters have certain properties different from other, more common micro-mobility forms, like (e-) bicycles and mopeds. Users (are expected to-) like the effortless, travel time savings, playfulness and low entrance barriers. For shared e-scooters, the vehicle density is an important determinant for mode choice. Lastly, E-scooters can be an alternative for urban car travel as well. Users of e-scooters are mostly men between 18 and 35 years of age and higher educated. An upwards age trend is observed when e-scooters are available in a city for a while.
E-scooters are used for both commuting (education and work) as leisure purposes. There is not a clear dominant purpose. E-scooters are mostly used for shorter trips (1.8 – 4 km) in the afternoon.
Most trips made with e-scooters replace trips previously made with active travel modes. US-based studies show a relatively large shift from the car as compared to EU based studies, which show a relatively large shift from public transportation.
Not many studies touch upon multimodal trips with e-scooters, those that do found that a large proportion of the trips were made in combination with another means of transport.
Furthermore, not many studies investigated whether e-scooters influence travel patterns. If this is done, an increase of 8-20% of trip frequencies is found. The only available study that compared the use of private and shared e-scooters found that owners of e-scooters replace more car trips and use e-scooters more often in combination with public transportation.
Two life cycle assessments found that currently shared e-scooters are not beneficial for the environment, but there is a potential to improve this. Several studies found an increase in e-scooter related injuries after the introduction of a shared e-scooter system. However, in none of these studies is analysed if injuries related to other modes of transport increased or decreased in the study period. E-scooters can have a large effect on the liveability of urban areas; they add extra pressure to bicycle infrastructure and are often parked on footpaths. However, their small size is positive. E-scooters have the potential to increase the accessibility of places, however differences occur between areas depending on local situation. Potential lies in the connection of e-scooters to public transportation networks.
As becomes clear from this chapter there is currently no scientific research available that focus the impact that can be expected, on travel behaviour and society, by e-scooters when introduced in the Netherlands. The retrieved knowledge is used to identify the knowledge gap of this research and the insights in effects and policy instruments of e-scooters are used in the data synergy in Appendix 10, which is used to formulate conclusion in Chapter 7.

4 System diagram on a aggregated level

In this chapter, the system diagram on a aggregated level is elaborated on. This system diagram on an aggregated level provides insight in 'the system'; the situation of the introduction of e-scooters in the Dutch traffic system. It contains the most relevant factors and relationships of the urban transport system and travel behaviour theory on an aggregated level. It is used in the expert interviews as a guideline to gain insights in more detailed e-scooter related factors and effects. In Chapter 5 and Chapter 6 the system diagram on an aggregated level is supplemented with new insights, consequently in Chapter 7 the final system diagram is presented. Therefore this chapter contributes to sub-questions 1, 2 and 3.

Section 4.1 briefly describes the background of the system diagram. In Section 4.2 the validated system diagram on a aggregated level is presented and explained per arrow and factor. At last a conclusion of this chapter is provided in Section 4.3.

4.1 Background of the system diagram

The system diagram is based on factors and relationships of travel behaviour and the urban transportation system. The (urban) transportation system and its external effects are dependent on a seemingly infinite amount of factors and corresponding relations. Even when only `main factors` are taken into consideration, the list is extensive. Therefore these factors are demarcated into a hypothesis of the most important factors and relationships by the author. To keep this report compact, the literature study into travel behaviour and the urban transportation system is provided in Appendix 3.

Theoretical background

The system diagram is based on a utility theory-based framework that explains the formation of traffic volumes. This framework assumes that **1)** individuals have desires and needs **2)** to fulfil those desires and needs individuals need to participate in out-of-home activities (In some cases, the travel can also be the activity itself (Mokhtarian & Salomon, 2001)) **3)** individuals maximize their utility of activities within their abilities **4)** individuals minimise the dis-utility as a result of the generalised costs of transport resistances. Transport resistances consist of monetary costs, time and `effort` (Buehler, 2011; Van Wee, Annema, & Banister, 2013; van Acker, van Wee, & Witlox, 2010).

Factors, relationships and demarcation

Many different factors influence travel behaviour and therefore the transportation system's external effects (Götschi et al., 2017). Van Wee et al. (2013) agrees; they state that travel behaviour results from a complex interplay of all the variables". (Van Wee et al., 2013, p. 87). The 'PASTA' framework of Götschi et al. (2017) is used as base to identify these factors (see Appendix 3). Götschi et al. reviewed 65 publications studying factors influencing travel behaviour. They identified differences and similarities, and synthesised all these studies into a comprehensive framework for active travel modes. Götshi et al. (2017) identify three main categories of factors that influence the travel choices: Factors within the 1) social context, 2) the physical context (built and natural environment), and 3) the individual context. E-scooters have similarities with active travel modes but also differences. Therefore Götschi's framework is adjusted into a list of factors and relationships that functioned as background for the system diagram. This list is presented in Appendix 3. The list is not exhaustive, and many other lists could be created.
The diagram's complexity would increase enormously if all these factors were included separately (Pruyt, 2013). To maintain the communicative goals, and in line with the exploratory nature of this research, only factors on a high aggerate levels, combined with the determinants of the utility based framework, are included. This led to system diagram as shown in Figure 4-1. To gain insights into the relevant, e-scooter specific, factors on a more detailed level, in the interviews the experts are asked which factors they consider important in influencing travel choices.

4.2 The system diagram

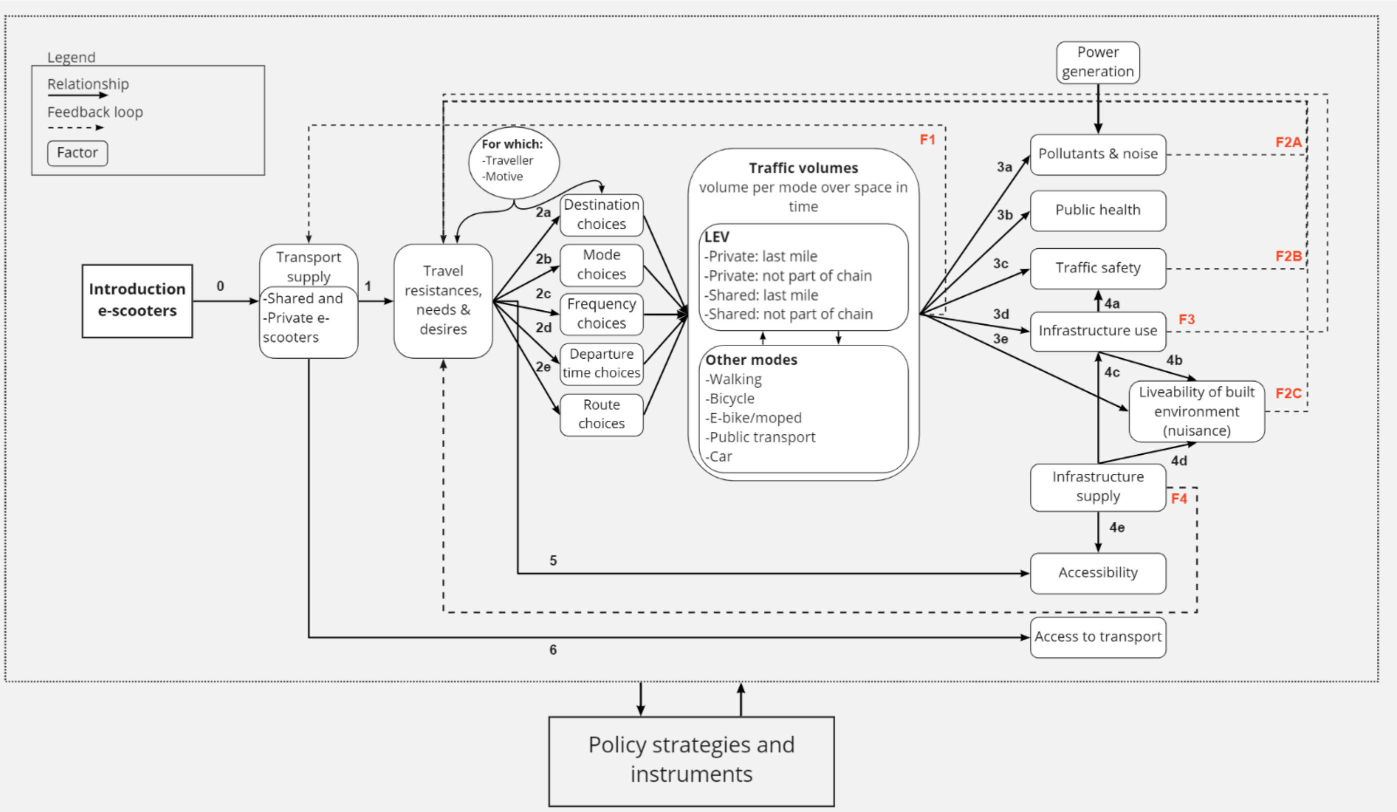


Figure 4-1: System diagram

The system diagram analyses the system with the introduction of e-scooters as starting point. From the literature and theory follows that, due to a changing transport supply, travel resistances, needs and desires change (arrow 1). From this follow travel behaviour effects (arrow 2a-2e) and from there resulting societal effects (arrow 3a-3e). There are also feedback loops in the system: if the e-scooter volumes on the road rise, people get more familiar with them, lowering the barrier to buy one (F1). The impact of e-scooters on society is also expected to influence the travel resistances, needs & desires (F2A-C). Finally, the infrastructure supply and usage are expected to influence the travel resistances, needs and desires as well. The policy strategies and instruments in this aggregated system diagram link up with the entire system. Chapter 6 of this research goes into policy and where different policies connect to the system. All the factors, arrows and routes in the system diagram are described in further detail in the coming paragraphs.

Validation

In the validating expert interviews, the experts were asked to the name comments on the validity and correctness of the systems diagram. A total of 4 comments were named, of which 2 were mentioned by at least a minority (three) of the experts.

This minority stated that they missed a feedback loop from health to the travel resistances. Contrastingly another minority stated that all feedbacks loops to resistances are not so relevant. Furthermore two interesting aspects were named by only one expert: there was one expert who stated that regulations up front are very important for the impact of e-scooters and there was one expert who stated that the feedback from liveability to policy is an important arrow. These two comments go deeply into the role of policy in this system. This study only aims to provide insight into the options for policy and not how they relate to the system exactly. That is why these two arrows have been left out of scope. There were no further comments on the system diagram by more than a minority of the experts. Indicating that the system diagram is validated for further use

Arrow 0 + 1

Introduction e-scooters > transport Supply > transport resistances, needs and desires: The introduction of e-scooters will change the transport supply in, in two ways: by adding a shared e-scooter system and private e-scooters to the existing transport supply. E-scooters have certain mode-specific-characteristics that influence travel resistances, needs and desires and the location of activities. The factor 'location of activities' is not incorporated in the system diagram because of the authors' hypothesis that e-scooters do not primarily influence this factor.
Next to the transport supply and the characteristics of e-scoters there are other factors that influence the transport resistances and needs and desires. Examples are physical context factors like the climate, hilliness and infrastructure (Rietveld & Daniel, 2004; Heinen, van Wee, & Maat, 2010; Parkin, Wardman, & Page, 2008; Van Wee et al., 2013), social context factors like norms and mobility cultures (Hany, 2012; Müggenberg, 2015) and individual aspects like attitudes, habits and lifestyle aspects (Klinger et al., 2013; Choo and Mokhtarian, 2004) As stated, these factors are not all included in the system diagram for complexity reasons. Appendix 3 elaborates more on these factors.

Arrow 2a - e

Transport resistances, needs and desires > travel choices > traffic volumes: It follows from theory that with the introduction of LEVs, travel behaviour can change. Travel behaviour consists of certain travel behaviour choices; choices for the number of trips, the destination, the route, the vehicle and the departure time. Al the travel choices that are made by individuals result in a composition of traffic over time and space (Van Wee, 2013).

Arrow 3 – 7

Traffic volumes > societal effects: (Changing) transport volumes due to the introduction of e-scooters have effects on society. The most important effects on society by the transportation system are identified in Appendix 3; environment, public health, traffic safety, liveability of public space, accessibility and inclusion.

3A: Emissions of pollutants and noise: Haghshenas and Vaziri (2012) identified three direct transport related effects on the environment: the emissions of the pollutants noise, NOx gasses and CO2 gas. The emission of NOx gasses is left out of scope in the figure. Indirect effects of these emissions, like the loss of biodiversity (Van Wee et al., 2013) ,is also not taken into consideration in the diagram.
Next to the composition of traffic volumes over space and time, also the usage of modes (eg: acceleration) influence the emission of pollutants (Hong & Goodchild, 2014). This is not taken into consideration in the systems diagram.

3B: Health: The most dominant travel related health effects of transport for an individual are: accidents, exposure to pollutants, physical activity and mental well-being. Furthermore there are health effects of transport for others, mainly the exposure of pollutants. (Van Wee & Ettema, 2016). Accidents are incorporated in the figure in the factor 'traffic safety, exposure to pollutants in the factor 'pollutants'. Mental well-being is not considered as a primary effect of the impact of e-scooters and therefore not incorporated in the system diagram. The factor 'health' in the figure refers to physical activity. Physical activity that is not transport related (like exercising) is also not taken into consideration in the system diagram.

3C, 3D, 4A: Safety: Schepers et al. (2014) developed a framework of traffic safety. In their framework accidents are derivatives of the exposure to risk and the risk itself. The expose to risk is a dependent on the travel behaviour and the risk is related to the 'three pillars of risk': man, vehicle and infrastructure. In the system diagram this framework is applied partly: traffic safety is dependent on the composition of traffic and the use of infrastructure (which is dependent on the infrastructure supply). Individual characteristics like the usage of modes is not is not taken into consideration in the system diagram, as stated before.

3E, 4B, 4D: Liveability of the built environment: In the context of this report, the societal effect 'liveability' is used in the same way as Van Wee et al. (2013) refers to the term 'non-emissions-related liveability': assuming that transport would not emit any pollutants and would not use any energy, even then transport has negative impacts, "as a result of land take (e.g. for parking) and community severance and by preventing streets being used for non- transport- related activities (e.g. for play)." (Van Wee et al., 2013, pp. 229).

Therefore the factor liveability is dependent of the traffic volumes, infrastructure supply and infrastructure use in the system diagram. In general, a shift away from the car towards smaller modes should make urban areas more attractive (Mackett, 2011, p. 100).

4E, 5, 6: Accessibility and access to transport

Accessibility, from a person's perspective, is defined as "The extent to which land- use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s) at various times of the day" (Van Wee et al., 2013, p. 5) ' The extent' is determined by the transport resistance. Accessibility can also be looked at from a location perspective, but since this research focusses on the mobility of persons that is not taken into account here.

The access to transport is a determinant of the in/exclusion of the transport system, which relates to social equity; it is about the distribution of the benefits and costs of transportation, the access to transportation and accessibility of transportation (CROW, 2020, appendix 4).

F1-F4: Feedback loops

There are also feedback loops in the system diagram. These are based on known relations from literature and assumptions by the author.

F1: Traffic volumes > transport supply: The assumption is that the (e-scooter) transport volumes on the roads influence attitudes and familiarities and probably also mobility cultures. From literature, it is known that these factors influence the willingness to use vehicles (Choo & Mokhtarian, 2004; Klinger et al., 2013; Arendsen, 2019). Assumed is that, if the willingness to use vehicles increases, more people will buy vehicles or more suppliers of shared vehicles will enter the market, therefore influencing the transport supply.

F2 A-C: Effects on society > transport resistances, needs & desires: Also assumed is that the impact of the traffic volumes on certain societal effect also influence the travel resistances, needs and desires. For the feedback from 'emission of pollutants', this is based on the findings of Zhao et al. (2018) and Collins and Chambers (2005); people are getting more aware of the environmental impact of transport. As a result transport resistances of polluting modalities increase. For traffic safety, the feedback loop is based on Garrard and Rose (2008). They showed that safety concerns are an important determinant of bicycle mode choice for females. Also Larsen, Buliung and Faulkner (2013) investigated the relationship between safety and travel mode. Employing a survey, they conclude that if a route is (perceived) as safer, walking has a higher modal share.

Van Wee and Ettema (2016) state that there is also likely a feedback loop from health to travel behaviour (in this example the use of active travel modes). However, they state that this relationship has not yet been investigated. Therefore, this feedback is neglected in the system diagram. A minority of the experts named in the interviews that they would have expected a feedback loop here however. To the best of the author knowledge, the feedback loop from liveability to transport resistances has also not been researched yet. However, because the effects on the liveability of cities are a prominent 'issue' regarding e-scooters this feedback loop has been added to the system diagram.

F3 and F4: Infrastructure use & infrastructure supply > transport resistances, needs & desires : Lastly, there are two feedback loops that involve the infrastructure and infrastructure use. The feedback loop F3 from infrastructure use to travel resistances, needs & desires involves congestion effects. As stated, transport resistances consist of, among other aspects, travel time. If roads get congested, travel times increase and thus transport resistances increase (Van Wee et al., 2013). Besides congestion effects, travel resistances and needs and desires are also influenced by the quantity and quality of infrastructure (Van Wee et al., 2013). This also encompasses parking infrastructure; if a certain place has low-quality infrastructure the resistance to go to that place can become higher.

4.3 Conclusion

In this chapter the system diagram on an aggregated level is presented. The system diagram provides insights in 'the system' of the introduction of e-scooters in The Netherlands, is further used as guideline in the expert interviews and supplemented with more detailed factors in the coming chapters.

The system diagram analyses the system with the introduction of e-scooters as a starting point. According to the literature, due to a changing transport supply, travel resistances, needs and desires change. Based on these aspects, people make certain travel choices: choices for a destination, mode, trip frequency departure time and route choice. All travel choices together lead to a composition of traffic over time and space. E-scooters can be used in four different ways: as part of a multimodal or unimodal trip and using a private or shared e-scooter. These traffic volumes over time and space lead to effects on the environment, public health, traffic safety, the liveability and accessibility and inclusivity of the transportation system. There are also feedback loops in the system.

In the next chapters, the system diagram is supplemented with effect estimates and policy options. In the conclusion (Chapter 7) the final system diagram is presented.

5 Effect estimations: results of the mobility expert interviews

In this chapter, the results of the mobility expert interviews are presented. The interviews are used to supplement the system diagram on the aggregate level with more detailed insights on underlying factors and effect estimates, related to e-scooters in the Netherlands. Therefore the results of the mobility expert interviews contribute to sub-question 1 and 2.
The responses of the interviews are transcribed, coded and grouped, as elaborated on in Chapter 2. The complete factor analysis can be found in Appendix 5. This chapter presents on the factors that are found after grouping the interview codes. The responses per interviewee can be found in Appendix 4.

Figure 5-1 shows the factors that were first mentioned in an interview. In the first interview, all mentioned factors are new. In the last two interviews only one new factor was mentioned by the interviewee. Based on this chart is concluded that the principle of saturation is achieved. This implies that further data collection is unnecessary (Saunders et al., 2018). The interviews took place in the following chronological order: 1, 6, 11, 10, 5, 9, 4, 8, 2, 7, 3. Thus interview number 1 in Figure 5-1 corresponds with interviewee 1, interview number 2 corresponds with interviewee 6, etc.

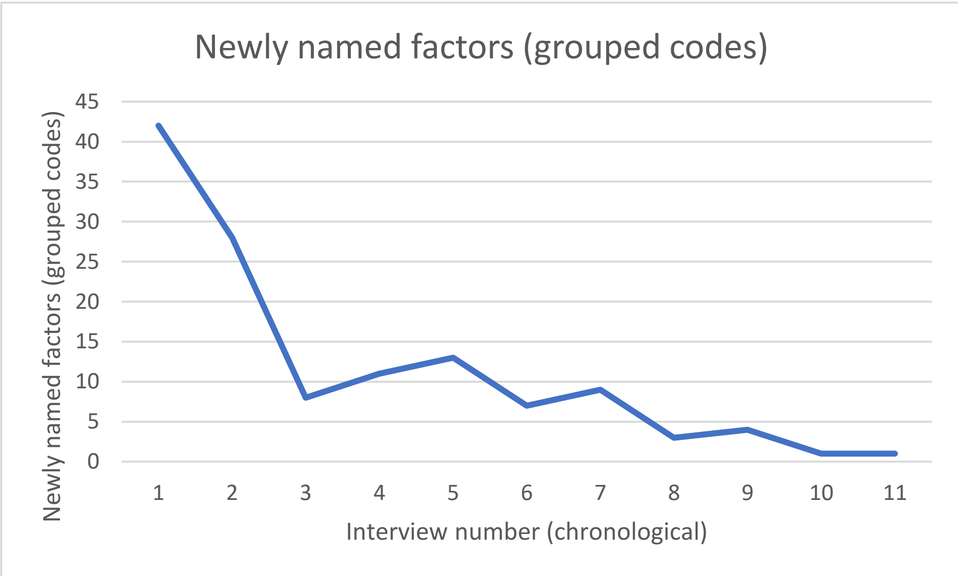


Figure 5-1: newly named factors by interviewees

The results of the interviews are shown in Table 5-1 till Table 5-3 on the next pages. From the tables is learned which factors are named by who and the total number of experts. The factors and effects per block and arrow of the system diagram are shown in the left column. If an expert mentioned a factor or effect there is a 'x' at their number. The right column shows the total count.

The grouped codes are presented in this chapter in two ways: **i)** if mentioned by at least a minority of the experts. **ii)** if only mentioned by 1 or 2 experts, but nevertheless considered as an meaningful result by the author. If 9 or more of the experts named a factor or effect: "a large majority" is reported. If 6 till 9 of the experts named a factor or effect "a majority" is reported. If 3 till 6 experts named a factor or effect "a minority" is reported. If less then 3 experts (a small minority) named a factor or effect, that result is most of the time not reported in this chapter. Unless considered as an meaningful result by the author. These full list of responses can be found in Appendix 5. The numbers between brackets in super script refer to the interviewees.

Section 5.1 elaborates on the results of estimations on effects on travel behaviour. Section 5.2 provides the results of the effects on society. In Section 5.3 the effect estimations by the experts are added to the system diagram. Lastly, in Section 5.4 conclusions of this chapter are formulated.

Transport resistances, needs & desires	Expert:	1	2	3	4	5	6	7	8	9	10	11	Total
	Convenience / comfort	x	x		x	x	x	x	x	x	x	x	10
	-Due to size	x	x		x						x		4
	-Due to easy access							x		x	x		3
	-Due to physical requirements				x				x	x			3
	Availability	x	x	x	x	x	x	x		x		x	9
	-Reliabillity of the availabillity	x						x				x	3
	Image / lifestyle	x	x		x		x		x	x		x	7
	Pricing / cost of use		x	x	x		x	x	x		x	x	8
	Infrastructure quality and quantity		x		x		x	x		x	x	x	7
	Precise set-up shared system				x	x	x	x		x	x	x	7
	-Parking and hand in system				x	x	x	x					4
	-Connecting transport options					x	x			x	x		4
	Novelty	x		x				x		x		x	5
	Copying behaviour					x				x		x	3
	Dutch bycicle culture							x			x	x	3
	Speed / travel time savings			x		x		x					3
	More car, other modes more attractive						x	x	x	x	x		5
	Hygiene situation								x				1
	Familiairity		x								x		2
Travel choices													
	Mode choices	x	x	x	x	x	x	x	x	x	x	x	11
	In general no large effects	x	x		x	x		x		x	x	x	8
	Route choice	x		x			x				x	x	5
	-due to mode choices	x										x	2
	Trip frequency							x	x	x			3
	Most effects on activity side						x						1
	-Behave more like an inhabitant												
Users & purpose													
	Younger people	x	x	x	x	x	x	x	x	x	x		10
	Visitors						x		x	x	x		4
	Non-cyclists		x			x	x		x				4
	Lower educated					x		x	x				3
	Leisure purpose	x	x	x					x	x			5
	Commuting purpose			x					x	x			3

Table 5-1: Results mobility expert interviews part 1

Traffic volumes	**Expert:**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
	Sharing highest potential	x	x		x	x	x	*x*		x		x	8
	Small share private	x	x		x	x	x	x		x			7
	Multimodal use	x	x		x	x	x	x	x	x	x	x	10
	-In combination with the train		x				x	x	x	x	x	x	7
	-In combination with the car						x			x	x	x	4
	Unimodal use			x	x	x		x	x	x	x		7
	Largest share activity side		x				x						2
	First hype, in time small amount of users				x								1
Modal shift													
	Modal shift: bycicle	x	x		x	x	x	x	x	x	x	x	10
	Modal shift: walk	x	x	x	x	x	x			x	x		8
	Modal shift: public transportation	x		x		x		x					4
	Modal shift: car, (very) small			x		x	x	x	x	x		x	7
	Modal shift: car, virtual none	x	x		x						x		4

Table 5-2: Result mobility expert interviews part 2

	Expert:	1	2	3	4	5	6	7	8	9	10	11	Total
Environment	Overal negative effect	x		x			x			x			4
	Slghtly posive effect in time					x		x	x				3
	Potential for possivite effect in time									x	x	x	3
	Whole lifecylce effects important			x	x	x			x				4
Public health	overal negative effect	x							x	x	x		4
	no idear (afh. Van modal shift)		x	x			x					x	4
Traffic safety	Negative effect	x						x		x	x		4
	Virtually no influence					x			x			x	3
	Perception of safety decreases		x		x	x				x			4
	Verkeersveiligheid daalt een beetje	x											1
	No idear			x			x						2
	Already busy on bycicle lanes		x	x	x	x				x	x		6
	-Diversity of transport modes on bycle lanes				x	x		x					3
	New, people dont know how to use it	x	x			x				x		x	5
	Obtacles on footpath	x		x									2
	Pricing system promotes speeding											x	1
Liveabillity	Way they are parked	x		x		x	x	x	x	x	x	x	9
	-mainly relevant for shared e-scooters						x	x					2
	Regulations important	x	x			x		x	x	x	x	x	8
	Limit space required positive	x				x	x				x		4
	E-scooters contribute to cluttering public space							x		x			2
	Negative impact on space in public transportation										x		1
Accessibillity & inclusivity													
	Increase for small group	x	x		x	x	x	x	x		x		8
	-Of non cyclists		x			x	x		x				4
	Increases accessibility of PT		x		x	x	x	x	x	x		x	8
	Not a large impact			x					x	x	x		4
	Digital accessibility relevant	x							x	x			3
	Increase for transport poverty places						x						1

Table 5-3: Results mobility expert interviews part 3

5.1 Effects on travel behaviour

Transport resistances, needs & desires

Regarding the question on the influence of the changed transport supply and the feedback loops on the travel resistances, needs and desires and the most important underlying factors, a total 18 factors are found (after grouping the interview codes). Of those 18 factors, 13 factors were named by at least 'a minority' (3 or more) of the experts.

A large majority of the experts named convenience / comfort aspects[1, 6, 11, 10, 2, 5, 9, 4, 8, 7] of e-scooter as important influencers of the travel resistances. A minority (of the total questioned experts, not this mentioned large majority), specified this by naming the convenience of e-scooters due to its size[1, 10, 2, 4], easy access[5, 8] and/or the required physical effort[9,4,8]
Also a large majority of the experts stated that the 'availability of e-scooters in a shared system'[1, 6, 11, 2, 3, 5, 9, 4, 7] is an important influencer of the travel resistances, a minority added to this statement that 'the reliability of the availability'[1, 11, 7] is also relevant here.

A majority of the experts named image / lifestyle aspects[1, 6, 11, 2, 9, 4, 8] of e-scooters important influencers of the travel resistances. A majority also named the pricing[6, 11, 10, 2, 3, 4, 8, 7] of e-scooters, in the shared system as well as private e-scooters and the infrastructure supply for e-scooters (F4) (quality and quantity) [6, 11, 10, 2, 4, 7, 9]. Lastly a majority stated that the 'precise set-up of the shared e-scooter system'[6, 11, 10, 5, 9, 4, 7] is important. A minority specified this by stating that the parking system[6, 5, 4, 7] and/or the connected transport options[6, 10, 5, 9] of the shared system are relevant.

A minority of the experts named the following factors: novelty of the e-scooters[1, 11, 3, 9, 7], copying behaviour (relates to F1), the Dutch bicycle culture[11, 10, 7] (either positive or negative for the transport resistance) and the speed of e-scooters[3, 5, 7].
A minority stated at feedback loop 4 that is there are less options for cars to park, other vehicles get more attractive. A minority of the experts stated that feedback loop 3 is relevant in the sense that if there is more car congestion[6,10,9,8,7], the travel resistance of other modalities will decrease.

Lastly, two meaningful points were named by only one or two experts: the hygiene situation (especially during Covid-19)[8] and the familiarity[10, 2] with e-scooters.

Travel behaviour choices

Regarding questions on the resulting changes in travel choices, as a result of the changing transport resistances a total of 7 factors are found, of which 4 were named by at least a minority of the experts.

All experts stated they expect some changes in mode choice[1,2,3,4,5,6,7,8,9,10,11]. Furthermore, a majority stated that, in general, they did not expect large effects[1, 11, 10, 2, 5, 9, 4, 7] on travel choices. A minority stated that they expect changing route choices[1, 6, 11, 10, 3], a minority specified this by stating that this is due to changing mode choices. A minority of the experts stated that they expect an increase in trip frequencies [9, 8, 7] mainly for leisure trips.

Lastly, one meaningful point was made by only two experts: they expect that the most effects on travel behaviour can be expected on the activity side[6, 2]. One expert specified this by stating that he expect visitors of cities to behave more like inhabitants[6].

Users & purpose

Regarding questions on users of e-scooters and their travel purpose a total of 7 factors were found, of which 6 were mentioned by at least a minority of the experts.

A large majority of the experts named younger individuals[1, 6, 10, 2, 3, 5, 9, 4, 8, 7] as most promising users of e-scooters. A minority stated that they expect visitors of cities[6, 10, 9, 8], non-cyclists[6, 2, 5, 8] and/or lower educated people[5, 8, 7] as potential users. Regarding travel purpose, a minority named a leisure purpose [1, 2, 3, 9, 8]. Also a minority named a commuting purpose[3, 9, 8].

Traffic volumes & modal shift effects

Regarding questions on the resulting effects on traffic volumes per mode over time and space and thus modal shift effects a total of 12 factors and/or effects are found. Of which 9 are named by at least a minority of the experts.

Considering the use of e-scooters, a majority of the experts stated that they expect the largest share of e-scooter usage to be in a shared system[1, 6, 11, 2, 5, 9, 4, 7], a majority also expects that there will be a small share of users that use a private e-scooter[1, 6, 2, 5, 9, 4, 7]. A large majority expects that e-scooters will be used in multimodal trips[1, 6, 11, 10, 2, 5, 9, 4, 8, 7], a majority specified this by stating that the combination with the train[6, 11, 10, 2, 9, 8, 7] is promising, a minority specified this by stating that the combination with the car [6, 11, 10, 9] is promising. Lastly, a majority of the experts stated that e-scooters will be used for shorter unimodal trips[10, 3, 5, 9, 4, 8, 7].

There were two meaningful factors that were mentioned by only one or two experts: they expect the largest share of usage on activity sides of trips[2]. Besides one expert mentioned that he expects that there will be at first a relative large amount of users, and afterwards a small amount of users remains[4].

Considering modal shift effects, a large majority expects a shift from the bicycle[1, 6, 11, 10, 2, 5, 9, 4, 8, 7]. A majority expects a shift from walking[1, 6, 10, 2, 5, 9, 4, 3]. A minority expects a shift from BTM[1, 3, 5, 7]. A majority expects a (very) small modal shift from the car[6, 11, 3, 5, 9, 8, 7]. A minority expects (almost) no shift from the car at all[1, 10, 2, 4]

Lastly, there was one meaningful factor mentioned by only one expert; he- mentioned he expects a modal shift from mopeds[8]

5.2 Societal effects

The experts also answered questions about their expectations of the resulting societal effects, and important factors that also account for those effects. Considering their expectations on the traffic volumes.

Environment

Regarding effects and factors on the environment (pollutants and noise), a total of 7 factors and/or effects are found, of which 4 mentioned by at least a minority of the experts.

A minority of the expert stated that they expect overall e negative effect[1, 6, 3, 9] on the environment due to the introduction of e-scooters. Another minority stated they expect a slightly positive effect, in time[5, 8, 7]. A minority also stated they see potential for a positive effect on the environment of e-scooters[11, 10, 9].

The majority of the experts stated that it is important to consider the whole life cycle[1, 3, 5, 9, 4, 8] eg: the impact on the environment on the whole supply chain to estimate the effect on the environment.

Health

Regarding effects on health, a total of 4 factors/effects are found of which 2 were mentioned by at least a minority of the experts.
A minority of the experts stated that they expect an overall negative effect[1, 10, 9, 8] on health due to the introduction of e-scooters. Another minority stated that they have no idear on the impact of E-scooters on health[6, 11, 2, 3].

Traffic safety

Regarding effects and factors on traffic safety a total of 10 factors and/or effects are found, of which 5 were mentioned by at least a minority of the experts.

A minority of the experts stated that they expect that traffic safety decreases[1, 10, 9, 7] due to the introduction of e-scooters. Another minority expects that e-scooters have virtually no influence on traffic safety[11, 5, 8], if the vehicles are no longer a novelty. A minority of the experts stated that the perception of safety decreases[2, 5, 9, 4].

The majority of the experts stated that it is already busy on cycling lanes[10, 2, 3, 5, 9, 4]. A minority specified this by stating the diversity of transport modes on cycling lanes can be a problem[5, 4, 7]. Furthermore, a minority stated that the fact that e-scooters are new and people don't know how to use it properly[1, 11, 2, 5, 9] is a factor of traffic safety.

Lastly two interesting factors were mentioned by only one or two experts: e-scooters can be dangerous obstacles on footpaths[1, 3] and the pricing system of shared e-scooters promotes speeding[11].

Liveability

Regarding effects and factors on the liveability a total of 7 factors are found, of which 3 were mentioned by at least a minority of the experts.

The large majority of the experts named that the way e-scooter vehicles are parked[1, 6, 11, 10, 3, 5, 9, 8, 7] is of big influence on the impact on the liveability. A minority specified this, by stating that this is mainly relevant for shared e-scooters.
Also a large majority of the experts stated that (parking) regulations[1, 11, 10, 2, 5, 9, 8, 7] are very important for the impact of e-scooters on the liveability. Furthermore, a minority named that the limited space required[1, 6, 10, 5] to facilitate e-scooters is a positive aspect.

Lastly some aspects were mentioned by only one or two experts: e-scooters can contribute to cluttering of public space[9, 7], e-scooters can catch people by surprise and e-scooters can have impact on the space inside public transportation[10].

Accessibility, access and inclusivity

Regarding the accessibility, access to transport and the inclusivity of the transportation system a total of 6 factors and/or effects are found. Of which 4 are mentioned by at least a minority of the experts.

The majority of experts stated that they expect e-scooters will only increase accessibility for a small group of people[1, 6, 10, 2, 5, 4, 8, 7]. A minority specified this by mentioning they mean the group of non-cyclists in the Netherlands.
The majority of the experts expect that e-scooters will increase the accessibility of public transport networks [6, 11, 2, 5, 9, 4, 8, 7]. Furthermore, a minority of the experts think e-scooters will not have a really large impact[10, 3, 9, 8] on the accessibility in general. A minority also stated that the digital accessibility is relevant[1, 9, 8].

Lastly one aspect was named by only one expert: he expects e-scooters to have a potential of increasing the accessibility of places with 'transport poverty' (a lack of transportation options)[6].

5.3 Results in the system diagram

Figure 5-2 on the next page shows the results of the mobility expert interviews visualised in the system diagram. As indicated in the figure blue blocks are factors mentioned by at least a majority, yellow blocks by a minority and orange blocks by a small minority. White blocks are factors of the original system diagram. The figure is a supplemented version of the system diagram on a aggregated level (Figure 4-1).

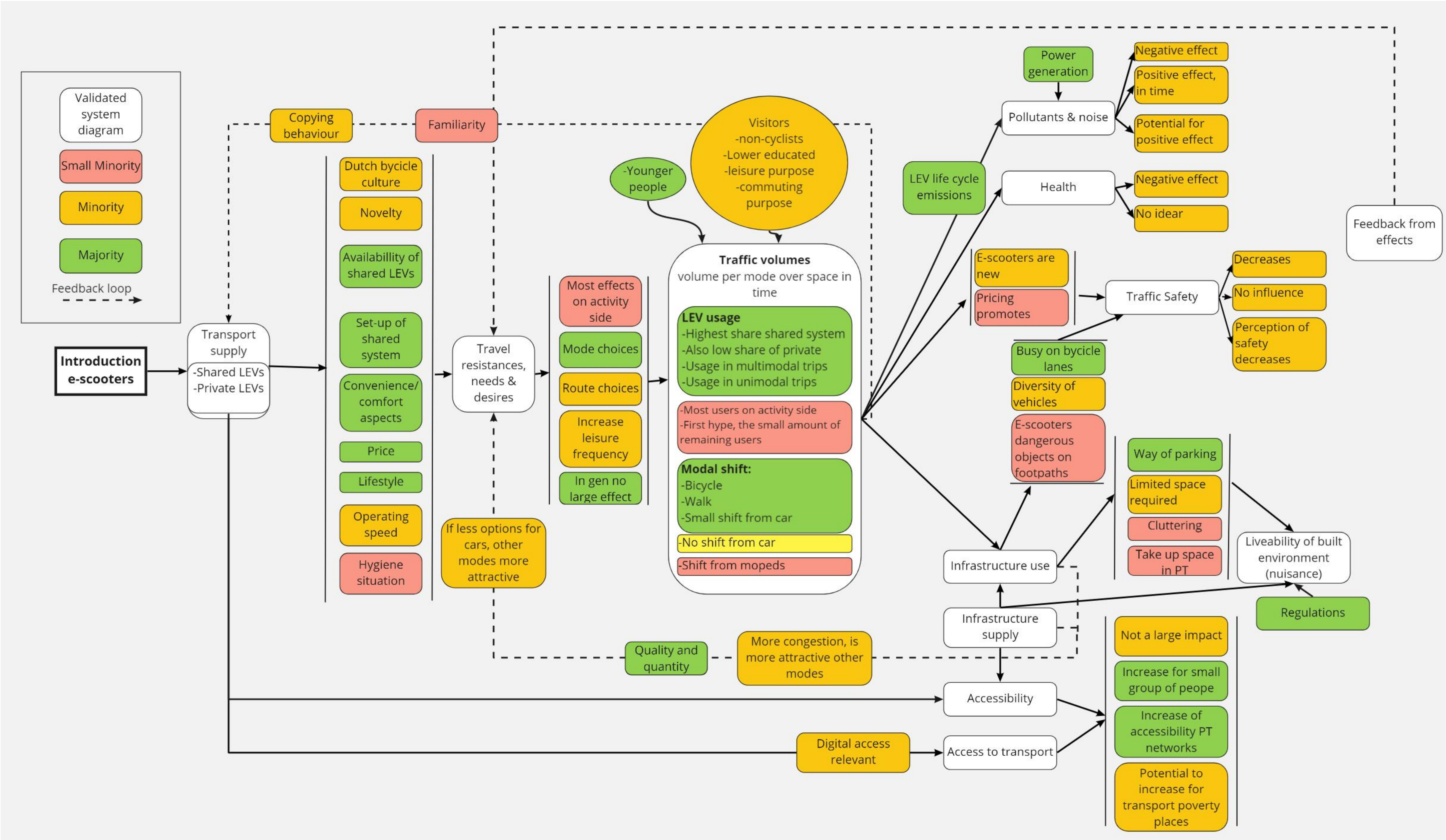


Figure 5-2: results of the mobility expert interviews added to the System Diagram

Systems Diagram as by the majority

Figure 5-3 shows the hypothesis of the system diagram (Figure 4-1) adjusted to the results of the interviews agreed on by a majority of the experts. The Figure shows for which aspects a homogenous picture emerged from the mobility expert interviews. For example, there is a clear picture that experts expect accessibility for a small group of people to be improved by e-scooters. But with regard to the effects on the environment or road safety, no clear picture can be seen from the expert interviews.

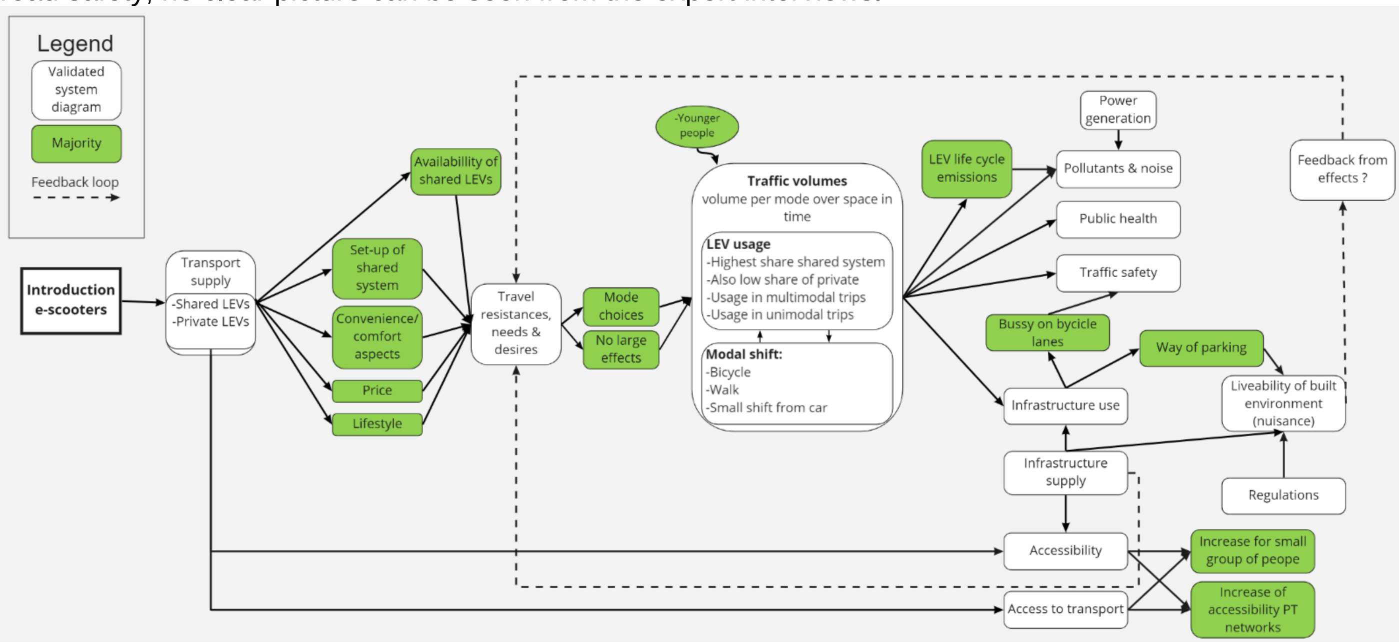


Figure 5-3: System diagram with factors, relationships and effects named by a majority of experts

5.4 Conclusion

In this chapter, the effect estimations of e-scooters in the Netherlands by the mobility experts are presented. These estimations are added to the system diagram and provide insights in more detailed e-scooter related factors and effects.

The majority of the experts believe that shared e-scooters will have a higher usage potential than private e-scooters. E-scooters are to be expected to be used in multimodal trips more than in unimodal trips. The largest shift is expected from active modes and bus, tram and metro. There are different expectations among the experts about the degree (or presence of) the modal shift from the car, the potential for the use of e-scooters for commuting trips and the share of private e-scooter users.

Consequently, there are different expectations of the effect of e-scooters on the environment and public health, ranging from negative to slightly positive in time. Concerning the effect of e-scooters on traffic safety, there are two prevailing views: i) e-scooters are not a risk to traffic safety, because of the Dutch cycling culture ii) e-scooters are harmful to traffic safety, because the Dutch bicycle paths are already busy. For the effect of e-scooters on the liveability, the experts assent that this depends mostly on the parking regulations. Lastly, the experts agreed that the positive accessibility effects of e-scooters are most relevant for the small group of non-cyclist and at improving public transportation networks.

From this chapter is learned that learned that there are uncertainties in the effect estimates with possible negative outcomes, where regulation is (possibly) required. Therefore the next chapter goes into policy options as retrieved from the policymaker interviews and the focus group session. In the conclusion (Chapter 7) the effect estimations as presented in this chapter are compared to the estimations from the other information sources (literature and congresses).

6 Policy implications: results policymaker interviews and the focus group

In this chapter the results of the policymaker interviews and the focus group session are presented. Within Chapter 5, is learned that there are uncertainties in the effect estimates with possible negative outcomes, where regulation is (possibly) required. At the same time, from Chapter 3 is learned that there is currently not a great extent of literature available on e-scooter related policy and how that translates to the Dutch context. Therefore this chapter provides insights that contributes to sub-question 3. This research question contains two elements: **i)** What policy instruments and strategies can be deployed to reach certain outcomes? **ii)** What are desirable outputs of the transportation system?

Section 6.1 elaborates on the desirable outcomes of the transportation system, based on the results of the policymaker interviews. Section 6.2 elaborates on the e-scooter related policy strategies and instruments that can be used to obtain those desirable outputs, retrieved in the policymaker interviews and focus group. In Section 6.3 the results of the focus group and policymaker interviews are added to the system diagram. In Section 6.4 a conclusion of this chapter is provided. Appendix 8 contains a full report for all three policymaker interviews. Appendix 9 contains the report and content analysis of the focus group session.

6.1 Desirable outcomes

This section elaborates on the desirable outcomes of the transportation system in the G5 municipalities. This information is based on the responses to the questions in policymaker interviews regarding the desirable outcomes of the transportation systems.

Current goal/objective of the mobility policy:

- **Eindhoven:** Increasing density ('verdichtingsopgave') in the city (mainly centre). Besides that decreasing car usage in the city centre. Not completely banning the car, but decreasing the reliance on the car by making other modalities more attractive and simultaneously decreasing car infrastructure.
- **Amsterdam:** The main pillars of Amsterdam's mobility policy are: less pollutants (also noise pollution), increase in traffic safety and increase of inclusivity of the transport system. These pillars are included in two major plans currently underway at the municipality: Amsterdam clean air and Amsterdam low-traffic.
- **Utrecht:** Objective: Healthy mobility for everybody. Focus on active mobility forms and PT, and realizing that for everybody. This includes a less prominent role for the car. People need mobility options, but this should be less about the car. Utrecht also wants to be the first city where sharing is more normal than owning (vehicles).

Desirable outputs/effects of the mobility policy:

- **Eindhoven:** Liveability and the environment are on top of the list while maintaining and increasing accessibility of the city. However, the goal is to improve *all* societal effects of the transport system.
- **Amsterdam:** This depends on the local situation. At every location is examined which effects are not that bad and which are the most desirable. Of course with the main goal as mentioned above.
- **Utrecht:** Environment, health and accessibility for everyone are the three desirable outputs of the mobility policy in Utrecht.

6.2 Policy instruments and strategies

From Chapter 5 is learned that there are uncertainties and possible negative effects of e-scooters. To make sure e-scooters contribute to the transportation system's desirable outputs identified in the previous section, regulation is (possibly) required. Therefore this section elaborates on policy strategies and instruments that can be used to regulate the impact e-scooters. In the policymaker interviews, the question was asked if and how the municipalities are currently regulating or are planning to regulate e-scooters and/or other forms of micromobility. Furthermore the results of the content analysis of the focus group is provided here.

Interviews with policymakers

Eindhoven

The municipality of Eindhoven is simultaneously making the car less attractive and filling those gaps with other transportation options. The municipality acknowledges that trade-offs have to be made between societal effects, asserting that it is unrealistic to expect perfect outcomes of the transportation system. Regarding the societal effects of (shared) micro-mobility, this is a process of trial and error. There is much collaboration between mobility suppliers and the municipality. Instruments that are currently being used are mainly aimed at shared mobility. The municipality makes regulations regarding safety, the number of vehicles, and the parking of the shared mobility modes. They mainly add these regulations to the permits for suppliers. They require all the suppliers to be available in one network (MaaS application). Furthermore, the municipality runs pilot projects and examines each pilot and each rule the effects of the pilot and adjust accordingly.

Amsterdam

The municipality of Amsterdam applies many different measures and instruments simultaneously to implement the mentioned plans in the previous section. For each measure, thorough (local) research is done. The municipality uses a trial and error strategy; they try things out step by step and check locally for the effects. The municipality mainly influences shared e-scooters that operate in the public space. Private e-scooters and 'private shared E-scooters' (e.g., in possession of hotels) are less within the municipality's control. For private e-scooters as well as shared e-scooters, the municipality can make parking regulations. Therefore the municipality is pleased with the announcement that e-scooters (probably) will require a license plate. This makes enforcement a lot easier. If e-scooters fall within the current vehicle classifications, then the current instruments are sufficient. If they form a completely new category, an adjustment of the ADV ('Algemene Plaatselijke Verordering') is necessary.

Utrecht

Utrecht is aiming to make the car less attractive and at the same time stimulating walking, cycling and PT. This includes P+R at the city's borders, less parking spaces for cars, more roads not accessible for cars and more 30km roads. The municipality uses the following micro-mobility (including in the future e-scooters) instruments: permits for suppliers with a vehicle limit and requirements in those permits to serve certain areas. In a number of vehicles, most permits are provided for bicycles, and cargo bikes, besides a small number of permits for mopeds are handed out. Because of uncertainties in the policy measures' outcomes, the municipality plans to do pilots (trial and error). Currently, they are not planning to make e-scooter specific policy.

Focus group

The results of the focus group are shown in Table 6-1 on the next page. From the table is learned which policy strategies and instruments are named by who and the total number of experts who named them. The policy strategies and instruments per societal effect are shown in the left column. If an expert mentioned a factor or effect there is a 'x' at their number. The right column shows the total count.

The grouped codes of the content analysis of the focus group is presented here in a similar way as in the previous chapter. A total of 7 experts participated in the focus group. If an strategy or instrument was mentioned by 6 or 7 this is reported as a 'large majority'. If mentioned by 4 or 5 experts it is reported as 'majority'. If mentioned by 2 or 3 experts his is reported by 'a minority' if mentioned by 1 expert (a small minority) the strategy or instrument is not reported. Except in the case that the author identified this as another 'meaningful results. The numbers between brackets in superscript refer to the interviewees.

	Expert	1	4	6	7	8	9	11	Total
Environment	Focus on modal shift from car	x		x		x	x	x	5
	-By connecting e-scooters to public transportation	x					x	x	3
	-By connecting e-scooters to car			x					1
	Set requirements for recharging with green energy			x	x	x		x	4
	Ensure enough capacity of charging points through the city		x			x			2
	Set requirements production process in tender	x	x		x				3
	-Or arrange this nationally		x						1
	Use geofencing or special locks to avoid dumping							x	1
	Dont allow shared e-scooters			x					1
	Combine charging points for all modalities				x				1
Public health	Dont allow shared e-scooters	x		x	x		x		4
	Driver requirment: minimum age							x	1
	Require an instruction for use							x	1
Traffic safety	Set requirements for users	x				x	x		3
	-Age requirements	x					x		2
	-Helmet requirements						x		1
	-Driving license requirements					x	x		2
	Arrangre safety standards nationally (road & vehicle design)			x	x				2
	Sepperate traffic flows						x	x	2
	Involve enforcers in policy making process							x	1
Liveabillity	Focus on parking	x	x	x				x	4
	-Use designated parking spots			x					1
	-Using geofencing			x					1
	-Specify per area							x	1
	Restrict driving in certain areas	x		x				x	3
	-Using geofencing			x					1
	Fold e-scooters in storage to optimally use public space	x							
Accessibility and inclusivity	Focus on the connection to other modalities with hubs	x	x	x			x		4
	Ensure enough parking places			x			x	x	3
	-At the cost of car parking places							x	1
	-By allowing parking everywhere			x			x		2
	Focus on the suburbs			x		x	x		3
	-By setting service requirements for shared e-scooter providers			x		x	x		3
	Set requirements for the cost of use				x				1
	Reduce the number of stops of BTM			x					1

Table 6-1: Results of the focus group

Policy instruments that focus on the environment

Regarding the discussion point on e-scooter related policy strategies and instruments that can be used to reduce the impact of the mobility system on the environment a total of 10 strategies and instruments were named of which 4 were mentioned by at least a minority of the experts.

A majority of the experts mentioned the focus of a modal shift towards the car[11, 6, 1, 9, 8], by means of connecting e-scooters to public transportation[11, 1, 9] and/or the car[6]. A majority mentioned: set requirements for recharging with green energy[11, 6, 7, 9] and a minority mentioned: making sure charging points have enough capacity throughout the city[8, 4]. Also a minority mentioned setting requirements for the production process of the shared e-scooters in the tenders for the suppliers[7, 1], or arrange this nationally in the admission framework[4]. Furthermore, some meaningful points were named by only one expert:

- Use geofencing or special locks to avoid dumping of e-scooters in canals and other places where they harm the environment[11]
- Don't allow shared e-scooters if a shift from the car is not achieved[6]
- Combine charging points for all electric modalities[7]
- Only allow e-scooters being used with a car license, to achieve the modal shift from the car[8]

Policy strategies and instruments that focus on public health

Regarding the discussion point on e-scooter related policy strategies and instruments that can be used to improve the contribution of the mobility system to public health total of 4 instruments were named of which 1 was mentioned by at least a minority of the experts.

A majority mentioned the instrument of not allowing (shared) e-scooters if the largest shift is from active modes[6, 7, 1, 9]. Furthermore two meaningful points were mentioned by only one expert:

- Protect users from themselves with rules for minimum age[11]
- Protect the users from themselves with instructions[11]

Policy strategies and instrument for traffic safety

Regarding the discussion point on e-scooter related policy strategies and instruments that can be used to improve the traffic safety, a total of 11 instruments were named of which 5 were mentioned by at least a minority of the experts.

A minority stated that requirements can be set for users[1, 9,8]; age requirements[1,9], the obligation to wear a helmet[9], and a driving license[9,8] could be demanded. Also a minority mentioned that safety standards could be arranged nationally with demands for road and vehicle design[6,7]. In this way also the self build of e-scooters will be prevented (mentioned by 1 expert)[9]. A minority mentioned furthermore that traffic flows should be separated[11,9]. At last an meaningful point was mentioned by one expert that enforces like the policy should be involved in the policy making process as well[11].

Policy strategies and instruments for liveability

Regarding the discussion point on e-scooter related policy strategies and instruments that can be used to improve the contribution of the mobility system to the liveability, a total of 5 instruments were named of which 3 were mentioned by at least a minority of the experts.

A majority stated that instruments should be used that focus on parking instructions by[11, 6, 1,4],: assigning designated parking spaces[1,6, geofencing[6] and specifying this per area[11]. A minority advised to use driving restrictions for certain areas[11, 6, 1], for example with with geofencing[6]. Furthermore one meaningful point was named by only one expert:

- Fold them in storage to optimally use public space[1]

Policy instruments that focus on the accessibility and inclusivity:

Regarding the discussion point on e-scooter related policy instruments that can be used to increase the accessibility and inclusivity of the mobility system in a municipality a total of 10 instruments emerged, of which 3 were named by at least a minority of the experts.

A majority names instruments that focus on the connection of e-scooters to other modalities[6, 1, 9, 4], mainly public transportation and trains (for example by means of hubs). A minority named instruments that to make sure there are enough parking options for e-scooters[11, 6, 9], either by providing parking places at the cost of car parking places[11] or allowing e-scooters to be parked everywhere[6, 9]. A minority named the strategy to focus on accessibility of the suburbs[6, 9, 8], for example by setting service requirements for shared e-scooter providers in those areas[6, 9, 8]. Also a minority named that requirements for the cost of use[7,6] can be set, to ensure e-scooters are accessible for everyone, Furthermore, an meaningful instruments was named by only one expert: Make bus, tram and metro faster by skipping stops, and serve the skipped stops with e-scooters[6].

6.3 Results in the system diagram

Figure 6-1 on the next page shows the results of the focus group and policymaker interviews visualised in the system diagram. As indicated in the figure blue blocks are factors mentioned by at least a majority, yellow blocks by a minority and orange blocks by a small minority. White blocks are factors of the original system diagram. The red arrows show were the policy strategies and instruments connect in the system diagram. The figure is a supplemented version of the aggregated system diagram (Figure 4-1).

6.4 Conclusion

This chapter provided insights in desirable outcomes of the mobility system in municipalities and policy strategies and instruments that can be deployed to achieve certain outcomes of the mobility system. Insights have been gathered as to which policy strategies and instruments can be used to achieve certain outcomes of the mobility system. In this way, it provides insight into the possibilities of dealing with uncertainties in the effect estimates, which were found in the previous chapter.

In the next chapter, the information from this chapter is compared to information on policy strategies and instruments from the other information sources (literature and congresses) to formulate final conclusions on the policy strategies and instruments. Besides that, final conclusions are formulated on the effect estimations.

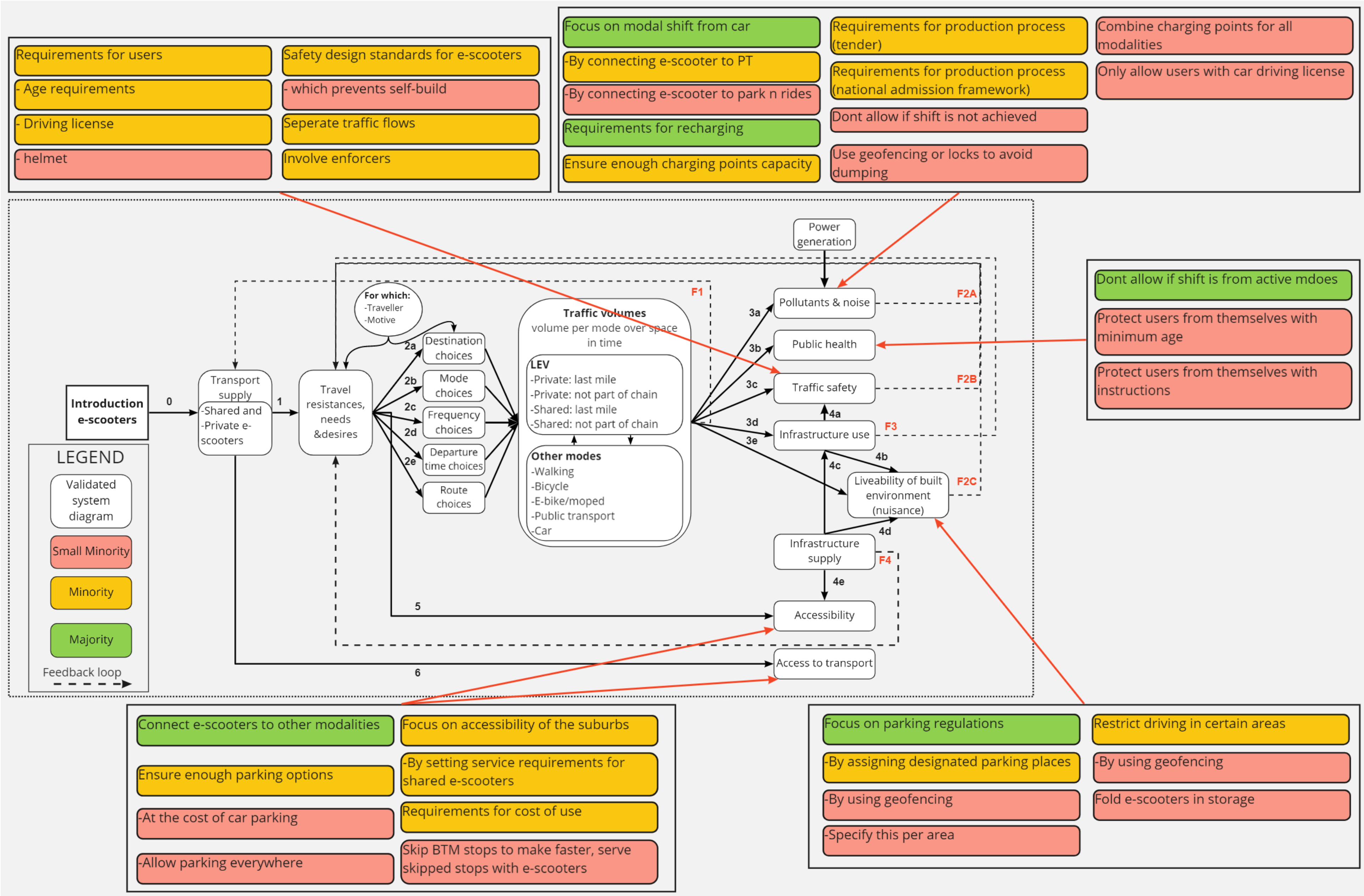


Figure 6-1: System diagram supplemented with results of the focus group and policymaker interviews

7 Conclusion

This chapter constitutes the final conclusions of this research. This report addresses the question: "*What relevant effects can be expected when e-scooters are (legally) introduced in the Netherlands, and what are the potential policy implications?"* This research is of an explorative nature. It was not the intention to provide conclusive evidence on the impact of e-scooters. The purpose is to provide the academic world and policymakers with a better understanding of the situation so that reasoned considerations can be made for further research or choices regarding regulations.

To answer this research question, a causal diagram (referred to as the system diagram) is made of the introduction of e-scooters and their impact. The diagram conceptually represents the expected impacts on travel behaviour and society of e-scooters. The effect estimations in the diagram are gathered through mobility expert interviews and compared to known effects abroad from literature. Consequently, a focus group session with mobility experts was organised to gain insights into policy strategies and instruments.

To answer the main research question, three sub-questions were formulated. This chapter examines the conclusions that can be formulated for each sub-question in Section 7.1 till Section 0. At the end of this chapter (Section 7.4), the final conclusion for this study is presented, and a conclusive system diagram is presented.

The conclusions are made by the synergy of the results of the information sources, as explained in Section 2.5. The complete synergy of the information sources for each factor, effects and policy strategy/instrument can be found in Appendix 10. The conclusions of the expected effects, underlying factors and policy options are added to the system diagram in Figure 7-1 at the end of section 7.2. The conclusion on most important effect estimations and policy strategies is shown in Figure 7-2 at the last page of this chapter.

7.1 What are the expected travel behaviour effects when e-scooters are introduced in the Netherlands?

To answer this research question, insight into the different factors that contain and determine travel behaviour is acquired. This encompasses travel resistances, needs and desires, users, travel choices, e-scooter usage and modal shift effects.

Factors that influence travel resistances, needs & desires

From this study is concluded that the factors: convenience/comfort aspects, the price and the 'quality and quantity of e-scooter infrastructure' are expected to influence the travel resistances, needs and desires of the Dutch inhabitants. Furthermore, there is a reasonable basis for the expectation that the factors travel time savings/operating speed, lifestyle aspects, 'portability in public transportation' and familiarity of e-scooters are influential factors of the travel resistances, needs & desires as well. A meaningful point was made, but not yet can a profound estimation be made for the factor 'hygiene situation', especially related to the Covid-19 situation.

Users & travel purpose

Younger persons are the expected dominant user group of e-scooters. E-scooters are expected to be used with for both leisure and commuting trips. It cannot be concluded yet which of these two will be dominant and whether the users will be mostly higher or lower educated.

Travel choices

There is a reasonable basis for the expectation that e-scooters will not change travel patterns regarding destination, frequency, route and departure time choices substantially, but there is the possibility that an increase in trip frequency will occur, especially for leisure trips.

E-scooter usage

E-scooters are expected to be mostly used in shared e-scooter systems. There is a reasonable basis for the expectation that there will be a niche of private e-scooter users ; it is unclear yet how large this group will be.

E-scooters are expected to be used in multimodal and unimodal trips; which one of the two will be dominant is unclear yet.

Modal shift effects

E-scooter users are expected to switch mostly from the active travel modes walking and cycling. A smaller modal shift from public transportation is also expected. A (very) small shift from the car is also anticipated, in what order of size is still unknown.

7.2 What relevant societal effects can be expected from these travel behaviour effects in the Netherlands?

To answer this research question, insights into the factors that determine the impact of e-scooters and their impact on societal effects are gathered.

Environment

There is a reasonable basis for the expectation that e-scooters will harm the environment, but e-scooters have the potential to have a more positive effect on the environment.
All sources agreed that whether e-scooters positively impact the environment depends on the shift from the car that e-scooters effectuate the life cycle of e-scooters and the power generation for the batteries.

Public Health

E-scooters are not an active travel mode since no physical effort is required to go around; therefore, a positive impact on public health is not expected.

Traffic safety

E-scooters can either have no influence on traffic safety, decrease traffic safety, and/or traffic safety perception can decrease. However, no profound estimations can be made on either of those statements. There is a reasonable base for the expectation that the added busyness on cycling lanes and more obstacles on the footpaths will influence the influence of e-scooters on traffic safety. A meaningful point was made, but a profound estimation cannot be made yet for the factor that the pricing system of shared e-scooters promotes speeding.

Liveability

All information sources agree that the impact of e-scooters on liveability can be large, but if well-regulated, the impact is moderate. Parking and (parking) regulations are important determinants for the impact. A meaningful point was made, but a profound estimation cannot be made yet for the expected effect that e-scooters will negatively influence space inside public transportation vehicles.

Accessibility and inclusivity

An increase in accessibility for a small group of people can be expected from e-scooters. It is still unclear how large this group and how large the impact will be. Besides, it is expected that e-scooters will contribute to the accessibility of the public transportation network. E-scooters are not accessible for disabled people, and prices can be high, which is not beneficial for the inclusiveness of the transportation system.

7.3 Which e-scooter related policy instruments and strategies can the Dutch government use, to maximize desirable outputs of these societal effects?

To answer this research question, insight in the desirable outcomes of the transportation system and e-scooter related- policy strategies and instruments that lead to certain outcomes of the transportation system is provided.

Desirable outcomes

In general municipalities stated that a contribution of e-scooters to all named societal effects (environment, health, safety, liveability, inclusivity and accessibility) is desirable and must be pursued. However the focus on these effects differ per municipality and per area in the municipality. The focus of the mobility policy differs per city as well, but also here is a common thread: the municipalities try to reduce the car dependency in their cities, especially in the city centres. At the same time they try to make the alternatives for the car more attractive, for everyone.

Policy strategies and instruments

In conclusion, the policy instruments that emerged from the focus group session and policymaker interviews are complemented by policy instruments, as mentioned in the literature. The policy instruments and strategies are classified according to the societal effect to which they contribute. Some policy strategies and instruments can contribute to multiple societal effects and, at the same time, harm other societal effects.

In general
It is important to make a policy before the introduction of e-scooters in a city. Besides that, a controlled trial & error procedure with pilot projects can be used. In this way, the policy can be tested, and adjustments can be made based on location-specific effects of e-scooters. As it becomes clearer in the next paragraphs, municipalities have the most regulation options over public shared e-scooters and fewer options to regulate private e-scooters.

From this research, the following strategies and instruments emerge that should ensure that the introduction of e-scooters contributes to limit their impact on the environment: 1) Ensure e-scooters lead to a modal shift from the car by connecting e-scooters to public transportation and car points, and improve the ease of use of e-scooters by ensuring there is enough capacity of charging points. In this way, car users can be convinced to choose e-scooters as an alternative. 2) Setting environmental requirements by setting requirements for the charging of shared e-scooters, only with green energy in the permits of shared e-scooter providers, and set requirements for the production process of e-scooters either in the permits for shared e-scooter providers or the national admission framework. 3) Prevent the dumping of (shared) e-scooters by; applying geofencing and/or special locks. 4) Finally, if these measures do not work, and the sole purpose is to protect the environment, do not allow shared e-scooters.

The following strategies and instruments emerged that should ensure that the introduction of e-scooters contributes to an improvement of public health: **1)** Since e-scooters are not an active mode of transport, don't allow shared e-scooters.

The following strategies and instruments emerged that should ensure that the introduction of e-scooters contributes to an improvement of traffic safety: **1)** Set requirements for e-scooter users by setting a minimum user age, obligate helmet usage and only allow e-scooters to be used with a car driving license. **2)** set requirements for e-scooters themselves by requiring a license plate and safety design standards **3)** Set requirements for e-scooter infrastructure (use) by only allowing the use of e-scooters on bicycle infrastructure and separating traffic flows **4)** Inform & involve users and non-users by organising a safety marketing campaign and involving enforcers in the policymaking process.

The following strategies and instruments emerged that should ensure that the introduction of e-scooters contributes to the liveability of public space **1)** Focus on cluttering of public space by folding and stacking e-scooters in storage to optimally use public space this could be achieved with hub design, use applications to report broken e-scooters and apply smart scaling to prevent too much unused e-scooters in the public space **2)** focus on parking rules, by using designated parking places and enforce this through geofencing or parking tickets. **3)** focus on driving rules by designating certain areas where e-scooters may not be used; enforce this by employing geofencing.

The following strategies and instruments emerged that should ensure that the introduction of e-scooters contributes to the accessibility and inclusivity of the transportation system: **1)** Focus on the connection of e-scooter to other modalities by utilising hubs at public transportation stations and park and ride locations, and at the same time skip certain public transportation stops to make public transportation faster **2)** Focus on parking, by ensuring enough designated parking spaces or allow e-scooters to be parked everywhere **3)** focus on the service of the whole town, by setting service requirements in certain areas. **4)** Focus on pricing by setting requirements for the cost of use in tenders and/or use low-income plans.

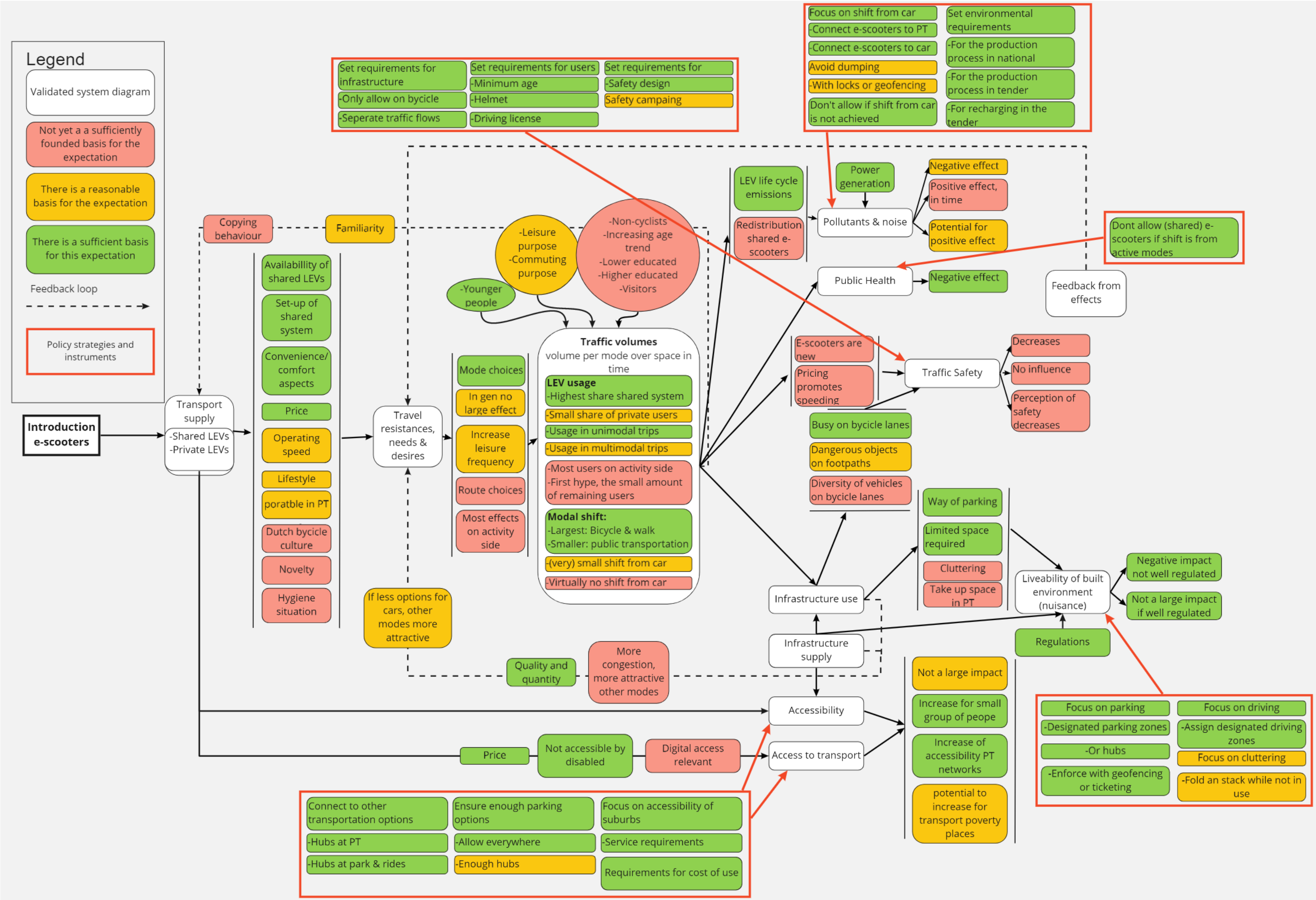


Figure 7-1: System diagram with the effects, underlying factors and policy implications that can be expected if e-scooters are introduced on the Dutch roads.

7.4 What relevant effects can be expected when e-scooters are (legally) introduced in the Netherlands and what are the potential policy implications?

The conclusions of the sub-questions lead to the conclusion for the research question of this study. This research shows with the system diagram, a literature review, expert interviews and a focus group session that the e-scooter situation is complex with different factors, relationships and effects: If just allowed, and minimally regulated (both shared and private), e-scooters can have a large an possibly negative impact on society, however there are uncertainties in the effects:

E-scooters are not expected to substantially change travel patterns regarding destination, frequency, route, and departure time choices, but an increase in trip frequency could occur. Shared e-scooters have the highest usage potential; only a niche market of private users is expected. E-scooters will mostly replace trips previously made by foot, bicycle or public transportation. Only a minimal shift from the car is expected.

Therefore the impact on the environment is expected to be negative (since cycling and walking are more beneficial to the environment), but the impact can be reduced by improving certain parameters. E-scooters are expected to have a negative effect on public health since they are not an active travel mode, and mostly, active travel modes will be replaced. No profound estimations can be made (yet) about the impact of e-scooters on traffic safety, though there are two prevailing views: e-scooters are not a risk to traffic safety, because of the Dutch cycling culture ii) e-scooters are harmful to traffic safety because the Dutch bicycle paths are already busy. The effect of e-scooters on the liveability of public space can be large, mainly due to space occupancy and cluttering of shared e-scooters. E-scooters have the potential to increase accessibility, but only for a small group of people (non-cyclists) and the public transportation network. E-scooter prices can be high compared to other transportation modes, and the vehicles are not accessible for the disabled, which is not beneficial for the inclusivity of the transportation system.

To ensure a contribution of e-scooters to desirable outcomes of the transportation system, regulations can be made to achieve a better impact on the environment by connecting e-scooters to public transportation points and park and rides (to achieve a shift from the car) and setting environmental requirements regarding recharging and vehicles in tenders or the admission framework. To ensure traffic safety, requirements can be set for users (age, helmet use or driving licenses), vehicles (safety standards in the admission framework) or related infrastructure (only allow on bicycle paths and or sperate traffic flows. Furthermore, a safety campaign could help to inform users and non-users about this new transport mode. The impact on liveability could be improved by setting rules for parking (designated parking zones, enforce by ticketing and/or geofencing), cluttering (fold and stack e-scooters while not in use) or driving (designate areas where e-scooters are not allowed). At last, to ensure the contribution to the accessibility and inclusivity, the connection of e-scooters to other modalities should be ensured (with hubs at public transportation stations and park and rides). There should also be enough parking options and service requirements for certain areas are required. At last, pricing requirements and low-income plans can be included in the permit for shared e-scooter suppliers.

In general, policy should be adaptive to account for uncertainties in the effects. If well-regulated, this research shows that e-scooters have the potential to contribute to the environment, the impact on the liveability of public space can be moderate, and e-scooters can contribute to the accessibility of a large group of people and areas, including transportation impoverished places. This conclusion for the research question is visualised in the conclusive system diagram on the next page (Figure 7-2).

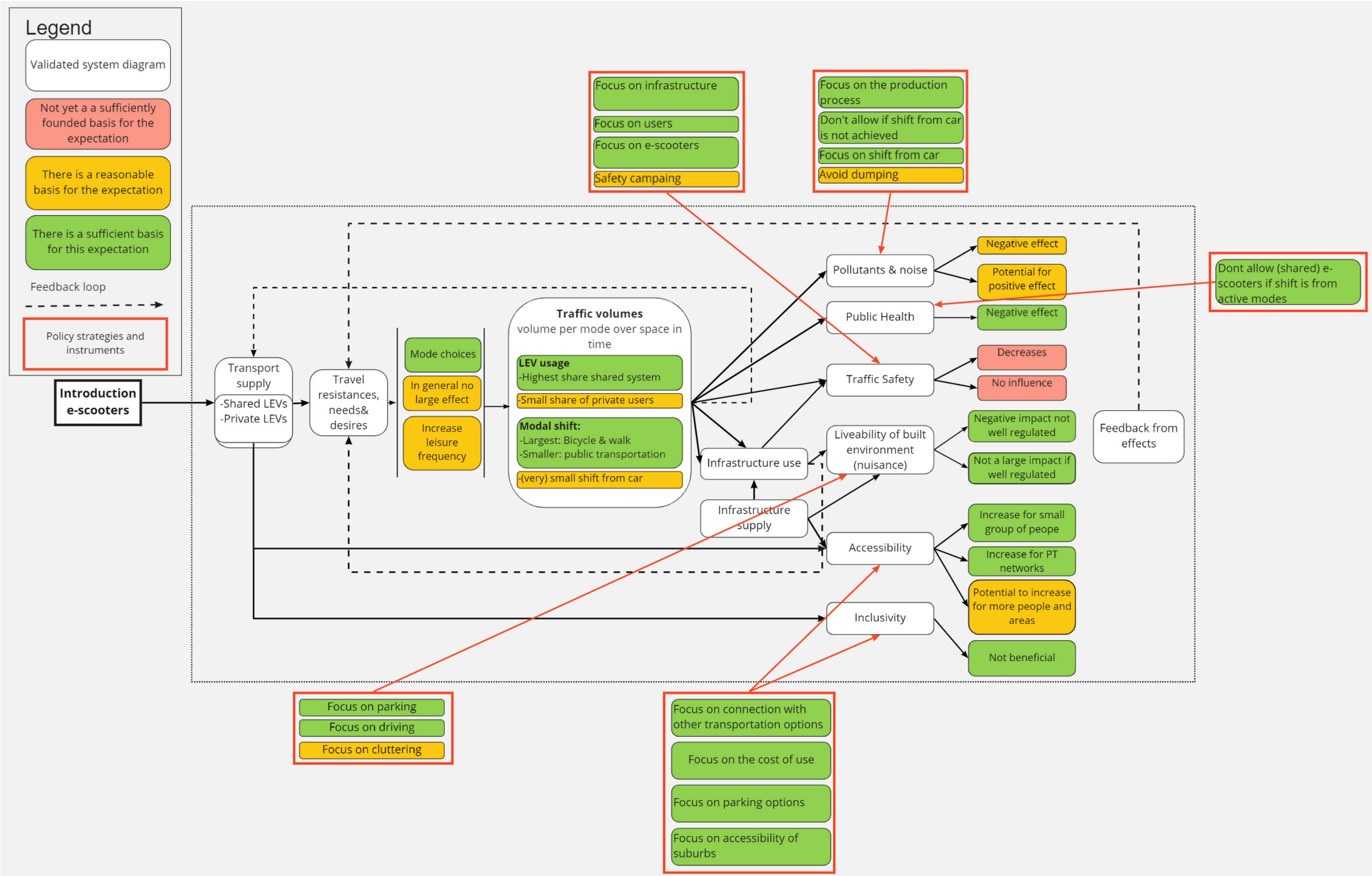


Figure 7-2: Conclusive system diagram with the most important effects and policy implications (strategies) of e-scooters

8 Reflection and recommendations

This chapter reflects on the research results and limitations of the results. In addition, recommendations are made for further research and for practice.

8.1 Reflection on results

In this section the results of this research are put in perspective, the generalizability of the results is elaborated on and the (hypothetic) effect on the results of other research methods is discussed.

Results in perspective

To the best of the author's knowledge, there is no existing literature on the impact of e-scooters to compare with the broad range of results found in this research. The results of the expert interviews and the focus group session for the effect estimations are already compared to other sources while formulating conclusions in the previous chapter. The expectations of the mobility experts on certain topics were in line with the literature, and on certain aspects were not.

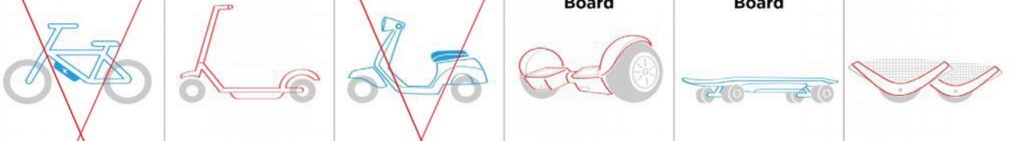
Bakker (2018) explored the role of electric two-wheelers (including e-scooters) on a range of societal effects with a qualitative assessment. It includes cases from China, Vietnam and the Netherlands. His conclusions are more promising than the conclusions of this study for the contribution of two-wheelers to sustainable urban mobility systems; He states that there is a large potential for the vehicles to contribute to a range of effects compared with other vehicles. The difference may be explained by the inclusion of a wider range of two-wheelers (including mopeds) and the analysed context: In Vietnam, most urban journeys are made on mopeds (Emberger, 2016). As a result, the modal shift results can differ and, thus, the sustainable impact estimations.

Generalizability of the research results

Generalizability to other vehicles

The results of this research can also be applied to other locations and other vehicles, depending on the context. E-scooters are lighter than 25 KG (with a few exceptions), which is the maximum portable weight by a person according to the EN 1005-2 and ISO 11228-1 norm. Being able to carry an e-scooter is an important feature in combination with public transportation (eg: Tuncer & Brown, 2020, p. 6). Besides, e-scooters have a fully electrical propulsion (no physical effort is needed) and have a maximum operating speed that falls between 15 km/h and 45 km/u (with a few exceptions). There are also other vehicles that fall within these characteristics; examples are shown in Figure 8-1. In the situation where these vehicles have the same supply and demand as e-scooters, it is expected that the results of this research regarding the impact can also be applied to these vehicles. However, this has not been investigated in this study. It is expected that this will not hold for the powered bicycle and seated scooter, marked with a red cross in Figure 8-1, because of their weight and size.

TYPES OF POWERED MICROMOBILITY VEHICLES[1]



	Powered Bicycle	Powered Standing Scooter	Powered Seated Scooter	Powered Self-Balancing Board	Powered Non-Self-Balancing Board	Powered Skates
Center column	Y	Y	Y	Possible	N	N
Seat	Y	N	Y	N	N	N
Operable pedals	Y	N	N	N	N	N
Floorboard / foot pegs	Possible	Y	Y	Y	Y	Y
Self-balancing[2]	N	N	N	Y	N	Possible

[1]All vehicles typically designed for one person, except for those specifically designed to accommodate additional passenger(s)
[2]Self-balancing refers to dynamic stabilization achieved via a combination of sensors and gyroscopes contained in/on the vehicle

Figure 8-1: Different types of powered micromobility vehicles that have similar characteristics of e-scooters (Source: OECD/ITF, 2020).

Generalizability to other locations

The same holds for other locations. This research focusses on the Dutch context; however, the effect estimations and policy implications can also apply to other countries/cities where e-scooters are not introduced yet, depending on the local context. Important variables to take into consideration while transferring these research outputs to other locations are:

- **The modal split situation**: this research found that e-scooter trips will mostly replace trips made previously by foot or by bicycle. This can be partly explained by the fact that these two modes account for 54% of the trips with a distance of 1-7 km in dense urban areas in the Netherlands (Kennisinstituut voor Mobiliteitsbeleid [KiM], 2019a). Different modal split situations could lead to different modal shift effects, and thus different societal effects of e-scooters.
- **The available e-scooter infrastructure**: from this research is learned that the available e-scooter infrastructure, quality and quantity, is an important determinant for the attractiveness of e-scooters and the for the effect of e-scooters on traffic safety. The effect expectations in this research have been gathered with the Dutch cycling infrastructure as context, which is considered as high quality and high in quantity (Coya, 2019, non peer-reviewed). Different e-scooter infrastructure situations could lead to different effects of e-scooters on travel behaviour and thus to different societal effects.
- **The electricity carbon intensity**: The power used to propel e-scooters is a determinant of the effect of e-scooters on the environment. As stated in Section 3.2, the 'electricity carbon intensity' measures the amount of carbon emitted per consumed electrical energy. This is a location-specific parameter, and it depends on how the electricity mix in a city is generated. In locations with a high electricity carbon intensity, electric driving is less good for the environment than in cities with a lower electricity carbon intensity.
- **Density of public space**: Cluttering and parked e-scooters are considered as a negative influence on the liveability of public space. In less dense areas with a lot of public space available, the influence of e-scooters on the public space might be less severe.

Possible results if another research method was used

As elaborated on in Section 2.6, other methodologies could have been used to estimate the impact of e-scooters in the Dutch context. If a transportation model had been applied, quantitative estimates would have been gathered. It is currently difficult to say whether those estimates would then be in the same direction as this study's results. This would depend on the transportation model's inputs, for example, the utilities for e-scooter trips. To the best of the author's knowledge, there haven't been any studies that found utilities for e-scooter trips in the Netherlands. Arendsen (2019) investigated the willingness to use (amongst other modes) shared e-scooters, but his research focusses on the specific situation of the first and last mile of train trips. In this study, a broader range of trips are central (unimodal, multimodal, private e-scooter, shared e-scooters); therefore, it is not possible to estimate the effect of estimates with a transport model.

A different qualitative research design could have also been used. For example, a survey to gather the effect estimates, a survey is a less time-consuming method. Therefore, it would have been possible to question more mobility experts. It could be that a questionnaire would have revealed clearer effect estimates for certain effects. It would also have been possible to organize an extra focus group in which the mobility experts of the expert interviews discussed their estimations with each other. It could be that certain experts would have drawn together or had changed their mind. Although the author thinks the changes in opinion would have been limited, the experts who participated in the focus group on policy instruments remained true to their views which they prevailed on the effects in the interviews.

8.2 Limitations of this research

This section goes into the limitations of the applied qualitative methodology.

Explorative and qualitative research

This research is of an exploratory nature. The results provide valuable insights, but with the interpretation of the results, one should consider that they are expectations. The results are in line with the exploratory nature, indications and are thus, not conclusive truths.

The results have been gathered with qualitative methods. Although attempts have been made to minimize biases in advance, for example, by selecting experts from various institutions, there may be biases in the results. By interviewing eleven experts, a saturation of information occurred (as shown in Figure 5-1). However, with a limited number of interviewees, one person's statements and opinions have a relatively large

influence on the research results. An attempt was made to keep this to a minimum by selecting experts from a range of institutions and reporting meaningful, less mentioned results. It would have been interesting to include the perspective of the providers of shared e-scooters in this report. Two interviews with e-scooter suppliers (Voi and Lime) have been conducted; however, these interviews were not useful as the interviewees could only answer a small part of the questions. For that reason, these interviews are not used in this report. The same holds for the focus group session. With seven mobility experts attending, the statements and opinions made by one expert have a large influence on the outcomes of the focus group. Besides that, the focus group was moderated by the author of this research. The moderator of a focus group can impact the results of the focus group (Morgan, 1996). This considered, the author aimed to be as objective as possible; however, arranging an external moderator would have been better to ensure minimum moderator bias.
Lastly, the participants in the interviews and focus group session mentioned several times that the topic of e-scooters is new and that it is difficult for experts to make sound estimates. This may also have affected the results.

Structure and depth of each interview

The expert interviews were conducted in a semi-structured manner. The system diagram served as an interview guide. However, in some interviews, some blocks and arrows were questioned in further detail than in other interviews. In short, the emphasis of the interview was not exactly the same everywhere. This may have affected the results; it may be that slightly different results would have been obtained if everyone had the same depth of questions for each block/arrow. This might also explain the differences in found factors for the interviews: an average of 39.5 factors was named in the interviews, with a standard deviation of ~5. The lowest number of found factors was 28, and the highest was 46. This shows that not in every interview the same amount of information was retrieved. Although during the feedback of the results during the focus group, no comments emerged from experts to revise their opinion.

Interpretation by the author

The results of the mobility expert interviews and the focus group are presented on the basis of two rules: on frequency and on the basis of 'meaningful outcomes' that were not mentioned by at least 25% of the interviewees. These 'meaningful results' have also been mentioned because this is an exploratory study on a new topic, and so it is possible that something mentioned by a single expert is also of great value. However, the author's bias may have influenced the presentation of these results, and a different author could have selected different results. To minimize this bias, external expert(s) could have been used to (help) identify these 'meaningful results'.

Complex system and a simple system diagram

As mentioned in the research, the urban transport system is a complex system with a seemingly endless amount of factors and relationships. Moreover, the state of the system depends on behaviour and not purely on exact science. Due to the duration of the research and the scheme's communicative purposes, it has not been possible to capture all these factors in one system diagram. Hence, it is simplified to an aggregated level and assumptions are made on the most important factors. Therefore some factors are left out of scope. Although the mobility experts validated the system diagram, it is still possible that different results were obtained with another (more detailed) diagram. On the other hand, it can be argued that, given the exploratory nature of the research in which expectations are central, it is not useful to go into more detail and thus create 'apparent certainties'.
Moreover, within the system diagram, it is not (explicitly) taken into account that e-scooters, in addition to the effects on society mentioned, can also simply 'be fun" and contribute to 'the freedom of choice' and thereby contribute (positively) to society. If this had been included, the conclusions might have been more positive towards the impact of e-scooters.

Short duration focus group

The third sub-question deals with policy strategies and instruments. Insights have been gathered here, but they are not very detailed. For example, it has not become clear exactly where they hook up in the system diagram, only that they influence 'the system'. An important method used in answering this sub-question is the focus group. During the focus group, there was eventually about 45 minutes for discussion, in addition to an explanation of the results and the case. If there had been more time, or if a second session had been

organized, then the policy instruments could have been discussed in more detail. It would have been interesting to go into more detail occasionally during the discussion. For example, for the instrument 'connect e-scooters to other modalities by means of hubs' it would be interesting to discuss in more detail. How exactly? What should you pay attention to? What is important for success? Etc.
If there had been more time, there would also have been more opportunity for experts to enter into the discussion and agree or disagree. A number of instruments seem reasonably 'logical' (for example: helmet requirement to guarantee safety), but have only been mentioned by a minority. The author suspects that if there was an opportunity to engage in a longer conversation, a number of instruments would have been mentioned by more people.

8.3 Recommendations for further research

This section goes into recommendations for further research to gain more insights into the effects on travel behaviour and society of e-scooters. Besides, recommendations for research on e-scooter policy is provided.

Travel behaviour and societal effects

For the aspects of travel behaviour; share of private e-scooter users, multimodal or unimodal use, the amount of shift from the car and bus tram metro, this study did not provide a clear picture of the estimate. More detailed insights in the usage potential and modal shift effects of e-scooters could be retrieved by first doing a stated preference study. The utilities that emerge from this stated preference study could subsequently be applied in utility-based transportation models. In this way, detailed estimates can be made of the effects on travel behaviour before e-scooters are allowed on the Dutch road. This then results in more detailed estimates of the effects of e-scooters on society as well.

These studies would provide insight into the aspects for which no unambiguous picture has emerged in the conclusion and provide a more quantitative estimation for the expectations for which a ambiguous picture has emerged.

If the admission framework is completed, and e-scooters are allowed on the Dutch road, there is also a possibility to collect empirical data. Pilots can be started to investigate the effects on the travel behaviour of e-scooter users. Pilots come in many forms, with both shared e-scooters and private e-scooters. A possibility is, for example, to give a selection of potential users e-scooters on loan for a while, and to have the participants keep a travel diary. An example of such research, but then focused on e-bikes, is the research by the Active Mode Lab of the TU Delft (2019).
Data from shared e-scooters, once operating in the Netherlands, can also be requested and then combined with a user survey to gain insight into the effects on travel behaviour. In a similar way as is done in Portland by the PBT (2018).

Policy

From the literature review is learned that, to the best of the author's knowledge, there is currently not any research into the performance and effectiveness, and determinants thereof, of policy instruments for e-scooters. It could be interesting for both Dutch policymakers for an ex-ante policy, as well as for policymakers in cities where e-scooters are currently already allowed to gain some insights into the performance of policy instruments and what precisely affects that performance. With these insights, the precise starting points of policy can also be added to the system diagram. This applies to all policy instrument ideas that followed from this research.
A qualitative research design could be used, in which policymakers and other mobility experts are asked about the policy instruments already deployed and their opinion on their effectiveness and determinants of that effectiveness. E-scooter users could also be involved by questioning them about changing travel behaviour after implementing policy instruments. Various methods can be used to achieve this, such as surveys, interviews and focus groups.
A more quantitative research design can also be applied, for example, by using data sharing e-scooters providers. To analyse whether and what influence certain policy instruments have had on travel behaviour. The advantage of such a setup compared to the mentioned qualitative setup is that you work with empirical data. A disadvantage is that it is more difficult to gain insight into private e-scooter use and multimodal use of e-scooters.

Another possibility is to apply modelling techniques to estimate the effect of policies that are not in use yet or to estimate the effectiveness of policies in situations where e-scooters are not yet allowed, like the Netherlands.

8.4 Recommendations for public entities

This section suggests recommendations for policy strategies and or instruments that can be used to regulate e-scooters. While formulating transport policies, trade-offs often have to be made. For example, more roads can lead to more accessibility, but consequently, less liveable cities. Or another example: how many switchers from the bicycle towards e-scooters are worth one switcher from the car towards e-scooters? These trade-offs are often political choices; therefore, no statements are made in this report for the best choices herein.

On the national level, there are options to add requirements to the admission framework:

- Safety standards for e-scooters, including reflectors, lights and a maximum speed, these measurements are expected to contribute to traffic safety when e-scooters are introduced.
- Environmental requirements for the production process of e-scooters.
- Require a license plate so that it is easy to distinguish between approved and non-approved e-scooters to ensure safety, and licenses make it easier to enforce regulations.
- Only allow the usage of e-scooters on bicycle infrastructure to ensure traffic safety and liveability.

On the municipal level, since only a niche market for private LEV users is expected, it is advised to focus policy at first on shared e-scooters. The regulations in the national authorisation framework are probably already sufficient to regulate the usage of private e-scooters. The results of this research consist of expectations with uncertainties. It is, therefore, advisable to ensure that policy is adaptive to deal with unexpected effects. This can be achieved, for example, with e-scooter pilots, or different shared e-scooter suppliers can be admitted with different set-ups of the shared system (free-floating, with hubs, etc.). To see how users react to this and what the effects are. To monitor the impact, it is also important to make agreements about data sharing in the permits for the shared e-scooter providers, as mentioned in the focus group.

To stimulate the (positive) contribution of e-scooters to society, policymakers can set certain requirements in the tender for shared e-scooter providers:

- Service requirements for areas (outside the city centre) and pricing to ensure accessibility of less served areas and lower-income people.
- Require shared e-scooter providers to charge e-scooter only with green energy and service them with green vehicles to limit the impact of e-scooter use on the environment.
- Require providers to apply smart scaling and ensure broken vehicles are removed from the streets to limit the impact on liveability.
- Require the use of geofencing to prevent usage and parking of e-scooters in restricted areas.
- (This study does not consider whether it is still possible with these requirements to set up a viable business case for shared e-scooter providers)

Policymakers can organise the transportation system in the municipality by:

- Create hubs or assign other designated parking spaces for e-scooters to ensure liveability.
- Connect the different transportation options by utilising e-scooter hubs at public transportation stations and park and ride locations to improve accessibility.
- Investigate if certain bus tram or metro stops can be skipped to make them faster if these transportation modes are well connected to other modes like e-scooters.
- Ensure business districts, universities and suburbs are connected to e-scooters (and other transportation alternatives) to stimulate people not to commute by car and thereby improve the environment.

If the impact of e-scooters on society is not desirable, despite attempts at regulation, the choice can be made not to allow shared e-scooters. Nevertheless, the choice can also be made that in that case, e-scooters may not add something in a positive sense to the social effects that are central to this report (environment, public health, traffic safety, liveability, accessibility and inclusivity), but do contribute something to choice, freedom and pleasure.

9 Bibliography

6t-bureau de recherche. (2019) Usages et Usagers des Trottinettes Electriques en Free-Floating en France. p. 158 https://6-t.co/etudes/usages-usagers-trottinettes-ff/

Van Acker, V., van Wee, B., & Witlox, F. (2010). When transport geography meets social psychology: toward a conceptual model of travel behaviour. *Transport Reviews*, *30*(2), 219-240.

Albrantes, P.A.L. and M.R. Wardman (2011), 'Meta- analysis of U.K. values of travel time: an update', *Transportation Research Part A, 45*, 1–17.

ANWB (n.d.) Elektrische step – hoe zit dat? Retrieved from: https://www.anwb.nl/belangenbehartiging/mobiliteit/elektrische-step

Arana, P., Cabezudo, S., & Peñalba, M. (2014). Influence of weather conditions on transit ridership: A statistical study using data from Smartcards. *Transportation research part A: policy and practice*, *59*, 1-12.

Arendsen, J. (2019) Shared mobility for the first and last mile: Exploring the willingness to share.

Bakker, S. (2018). Electric two-wheelers, sustainable mobility and the city. Sustainable Cities-Authenticity, Ambition and Dream.

Bamberg, S., Rölle, D., & Weber, C. (2003). Does habitual car use not lead to more resistance to change of travel mode?. *Transportation*, *30*(1), 97-108.

Bertolini, L. (2017). Planning the mobile metropolis: Transport for people, places and the planet. Macmillan International Higher Education.

Bierbag, M. Adolph, T. Frey, A. Kollmus, B. (2018) Untersuching zu Elktrokleinstfahrzeugen. Retrieved from: https://www.bast.de/BASt_2017/DE/Publikationen/Berichte/unterreihe-f/2019-2018/f125.html

Blomberg, S. N. F., Rosenkrantz, O. C. M., Lippert, F., & Christensen, H. C. (2019). Injury from electric scooters in Copenhagen: a retrospective cohort study. *BMJ open*, *9*(12), e033988.

de Bortoli, A., & Christoforou, Z. (2020). Consequential LCA for territorial and multimodal transportation policies: method and application to the free-floating e-scooter disruption in Paris. *Journal of Cleaner Production, 273*, 122898.

Boston Consultancy Group [BCG] (2020) How E-scooters Can Win a Place in Urban Transport. Retrieved from: https://www.bcg.com/publications/2020/e-scooters-can-win-place-in-urban-transport#close-modal

Buehler, R. (2011). Determinants of transport mode choice: a comparison of Germany and the USA. *Journal of transport geography*, *19*(4), 644-657.

Centraal Bureau voor de Statistiek [CBS] (2019) *Onderweg in Nederland (ODIN) 2018*. Retrieved from: https://www.cbs.nl/-/media/_pdf/2020/03/eindrapportageodin2018v10.pdf

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research D, 2(3)*, 199–219

Chapin, F. S. (1974). *Human activity patterns in the city: Things people do in time and in space* (Vol. 13). Wiley-Interscience.

Choo, S., & Mokhtarian, P. L. (2004). What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. *Transportation Research Part A: Policy and Practice*, *38*(3), 201-222.

Christoforou, Z., Gioldasis, C., de Bortoli, A., & Seidowsky, R. (2021). Who is using e-scooters and how? Evidence from Paris. *Transportation Research Part D: Transport and Environment, 92*, 102708.

Church, A., Frost, M., & Sullivan, K. (2000). Transport and social exclusion in London. Transport policy, 7(3), 195-205. *Transport Policy, 7* (2000), pp. 195-205

Civity Management Consultant [CMC] (2019) E-Scooter in Deutschland - Ein datenbasierter Debattenbeitrag Civity Management Consultants. Retrieved from: http://scooters.civity.de

Clewlow, R., Foti, F., & Shepard-Ohta, T. (2018). Measuring equitable access to new mobility: A case study of shared bikes and electric scooters.

Collins, C. M., & Chambers, S. M. (2005). Psychological and Situational Influences on Commuter-Transport-Mode Choice. *Environment and Behavior, 37(5),* 640–661. Retrieved from: https://doi.org/10.1177/0013916504265440

Coya (2019) Bicycle Cities Index 2019. Retrieved from: https://www.coya.com/bike/index-2019

CROW (2020) Position Paper Micromobiliteit. Retrieved from: https://www.crow.nl/getmedia/bafe620c-2e61-4653-a46c-7f1a8603f31d/K-D077-Position-paper-Micromobiliteit.pdf.aspx?ext=.pdf

Dorussen, H., Lenz, H., & Blavoukos, S. (2005). Assessing the reliability and validity of expert interviews. *European Union Politics*, *6*(3), 315-337.

DuPuis, N., Griess, J., & Klein, C. (2019). Micromobility in Cities: A History and Policy Overview.

Eccarius, T., & Lu, C. C. (2018). Exploring consumer reasoning in usage intention for electric scooter sharing. *Transp. Plan. J. 運輸計劃季刊*, *47*(4), 271-295.

Elliott, M. A., & Thomson, J. A. (2010). The social cognitive determinants of offending drivers' speeding behaviour. *Accident Analysis & Prevention*, *42*(6), 1595-1605.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of advanced nursing*, *62*(1), 107-115.

Emberger, G. (2016). Urban Transport in Ho Chi Minh City, Vietnam. In Sustainable Ho Chi Minh City: Climate Policies for Emerging Mega Cities (pp. 175-191). Springer, Cham.

Ernst, J. (2011), 'Environmental challenges of urban transport: the impacts of motorization', in H. Dimitriou and R. Gakenheimer (eds), Urban Transport in the Developing World: Perspectives fr om the First Decade of the New Millennium, Cheltenham, UK

Eurostat (2019) Statistieken van het personenvervoer. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Passenger_transport_statistics/nl#Personenvervoer_over_land.2C_uitgesplitst_naar_vervoerswijze

Ewert, A., Brost, M., & Schmid, S. (2019, May). Fostering small electric vehicles on a municipal level. In *Proceedings of the 32nd Electric Vehicle Symposium (EVS32), Lyon, France* (pp. 19-22).

Ewing, R., & Cervero, R. (2010). Travel and the built environment: a meta-analysis. *Journal of the American planning association*, *76*(3), 265-294.

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.

Fitt, H., & Curl, A. (2019). E-scooter use in New Zealand: Insights around some frequently asked questions. *Retrieved August*, *21*, 2020.

Garrard, J., Rose, G., & Lo, S. K. (2008). Promoting transportation cycling for women: the role of bicycle infrastructure. *Preventive medicine*, *46*(1), 55-59.

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British dental journal, 204(6*), 291-295.

Giuliano, G., & Dargay, J. (2006). Car ownership, travel and land use: a comparison of the US and Great Britain. *Transportation Research Part A: Policy and Practice*, *40*(2), 106-124.

Givoni, M and Rietveld, P. (2007) The access journey to the railway station and its role in passengers'

Gordon, T. J. (1994). The delphi method. *Futures research methodology*, *2*(3), 1-30.

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.

Götschi, T., de Nazelle, A., Brand, C., Gerike, R., & Pasta Consortium. (2017). Towards a comprehensive conceptual framework of active travel behavior: a review and synthesis of published frameworks. *Current environmental health reports*, *4*(3), 286-295.

Goudappel Coffeng (2020) Samenvatting stakeholder experttraject: Lichte elektrische voertuigen April/Mei 2020. Retrieved from: https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2020/07/16/bijlage-5-samenvatting-stakeholdertraject-lev-mei-2020/bijlage-5-samenvatting-stakeholdertraject-lev-mei-2020.pdf

Hägerstrand, T. (1970). What about people in regional science? *Papers Regional Science Association, 24*(1), 7-71.

Haghshenas, H., & Vaziri, M. (2012). Urban sustainable transportation indicators for global comparison. *Ecological Indicators*, *15*(1), 115-121.

Hardt, C., & Bogenberger, K. (2019). Usage of e-scooters in urban environments. *Transportation research procedia*, *37*, 155-162.

Harms, L. W. J. (2008). Overwegend onderweg: de leefsituatie en de mobiliteit van Nederlanders (Doctoral dissertation, Sociaal en Cultureel Planbureau).

Haustein, S., & Nielsen, T. A. S. (2016). European mobility cultures: A survey-based cluster analysis across 28 European countries. *Journal of Transport Geography*, *54*, 173-180.

Heemskerk, M., Wilson, K., & Pavao-Zuckerman, M. (2003). Conceptual models as tools for communication across disciplines. *Conservation Ecology*, *7*(3).

Heinen, E., & Handy, S. (2012). Similarities in attitudes and norms and the effect on bicycle commuting: Evidence from the bicycle cities Davis and Delft. *International Journal of Sustainable Transportation*, *6*(5), 257-281.

Heinen, E., B. van Wee and K. Maat (2010), 'Commuting by bicycle: an overview of the literature', *Transport Reviews*, 30 (1), 59–96.

Higgs, C., Badland, H., Simons, K., Knibbs, L. D., & Giles-Corti, B. (2019). The Urban Liveability Index: developing a policy-relevant urban liveability composite measure and evaluating associations with transport mode choice. *International journal of health geographics*, *18*(1), 14.

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), 084031.

Hulshof, R. (2020) Micromobiliteit congress. Robert Hulshof Min I&W

Hulshof, R. (2021) Phone call

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.

Jonkeren, O., Harms, L., Jorritsma, P., Huibregtse, O., & Bakker, P. (2018) Waar zouden we zijn zonder de fiets en de trein?.

Kager, R., Bertolini, L., & Te Brömmelstroet, M. (2016). Characterisation of and reflections on the synergy of bicycles and public transport. *Transportation Research Part A: Policy and Practice, 85*, 208–219.

Kennisinstituut voor Mobiliteitsbeleid [KiM] (2019a) Mobiliteit in stedelijk Nederland. ISBN/EAN: 978-90-8902-205-9

Kennisinstituut voor Mobiliteitsbeleid [KiM] (2019b) Mobiliteitsbeeld

Kitzinger, J. (1994). The methodology of focus groups: the importance of interaction between research participants. *Sociology of health & illness, 16(1),* 103-121.

Laa, B., & Leth, U. (2020). Survey of E-scooter users in Vienna: Who they are and how they ride. *Journal of transport geography*, *89*, 102874.

Larsen, K., Buliung, R. N., & Faulkner, G. E. J. (2013). Safety and School Travel: How Does the Environment along the Route Relate to Safety and Mode Choice? Transportation Research Record, 2327(1), 9–18. https://doi.org/10.3141/2327-02

Larson, K., Grudens-Schuck, N., & Allen, B. L. (2004). Methodology Brief: Can You Call It a Focus Group?.

Lawrence, D., & Low, S. (1990). The Built Environment and Spatial Form. *Annual Review of Anthropology, 19*, 453-505. Retrieved December 9, 2020, from http://www.jstor.org/stable/2155973

Lime. (2018) End of the year report. Retrieved from: *https://www.li.me/hubfs/Lime_Year-End%20Report_2018.pdf*

Lime (n.d.) Homepage website lime. Retrieved from*:* https://www.li.me/en-us/home

Liu, M., Seeder, S., & Li, H. (2019). Analysis of E-scooter trips and their temporal usage patterns. *Institute of Transportation Engineers. ITE Journal*, *89*(6), 44-49.

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.

Metrixlab (2020, May) *Toelatingskader* Lichte Elektrische Voertuigen. Retrieved from: https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2020/07/16/bijlage-4-kwalitatief-publieksonderzoek-tbv-toelatingskader-lichte-elektrische-voertuigen-mei-2020/bijlage-4-kwalitatief-publieksonderzoek-tbv-toelatingskader-lichte-elektrische-voertuigen-mei-2020.pdf

Van Mil, J. F., Leferink, T. S., Annema, J. A., & van Oort, N. (2020). Insights into factors affecting the combined bicycle-transit mode. *Public Transport*, 1-25.

Milakis, D., Gebhardt, L., Ehebrecht, D., & Lenz, B. (2020). Is micro-mobility sustainable? An overview of implications for accessibility, air pollution, safety, physical activity and subjective wellbeing. *Handbook of Sustainable Transport*.

Mobility Foresights (2020) Electric Scooter Sharing Market In Us And Europe 2019-2025. Retrieved from: https://mobilityforesights.com/product/scooter-sharing-market-report/

Mokhtarian, P. L., & Salomon, I. (2001). How derived is the demand for travel? Some conceptual and measurement considerations. *Transportation research part A: Policy and practice*, *35*(8), 695-719. *record*, 1780(1):87–114, 2001.

Mokhtarian, P.L. and X. Cao (2008), ‘Examining the impacts of residential self- selection on travel behavior: a focus on methodologies’, *Transportation Research Part B*, 42 (3), 204–228.

Morgan, D. L. (1996). *Focus groups as qualitative research* (Vol. 16). Sage publications.

Müggenburg, H., Busch-Geertsema, A., & Lanzendorf, M. (2015). Mobility biographies: A review of achievements and challenges of the mobility biographies approach and a framework for further research. *Journal of Transport Geography*, *46*, 151-163.

Nederlandse Spoorwegen [NS] (2013). Presentatie bert vaessens, ns - kpvv, 2013. URL https://www.yumpu.com/nl/document/read/23941280/presentatie-bert-vaessens-ns-kpvv.

Van Nes, R. (2002). Design of multimodal transport networks: A hierarchical approach

Newcomer, K. E., Hatry, H. P., & Wholey, J. S. (2015). Conducting semi-structured interviews. *Handbook of practical program evaluation*, *492*.

OECD/European Commission (2020), Cities in the World: A New Perspective on Urbanisation, OECD Urban Studies, OECD Publishing, Paris, https://doi.org/10.1787/d0efcbda-en.

OECD/ITF (2020) *Safe micromobility.*.Retrieved from: https://www.itf-oecd.org/sites/default/files/docs/safe-micromobility_1.pdf

Oeschger, G., Carroll, P., & Caulfield, B. (2020). Micromobility and public transport integration: The current state of knowledge. *Transportation Research Part D: Transport and Environment*, *89*, 102628.

Parkin, J., Wardman, M. & Page, M. (2008) Estimation of the determinants of bicycle mode share for the journey to work using census data . *Transportation* **35,** 93–109 (2008). https://doi.org/10.1007/s11116-007-9137-5

Planbureau voor de Leefomgeving [PBL], 2007, Afgeschermde woondomeinen in Nederland, een verdieping.

Plazier, P. A., Weitkamp, G., & van den Berg, A. E. (2017). “Cycling was never so easy!” An analysis of e-bike commuters' motives, travel behaviour and experiences using GPS-tracking and interviews. *Journal of transport geography*, *65*, 25-34.

Pruyt, E., 2013. Small System Dynamics Models for Big Issues: Triple Jump towards Real-World Complexity. Delft: TU Delft Library. 324p.

Pucher, J., & Buehler, R. (2008). Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. *Transport reviews*, *28*(4), 495-528.

Portland Bureau of Transportation [PBT] (2018) E-scooter findings report. Retrieved from: https://www.portland.gov/sites/default/files/2020-04/pbot_e-scooter_01152019.pdf

RDW (2019) Wegwijzer Bijzondere Bromfietsen. Retrieved from: https://www.rdw.nl/over-rdw/actueel/dossiers/bijzondere-bromfietsen

Reck, D. J., Guidon, S., Haitao, H., & Axhausen, K. W. (2020). Explaining shared micromobility usage, competition and mode choice by modelling empirical data from Zurich, Switzerland. *Transportation Research Part C: Emerging Technologies*.

Rietveld, P., & Daniel, V. (2004). Determinants of bicycle use: do municipal policies matter?. *Transportation Research Part A: Policy and Practice*, *38*(7), 531-550.

Rijksoverheid (2019). *Klimaatakkoord.* Retrieved from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2019/06/28/klimaatakkoord/klimaatakkoord.pdf

Rodrigue, J. (2020) The Geography of Transport Systems. ISBN 978-0-367-36463-2

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., ... & Jinks, C. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & quantity, 52*(4), 1893-1907.

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

Schepers, P., Hagenzieker, M., Methorst, R., van Wee, B., & Wegman, F. (2014). A conceptual framework for road safety and mobility applied to cycling safety. *Accident Analysis & Prevention*, *62*, 331-340.

Schuilenburg, M. van Steden, R. (2015) Afgeschermd wonen in Nederland: een studie naar waarom mensen hiervoor kiezen en hoe zij omgaan met interne regelgeving. Tijdschrift voor Veiligheid 2015 (14) 0304 doi: 10.5553/TvV/1872794820150140304001

Shelat, S., Huisman, R., & van Oort, N. (2018). Analysing the trip and user characteristics of the combined bicycle and transit mode. *Research in transportation economics, 69*, 68-76.

Sinha, K. C. (2003). Sustainability and urban public transportation. *Journal of Transportation Engineering, 129(*4), 331-341.

Sipe, N., & Pojani, D. (2018). Can e-scooters solve the 'last mile'problem? They'll need to avoid the fate of dockless bikes.

Smith, C. S., & Schwieterman, J. P. (2018). E-scooter scenarios: evaluating the potential mobility benefits of shared dockless scooters in Chicago.

Stanton, N. A., McIlroy, R. C., Harvey, C., Blainey, S., Hickford, A., Preston, J. M., & Ryan, B. (2013). Following the cognitive work analysis train of thought: exploring the constraints of modal shift to rail transport. *Ergonomics, 56(*3), 522-540.

Sterman, J. (2002). System Dynamics: systems thinking and modeling for a complex world.

Tice, P. C. (2019, November). Micromobility and the Built Environment. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 63, No. 1, pp. 929-932). Sage CA: Los Angeles, CA: SAGE Publications.

TNO (2020) Ervaring met licht elektrische voertuigen in Europa. Retrieved from: https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2020/07/16/bijlage-2-rapport-tno-ervaringen-lev-in-europa/bijlage-2-rapport-tno-ervaringen-lev-in-europa.pdf

Transportøkonomisk institutt [TØI] (2020) Shared e-scooters in Oslo -summary. TØI report 1748/2020. Retrieved from: https://www.toi.no/getfile.php/1352251-1580474379/Publikasjoner/T%C3%98I%20rapporter/2020/1748-2020/1748-2020-sum.pdf

Tuncer, S., & Brown, B. (2020, April). E-scooters on the Ground: Lessons for Redesigning Urban Micro-Mobility. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-14).

Van Wee, B. (2009). Self-selection: a key to a better understanding of location choices, travel behaviour and transport externalities?. *Transport reviews*, *29*(3), 279-292.

Van Wee, B., Annema, J. A., & Banister, D. (Eds.). (2013). *The transport system and transport policy: an introduction*. Edward Elgar Publishing.

Van Wee, B., & Ettema, D. (2016). Travel behaviour and health: A conceptual model and research agenda. *Journal of Transport & Health*, *3*(3), 240-248.

Van Wee, B., De Vos, J., & Maat, K. (2019). Impacts of the built environment and travel behaviour on attitudes: Theories underpinning the reverse causality hypothesis. *Journal of transport geography*, *80*, 102540.

Voi (n.d.) Voi Website Home Page. Retrieved from: https://www.voiscooters.com/

Winters, M., Brauer, M., Setton, E. M., & Teschke, K. (2010). Built environment influences on healthy transportation choices: bicycling versus driving. *Journal of urban health*, *87*(6), 969-993.

Zagorskas, J., & Burinskienė, M. (2020). Challenges Caused by Increased Use of E-Powered Personal Mobility Vehicles in European Cities. *Sustainability*, *12*(1), 273.

Zhao, P., Li, S., Li, P., Liu, J., & Long, K. (2018). How does air pollution influence cycling behaviour? Evidence from Beijing. *Transportation research part D: transport and environment*, *63*, 826-838.

Appendices: overview

This report contains the following appendices with background information:

Appendix 1. Scientific Paper

Estimating the impact on society and policy implications of standing e-scooters in the Dutch context.

G.H.J. Alberts, G.P Van Wee, J.A. Annema, N. van Oort, E. Arends, P. Kole

Abstract - (standing) E-scooters are a promising mode of transport; the vehicles are electrically powered, light, and fit in the dense urban landscape. However, little is known about the impact of these vehicles that can be expected when introduced in the Netherlands. In this paper, effect estimations of e-scooters on travel behaviour and society are made, and insight is provided into the policy implications of these -expected-effects. A System Diagram is made of the introduction of e-scooters and their impact. The effect estimations in the diagram are gathered through mobility expert interviews and compared to known effects abroad from literature. Consequently, a focus group session with mobility experts was organised to gain insights into policy instruments. This paper concludes that the impact of e-scooters can be large and possibly negative if not well regulated. However, there are policy options that have the potential to improve the impact of e-scooters.

Keywords: standing, e-scooter, effects on travel behaviour, effects on society, e-scooter policy

I. Introduction

(standing) E-scooters are a promising mode of transport. Shared e-scooter suppliers claim that the vehicles are part of the solution for a sustainable and liveable city (Voi, nd; Lime, nd). E-scooters can be both an option for the first- and last-mile as for individual trips through the city (Gössling, 2020; Tuncer & Brown, 2020) E-scooters have certain properties that are different from other, more common forms of micro-mobility. They are electrically powered, light, easy to handle and fit into the tight urban landscape due to their size. Besides that, they are in general faster than the bicycle and require no physical effort to go around (Smith & Schwieterman, 2018; Oeschger, Carroll, & Caulifield, 2020; Ewert, Brost, & Schmid, 2019; Tuncer & Brown, 2020; Christoforou et al., 2021;). E-scooters are currently prohibited in the Netherlands, but the ministry is working on an authorization framework (Hulshof, 2021). However, little is known about the impact of these vehicles that can be expected when e-scooters are launched in the Netherlands. Being a relatively new and upcoming sub-field of urban transportation research, the available research is scarce (McKenzie, 2020) and focusses on countries where e-scooters are currently legal, like France, the USA and Norway.

A. E-scooter usage

From those studies, it is found that users of e-scooters are mostly men, between 18 and 35 years of age and higher educated (Christoforou et al., 2021; Laa & Leth, 2020;) An upwards age trend is observed when e-scooters are available in a city for a while (Hunternilsson, 2020)

E-scooters are used for both commuting (education and work) and leisure purposes. There is no clear dominant purpose; however, more studies show a dominant leisure purpose (Christoforou, 2021; Eccarius & Lu, 2018; Ewert et al., 2019) than studies that show a dominance in commuting purpose (TØI, 2020; Hollingsworth, Copeland, & Johnson, 2019).

E-scooters are mostly used for shorter trips (1.8 – 4 km) (Reck et al., 2020; Civity Management Consultant, 2019; Christoforou et al., 2021) in the afternoon; a clear afternoon peak is seen in the usage of e-scooters, based on data of shared e-scooter providers (Reck et al., 2020; Liu, Seeder, & Li, 2019; McKenzie, 2020; CMC, 2019; Portland Bureau of Transportation [PBT], 2018) and users surveys (TØI, 2020).

Literature shows that most trips made with e-scooters replace trips previously made with active travel modes (42% - 78%). US-based studies show a relatively large shift from the car (~35%) (PBT, 2018; Hollingsworth et al., 2019) as compared to EU based studies, which show a relatively large shift from public transportation (23% - 35%) (Transportøkonomisk institutt [TØI], 2020; Bortoli & Christoforou, 2020; 6t-bureau de recherche, 2019; Laa & Leth, 2020). Not many studies touch upon multimodal trips with e-scooters; those that do found that a large proportion of the trips were made in combination with another means of transport (TØI, 2020; 6t-bureau de recherche, 2019). Also, not many studies investigated whether e-scooters cause an increase in travel movements, when this research is done, an increase of 8-20% is found(PBT, 2018; Hollingsworth et al., 2019). The only available study that compared the use of private and shared e-scooters found that owners of e-scooters replace more car trips and use e-scooters more often in combination with public transportation (Lee and Leth, 2020).

B. Effects of e-scooters on society

Two life cycle assessments on shared e-scooters found that, at present time, e-scooters are not beneficial for the environment, but there is a potential to improve this. The impact of (shared) e-scooters on the environment depends largely on the modal shift effects, e-scooter lifetime, servicing of e-scooters and the 'electricity carbon intensity'. Improving these parameters can lead to a positive effect of e-scooters on the environment (Bortoli & Christoforou, 2020; Hollingsworth et al., 2019).

Regarding the effect of e-scooters on traffic safety, there are three reports on e-scooter related injuries (PBT, 2018; Mayhew & Bergin, 2019; Blomberg et al., 2019). In all cases, hospital data is compared with the situation before and after introducing e-scooters. All studies found an increase in e-scooter related injuries after the introduction of a shared e-scooter system. However, in none of these studies is analysed if injuries related to other modes of transport decreased/increased in the study period. In other words, there is no evidence of an increase or decrease in the total transportation-related injuries. In non-injury data-based studies, e-scooters are expected to have a similar risk profile as the bicycle (Bierbag et al., 2018; TNO, 2020;) Depending on modal shift effects, e-scooters have a negative influence on public health since no physicial effort is required to go around (Milakis et al., 2020).

Moreover, e-scooters can have a large effect on the liveability of urban areas. Conflicts over space and cluttering are among the most addressed issues post-introduction of e-scooters (Gössling, 2020). E-scooters add extra pressure to bicycle infrastructure and are often parked on footpaths; however their small size is positive (Gössling, 2020; CROW, 2020; Fang et al., 2018; James et al., 2019; Zagorskas & Burinskiené, 2019).

Finally, e-scooters have the potential to increase the accessibility of places; however differences occur between areas depending on local situation (Smith & Schwieterman, 2018; PBT, 2018). Potential lies in the connection of e-scooters to public transportation networks (Milakis et al., 2020; Jelbi, 2020) and also for short-distance trips (Milakis et al., 2020; Van Dam et al., 2020).

II. Gap

To the best of the authors knowledge, there are currently no scientific papers that focus the expected impact on travel behaviour and society by e-scooters when introduced in the Netherlands. Insight into the impact of e-scooters is required to make reasoned considerations about regulations.

This research aims to reduce this gap with an explorative study into the -expected- effects of e-scooters in the Netherlands. Besides, insights into possible policy strategies and instruments that can be used in relation to e-scooters is provided. The following research question is addressed in this study:

What relevant effects can be expected when e-scooters are (legally) introduced in the Netherlands, and what are the potential policy implications of these effects?

The intention of this study is not to provide conclusive evidence on the impact of e-scooters. The purpose is to provide the academic world and policymakers with a better understanding. Although the research focusses on the situation in The Netherlands, it is also useful for other cities and countries that consider the introduction of e-scooters.

III. Methodology

A. Defining the system: Conceptual diagram mapping

To answer this research question, a conceptual diagram (referred to as: the system diagram) is made of the introduction of e-scooters and the impact in the Netherlands. This method was chosen because it can provide insights into the complex relations between the introduction of e-scooters, behavioural changes and resulting societal effects and communicate these insights across disciplines (Heemskerk, Wilson, & Pavao-Zuckerman, 2003) The system diagram is made in the following way **i)** A literature study on factors and relationships of the urban transportation system and travel behaviour is performed, which led to a list of factors and relationships. **ii)** To reduce the complexity of the system diagram, the factors have been demarcated by the author using the project scope (explorative, broad research) and the goal of the diagram (communication between disciplines) as a criterium. This led to the creation of the system diagram on an aggregated level. **iii)** Validation of the system diagram by eleven mobility experts **iv)** Supplementing the system diagram with effect estimations based on e-scooter literature and expert interviews **v)** supplementing the system diagram with policy implications based on expert interviews and a focus group session.

B. Effect estimations: Mobility expert interviews

The effect estimations in the diagram are gathered through mobility expert interviews and compared to known effects abroad from literature. Interviews are used because of the limited data available on e-scooters and the research's broad and explorative nature. Experts from various institutes have been interviewed, including academia, policymakers, consultants and other researchers, all with expertise in (urban) mobility. The interviews are held in a semi-structured manner; for each block and arrow in the System Diagram, they are asked about their opinion on the most important underlying factors and expected effects,

C. Policy implications: Policymaker interviews and focus group session

The policy implications are gathered through expert interviews with policymakers, a focus group session and literature on e-scooter policy abroad. Three mobility policymakers of the municipalities of Utrecht, Amsterdam and Eindhoven, are interviewed. The focus group session was held with seven of the eleven interviewed mobility experts. A focus group was chosen because in a focus group there is room for discussion and interaction (Morgan, 1996). The author expected that there would not be one right or wrong option, and therefore a discussion could provide interesting insights. During the focus group session, discussion points were addressed, focusing on promoting a single social effect with e-scooters.

D. Data analysis and interpreting: Qualitative content analysis

The data retrieved in the interviews and focus group session is analysed using the principles of the qualitative content analysis (Elo & Kyngäs, 2008). Statements made by the expert are coded in keywords. Next, the codes of all the interviews are grouped; similar keywords are grouped into the same categories based on the interpretation by the author (see Figure A- 1).

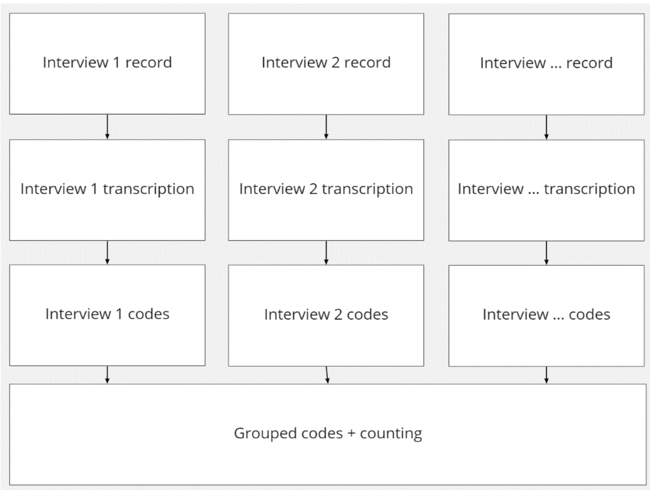


Figure A- 1: Content analysis

The data is presented based on two principles: **i)** based on frequency **ii)** Based on interpretation by the author of *other* meaningful results. These 'meaningful outcomes' have also been mentioned because this study is an exploratory study on a new topic. Therefore, it is possible that something mentioned by only a single expert is also of great value (Dorussen, Lenz, & Blavoukos, 2005).

E. Formulating conclusions: Information synergy

The conclusions are formulated and a judgment is made about the reliability of the estimate by comparing the expert interviews and focus group results to the existing base of knowledge from literature and congresses. The labels of reliability are added not to nullify the results of the research, but to emphasize that it is about expectations. Similar that a sensitivity analysis would be performed in a quantitative model study.

i) If the expectations of the mobility experts align with the existing base of knowledge, the conclusion is made that there is a sufficient basis for the expected effect. **ii)** If the sources are similar but not entirely, or a factor has been mentioned by a majority of experts but not yet studied in the literature, the conclusion is made that there is a reasonable basis for the expectation, but more research would provide a stronger basis. **iii)** If the information sources do not agree, conclusions are made that there is there is not yet a sufficiently founded basis for this expectation and the factor or effect must be further investigated to make substantiated estimations.

IV. Results

A. System diagram

The first aggerated system diagram is shown in Figure A- 3 on the last page of this paper. The diagram conceptually represents the impact on travel behaviour and society of e-scooters. The System Diagram analyses the system, with the introduction of e-scooters as a starting point (arrow 0). The literature and theory follow that; due to a changing transport supply (arrow 1), travel resistances, needs, and desires change. From this follow effects on the travel behaviour choices for the destination, mode, frequency, departure time and route (arrows 2a-2e) which leads to traffic volumes and from there resulting societal effects; on the environment (arrow 3a), public health (arrow 3b), traffic safety (arrow 3c) liveability (arrow 3d+4B and 3e), and accessibility (arrow 5 and 4e) and inclusivity (arrow 6). There are also feedback loops in the system (arrow F1-F4).

B. Expert interviews

Figure A- 2 shows the newly named factors in each interview. Based on this chart is concluded that the principle of saturation is achieved (Saunders et al., 2018).

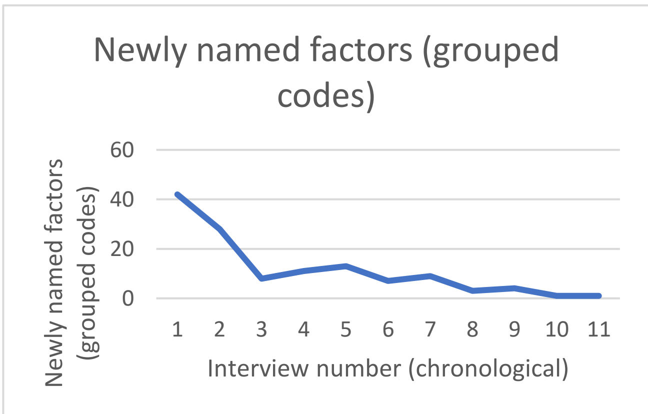


Figure A- 2: Newly named factors

The results of the expert interviews are added to the system diagram, shown in Figure A- 4 on the last page of this paper.

The majority of the experts believe that shared e-scooters will have a higher usage potential than private e-scooters. E-scooters are to be expected to be used in multimodal trips more than in unimodal trips. The largest shift is expected from active modes and bus, tram and metro. There are different expectations among the experts about the degree (or presence of) the modal shift from the car, the potential for the use of e-scooters for commuting trips and the share of private e-scooter users.

Consequently, there are differing expectations of the effect of e-scooters on the environment and public health, ranging from negative to slightly positive in time. Regarding the effect of e-scooters on traffic safety, there were two prevailing views i) e-scooters are not a risk to traffic safety because of the Dutch cycling culture ii) e-scooters are harmful to traffic safety because the Dutch bicycle paths are already busy. For the effect of e-scooters on liveability, the experts assent that this depends mostly on the rules regarding the use of public space, such as parking areas. Lastly, the experts agreed that the positive accessibility effects of e-scooters are most relevant for the small group of non-cyclist and at improving public transportation networks.

C. Focus group

From the effect estimations, it is found that there are uncertainties in the effect estimates with possible negative outcomes, where regulation is (possibly) required. Therefore insights into policy are required. The policy instruments and strategies identified in the interviews and focus group session are shown in Table A- 1 on the last page of this paper. There are options to set requirements in the tender for shared providers, set requirements for users, organise e-scooter infrastructure, and set driving rules. The policy options are classified according to the societal effect to which they contribute. Some policy options contribute to multiple societal effects, and some contribute to one societal effect while being negative for another.

V. Conclusions

This research shows that the e-scooter situation is complex with different relevant factors, relationships and effects. If allowed and minimally regulated (both shared and private), e-scooters can have a significant and possibly negative impact on society. The conclusions are added to the final system diagram, as shown in Figure A- 5, on the last page of this paper. The routes are explained here:

E-scooters are not expected to substantially change travel patterns regarding destination, frequency, route and departure time choices, but an increase in trip frequency could occur. E-scooters will mostly replace trips previously made by foot, bicycle or public transportation. Only a minimal shift from the car is expected.

As a consequence, e-scooters are expected to have a negative impact on the environment and public health.

There are two prevailing views about the impact of e-scooters on traffic safety: e-scooters are not a risk to traffic safety because of the Dutch cycling culture ii) e-scooters are harmful to traffic safety because the Dutch bicycle paths are already busy. The effect of e-scooters on the liveability of public space can be large and negative. At last, e-scooters have the potential to increase accessibility, but only for a small group of people (non-cyclists) and the public transportation network.

There are policy options to improve the impact of e-scooters; connecting e-scooters to public transportation points and park and rides (to achieve a shift from the car), setting environmental requirements regarding recharging and vehicles in tenders or the admission framework, setting requirements for users (age, helmet use or driving licenses), vehicles (safety standards in the admission framework) or the infrastructure (only allow on bicycle paths and or separate traffic flows, setting parking rules, setting service requirements for certain areas and make pricing requirements.

Generally, policies should be adaptive to account for uncertainties in the effects. If well-regulated, this research shows that e-scooters have the potential to contribute positively to the environment, the impact on the liveability of public space can be moderate, and e-scooters can contribute to the accessibility of a large group of people and areas, including transportation impoverished places.

VI. Discussion & recommendations

A. Generalizability of research results

There are other micro-mobility vehicles with similar characteristics as e-scooters regarding size, weight, propulsion technique and operating speed. The author believes that if these vehicles have the same supply and demand as e-scooters, the results are also applicable to these kinds of vehicles. The same holds for other locations; this research focusses on the Dutch context. However, the effect estimations can also apply to other countries/cities where e-scooters are not introduced yet, depending on the local context. Important contextual variables to consider while transferring this research outputs to other locations are; the modal split situation, the available e-scooter infrastructure (quality and quantity), the electricity carbon intensity and the density of public space. If these factors are comparable to those of the urban environment of the Netherlands, the results are better applicable than if these factors differ significantly.

B. Limitations of the research

The results of this research have been acquired with a qualitative methodology mix. The results provide valuable insights, but with the interpretation of the results, one should take into account that they are expectations. The results are, in line with the exploratory nature, indications and are thus, not conclusive truths.

Although attempts have been made to minimise these in advance, there may be biases in the research and, therefore, the results. The interviews and the focus group session were held with a limited number of experts (eleven and seven respectively); therefore the statements and opinions of one person have had a relatively large influence on the research results. To minimise this bias, experts have been selected from a range of institutions, and also meaningful, less mentioned results have been reported.

In the author's moderating role during the interviews and the focus group, bias could occurred as well. The author has tried to minimise this by following semi-structured interviews with the system diagram as guide line and in the focus group a discussion guide was made and followed. However, arranging an external moderator would have been better to minimise the author's role in the results.

Lastly, the results of the content analysis are processed on the basis of frequency, but also less frequent factors are presented if considered as `interesting results` by the author. The author's bias may have influenced the presentation of these results, and a different author could have selected different results. To minimise this bias, external expert(s) could have been used to (help) identify these `interesting results`.

C. Recommendations for research

To gain more detailed (quantitative) effect estimations, modelling studies can be performed. A stated preference study can be used to gain more detailed insights into the usage potential and modal shift effects of e-scooters. The utilities that emerge from this stated preference study could subsequently be applied in utility-based transportation models. In this way, more detailed (quantitative) estimates can be made of the effects of e-scooters.

If the admission framework is completed and e-scooters are allowed on the Dutch road, there is also a possibility to collect empirical data. Pilots can be started to investigate the effects on the travel behaviour of e-scooter users. Pilots come in many forms, with both shared e-scooters and private e-scooters. The pilots could be supplemented with travel surveys to gain further insights into e-scooter travel behaviour (changes).

Currently, there is not any literature on the performance and the effectiveness of e-scooter related policy instruments. Insights in these instruments could be retrieved with a qualitative research design in which policymakers and other mobility experts are asked about the policy instruments used and their opinion on their effectiveness. Or a quantitative approach could be used in which data from (shared) e-scooters is used to analyse whether and what influence certain policy instruments have had on travel behaviour and thus society.

D. Recommendations for public entities

On the national level, there are options to add requirements to the admission framework:

- Safety standards for e-scooters, including reflectors, lights and a maximum speed
- Require a license plate
- Designate cycle paths as a place on the road

On the municipal level, since only a niche market for private LEV users is expected, it is advised to focus policy at first on shared e-scooters. Furthermore, it is advised to ensure that policy is adaptive to deal with unexpected effects. Policymakers can set certain requirements in the tender for shared e-scooter providers:

- Service requirements for areas (outside the city centre) and maximum pricing requirements.
- Require shared e-scooter providers to charge e-scooter only with green energy and service them with green vehicles
- Require providers to apply smart scaling and ensure broken vehicles are removed from the streets.
- Require the use of geofencing to prevent usage and parking of e-scooters in restricted areas

And policymakers can organize the transportation system in the municipality by:

- Creating hubs or assign other designated parking spaces
- Connecting the different transportation options to each other by means of e-scooter hubs at public transportation stations and park and ride locations
- Investigate if certain bus tram or metro stops can be skipped to make them faster if these transportation modes are well connected to other modes like e-scooters.
- Ensure also business districts, universities and suburbs are connected to e-scooters (and other transportation alternatives) to stimulate people not to commute by car and thereby improve the environment.

If the impact of e-scooters on society is not desirable, the choice can be made not to allow shared e-scooters. Nevertheless, the choice can also be made that in that case, e-scooters may not add something in a positive sense to the social effects that are central to this report (environment, public health, traffic safety, liveability, accessibility and inclusivity), but do contribute positively to choice freedom and pleasure.

VII. References

6t-bureau de recherche. (2019) Usages et Usagers des Trottinettes Electriques en Free-Floating en France. p. 158. Retrieved from: https://6-t.co/etudes/usages-usagers-trottinettes-ff /

Bierbag, M. Adolph, T. Frey, A. Kollmus, B. (2018) Untersuching zu Elktrokleinstfahrzeugen. Retrieved from: https://www.bast.de/BASt_2017/DE/Publikationen/Berichte/unterreihe-f/2019-2018/f125.html

Blomberg, S. N. F., Rosenkrantz, O. C. M., Lippert, F., & Christensen, H. C. (2019). Injury from electric scooters in Copenhagen: a retrospective cohort study. BMJ open, 9(12), e033988.

Christoforou, Z., Gioldasis, C., de Bortoli and Christoforou, A., & Seidowsky, R. (2021). Who is using e-scooters and how? Evidence from Paris. Transportation Research Part D: Transport and Environment, 92, 102708

Civity Management Consultant CMC (2019) E-Scooter in Deutschland - Ein datenbasierter Debattenbeitrag Civity Management Consultants. Retrieved from: http://scooters.civity.de

CROW (2020) Position Paper Micromobiliteit. Retrieved from: https://www.crow.nl/getmedia/bafe620c-2e61-4653-a46c-7f1a8603f31d/K-D077-Position-paper-Micromobiliteit.pdf.aspx?ext=.pdf

de Bortoli and Christoforou, A., & Christoforou, Z. (2020). Consequential LCA for territorial and multimodal transportation policies: method and application to the free-floating e-scooter disruption in Paris. Journal of Cleaner Production, 273, 122898.

Dorussen, H., Lenz, H., & Blavoukos, S. (2005). Assessing the reliability and validity of expert interviews. European Union Politics, 6(3), 315-337.

Eccarius, T., & Lu, C. C. (2018). Exploring consumer reasoning in usage intention for electric scooter sharing. Transp. Plan. J. 運輸計劃季刊, 47(4), 271-295.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. Journal of advanced nursing, 62(1), 107-115.

Ewert, A., Brost, M., & Schmid, S. (2019, May). Fostering small electric vehicles on a municipal level. In Proceedings of the 32nd Electric Vehicle Symposium (EVS32), Lyon, France (pp. 19-22).

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.

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.

Heemskerk, M., Wilson, K., & Pavao-Zuckerman, M. (2003). Conceptual models as tools for communication across disciplines. Conservation Ecology, 7(3).

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), 084031.

Hunternilson, M. (2020) VoI congress. *Conference notes*.

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.

Jelbi (2020) VoI congress. *Conference notes*

Laa, B., & Leth, U. (2020). Survey of E-scooter users in Vienna: Who they are and how they ride. Journal of transport geography, 89, 102874.

Lime (n.d.) Homepage website lime. Retrieved from: https://www.li.me/en-us/home

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.

Milakis, D., Gebhardt, L., Ehebrecht, D., & Lenz, B. (2020). Is micro-mobility sustainable? An overview of implications for accessibility, air pollution, safety, physical activity and subjective wellbeing. Handbook of Sustainable Transport.

Morgan, D. L. (1996). Focus groups as qualitative research (Vol. 16). Sage publications.

Oeschger, G., Carroll, P., & Caulfield, B. (2020). Micromobility and public transport integration: The current state of knowledge. Transportation Research Part D: Transport and Environment, 89, 102628.

Portland Bureau of Transportation (2018) E-scooter findings report. Retrieved from: https://www.portland.gov/sites/default/files/2020-04/pbot_e-scooter_01152019.pdf

Reck, D. J., Guidon, S., Haitao, H., & Axhausen, K. W. (2020). Explaining shared micromobility usage, competition and mode choice by modelling empirical data from Zurich, Switzerland. Transportation Research Part C: Emerging Technologies.

Smith, C. S., & Schwieterman, J. P. (2018). E-scooter scenarios: evaluating the potential mobility benefits of shared dockless scooters in Chicago.

Tuncer, S., & Brown, B. (2020, April). E-scooters on the Ground: Lessons for Redesigning Urban Micro-Mobility. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-14).

TØI (2020) Shared e-scooters in Oslo -summary. TØI report 1748/2020. Retrieved from: https://www.toi.no/getfile.php/1352251-1580474379/Publikasjoner/T%C3%98I%20rapporter/2020/1748-2020/1748-2020-sum.pdf

Van Dam, T. (2020) CROW Congress, breakout room inclusivity

Hulshof, R. (2021) phone call.

Voi (n.d.) Voi Website Home Page. Retrieved from: https://www.voiscooters.com/

Zagorskas, J., & Burinskienė, M. (2020). Challenges Caused by Increased Use of E-Powered Personal Mobility Vehicles in European Cities. Sustainability, 12(1), 273.

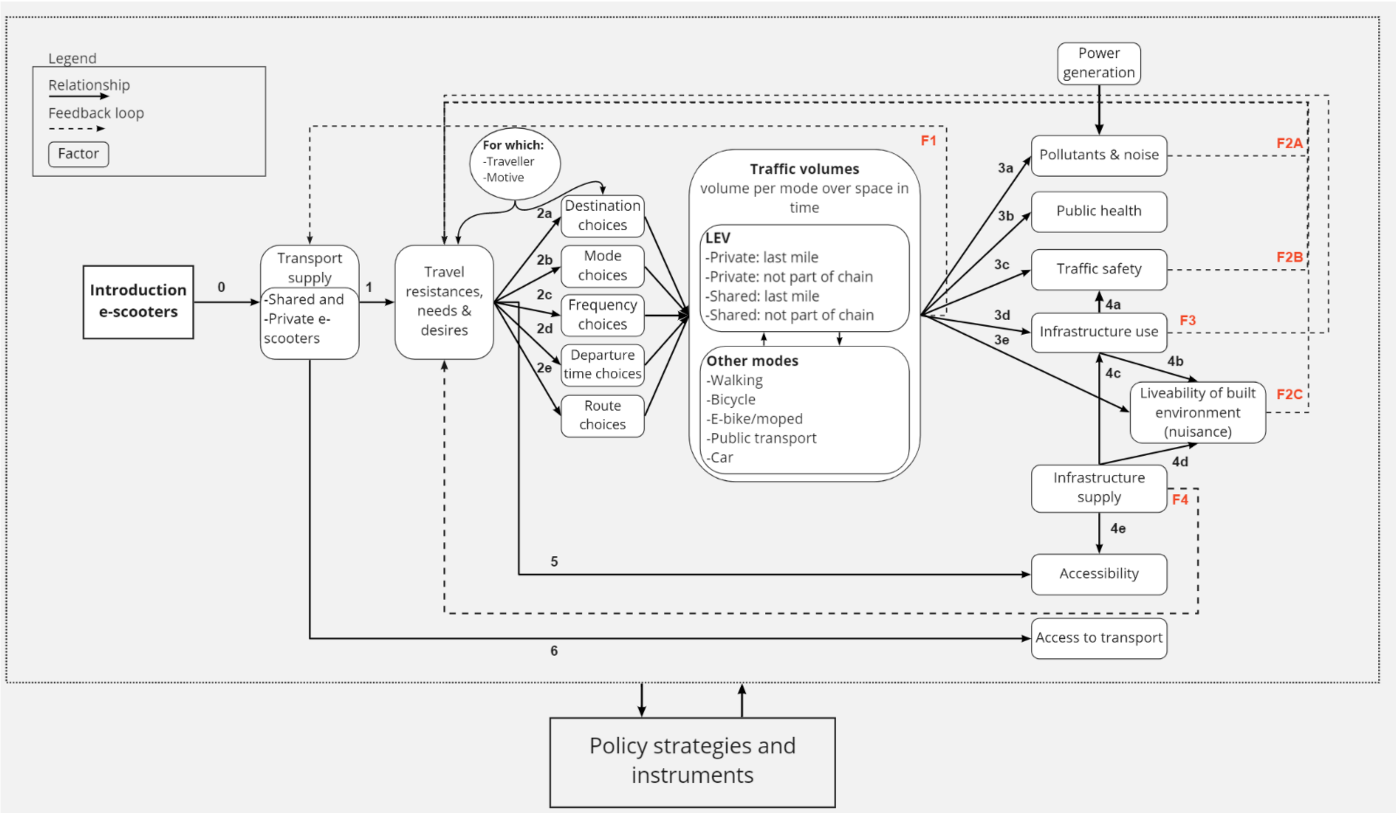


Figure A- 3: System diagram on an aggregated level

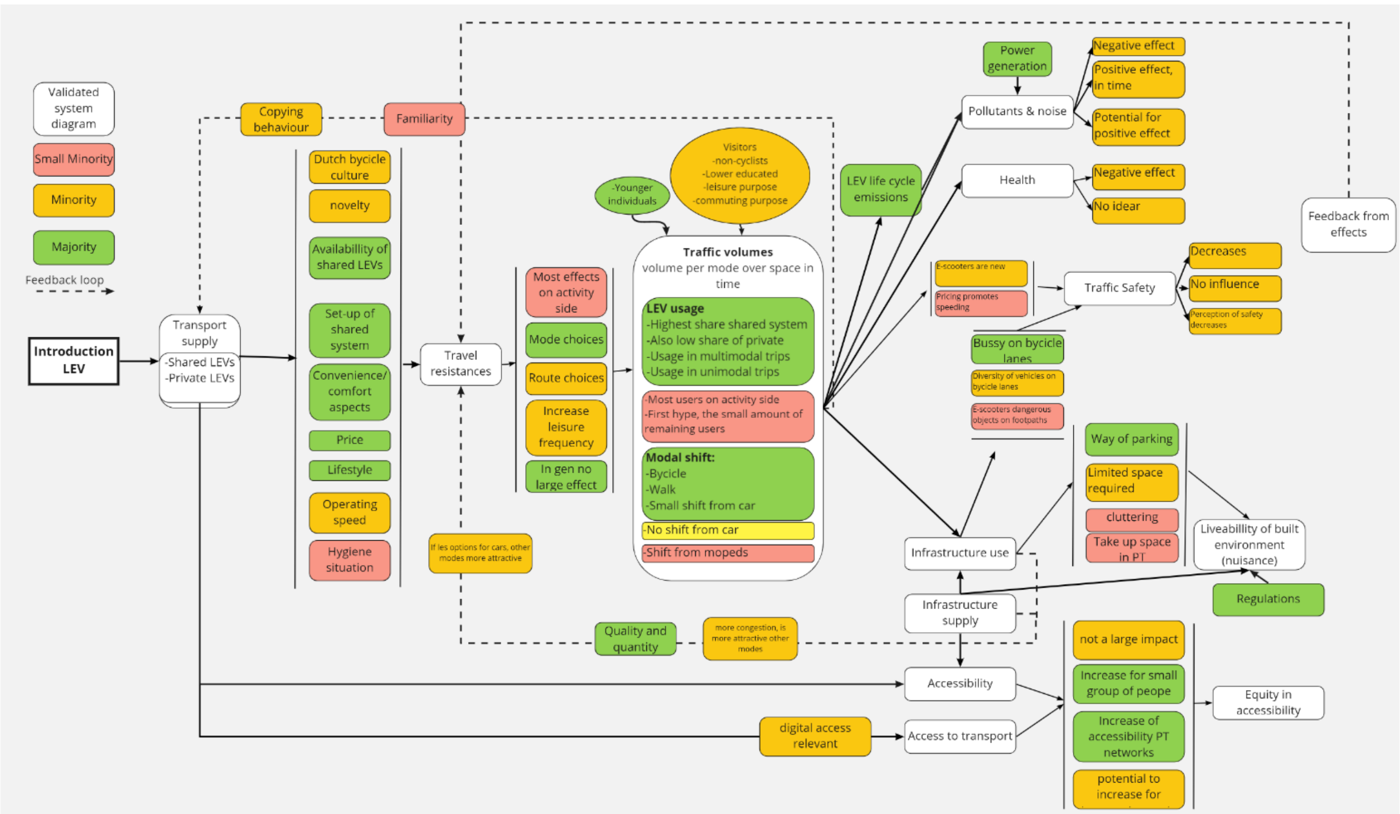


Figure A- 4: Results of the mobility expert interviews

Type	Strategy or instrument	Contributing to societal effects
Setting requirements in the tender for shared e-scooter suppliers (local) or the admission framework (nationally)	Requirements for recharging (with green energy)	Environment
	Requirements for the production process of e-scooters	Environment
	Requirements for safety design of e-scooters: reflectors, lights, maximum speed, license plate	Traffic safety
	Requirements for the production process of e-scooters	Environment
	Requirements for the number of vehicles using smart scaling	Liveability
	Service requirements for certain areas	Accessibility and inclusivity
	Requirements for the maximum cost of use	Accessibility and inclusivity
Organise the transportation system	Connect e-scooters to public transportation and the car by means of hubs	Environment, accessibility
	Place enough charging points and make sure charging points can be used by all electric modalities	Environment, liveability
	Allow parking everywhere or ensure enough parking places	Accessibility
	Use geofencing to avoid dumping, driving in restricted areas and parking in restricted areas	Environment, liveability, traffic safety
Set requirements for e-scooter users	Minimum age, (car) driving license, helmet use	Safety
Driving rules (local or national)	Only allow usage on bicycle infrastructure	Traffic Safety
	Don’t allow riding next to each other	Traffic safety
Other	Organise an information campaign	Liveability, traffic safety, public health
	Skip certain bus tram or metro stops to make them faster and connect e-scooters to serve the skipped stops	Accessibility
	Don’t allow shared e-scooters if only a shift from active modes is achieved	Environment, public health

Table A- 1: Results of the policymaker interviews and focus group

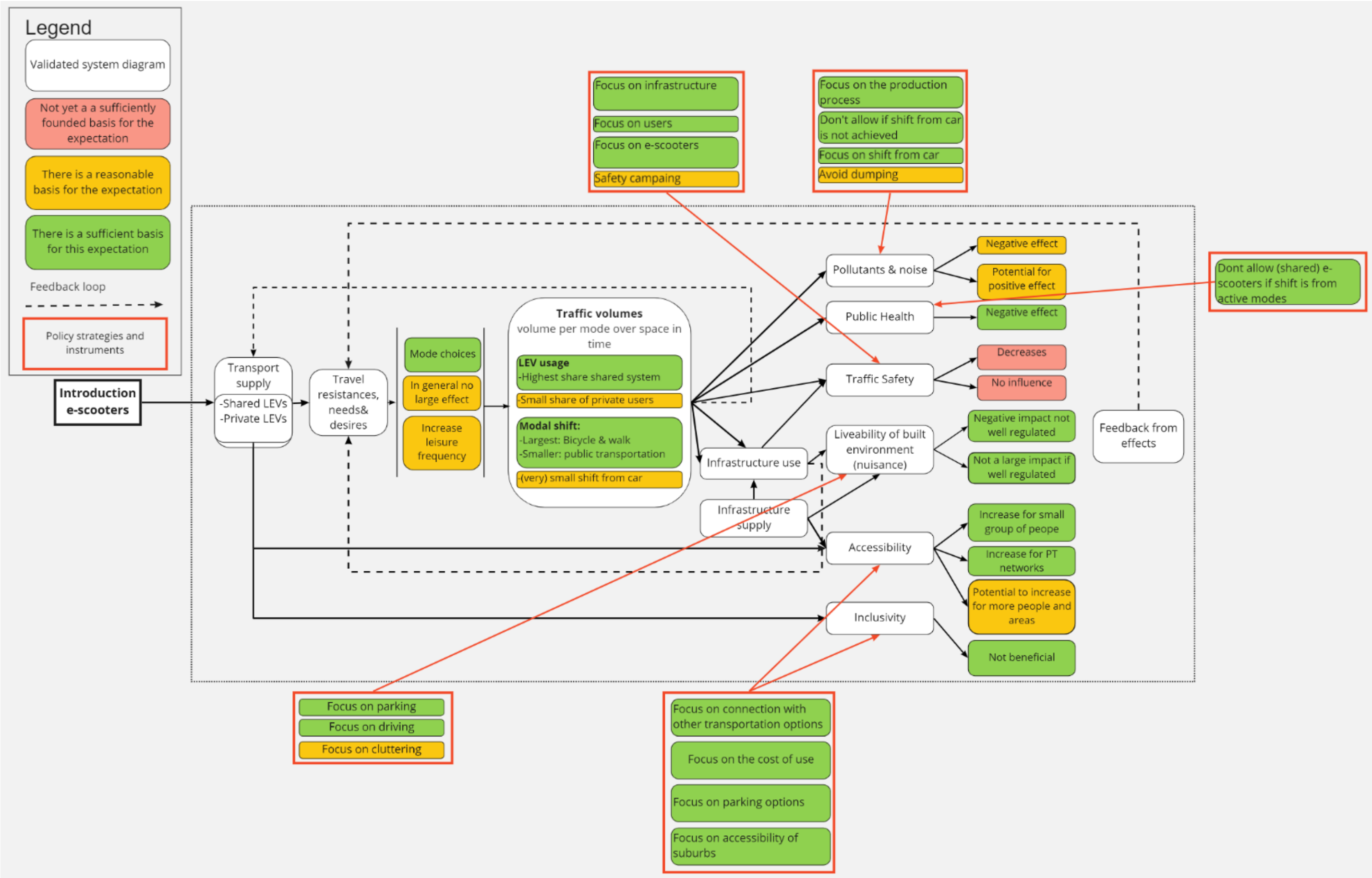


Figure A- 5: Conclusive system diagram with the most important effects and policy implications (strategies) of e-scooters

Appendix 2. Experts expertise

This appendix elaborates on the professional function (Table 2-1) and expertise (Table 2-2, next page) per interviewed expert.

Category	Expert number	Organisation	Function	Work experience
Academia	(1)	TU Delft	Assistant professor Public Transportation	Co-director smart public transportation lab, researcher at HTM and MIT. Consultant at Goudappel Coffeng
	(2)	TU Delft	Doctoral candidate	PhD researcher
	(3)	Eurovia & Ecole Des Ponts ParisTech	Research scientist	Postdoctoral associate, research into environmental impact of e-scooters
Policymakers	(4)	Ministery of Infrastructure and Watermangement	Senior Executive Intelligent Transport Systems	Broad experience in intelligence in traffic & transport projects
	(5)	Ministery of Infrastructure and Watermangement	Senior policy advisor smart mobility	Consultancy, advisor at KNMI, public-private partnerships, mobility
Consultancies	(6)	Studio Bereikbaar	Consultant	Work experience in the transition to green mobility and accessibility in urban environment
	(7)	AT Osborne	Management consultant & projectmanager	Experience in urban development, smart and green mobility, MaaS and infrastructure projects
	(8)	AT Osborne	Consultant smart mobility	Experience in diverse mobility related projects; automated vehicles, smart mobility
	(9)	AT Osborne	Consultant mobility	Experience in mobility projects related to smart mobility and green mobility.
Others	(10)	Dutch Cycling Embassy	Managing director	Senior researcher at PBL, UVA and KiM. PhD on mobility in the Netherlands
	(11)	TNO	Senior consultant traffic & transportation	Experience in business analyses and traffic and transport projects

Table 2-1: Function and work experience per expert

Name	Travel Behaviour	Societal effects	Transport policy	(Shared) Urban mobility	Micro - Mobility
(1)	X	X	X	X	
(2)				X	X
(3)	X	X			X
(4)			X		
(5)	X		X		
(6)	X			X	X
(7)			X	X	
(8)			X	X	
(9)				X	X
(10)	X		X	X	
(11)				X	X

Table 2-2: Expertise per expert

Appendix 3. Literature into travel behaviour and factors and relationships of the urban transportation system

This appendix includes the literature study that has led to the various factors and relationships from the urban transport system and travel behaviour. The demarcation of these factors and relationships has led to the system diagram as presented in Chapter 4.

Theoretical background of travel behaviour

This paragraph elaborates on the theory behind the development of transport volumes. This theory acts as the basis for the system diagram. To estimate the impact of LEV in the Netherlands, a multidisciplinary perspective is applied, In travel behaviour studies, most of the time, findings from four 'classical schools' (Hägerstrand, 1970; Chapin, 1974; Cullen, 1978; Giddens, 1984) are combined with insights from other disciplines like geographics, psychology and economics (Harms, 2008). Van Wee (2013) agrees on this multidisciplinary approach, he states (pp. 46) "each discipline (psychology, economics and geography) explains only a part of the reality of behavioural choices. Only the combination of these disciplinary perspectives can lead to a more comprehensive understanding of travel behaviour."

Present time, most transport related studies use the utility based framework (coming from the economics discipline) to explain travel behaviour. But findings from the other disciplines, like habits and abilities, are added to the framework. This framework assumes that:1) individuals have desires and needs, 2) to fulfil those desires and needs individuals need to participate in out-of-home activities (In some cases the travel can also be the activity itself (Mokhtarian & Salomon, 2001)) 3) individuals maximize their utility of activities within their abilities 4) individuals minimize the dis-utility as a result of the generalised costs of transport resistances (Buehler, 2011; Van Wee, 2013; Van Acker et al., 2010).

Needs, desires and locations of activities

Individuals have needs and desires, and some of those needs and desires need to be fulfilled at different locations. The needs and desires individuals have, differ per person, but at the same time individuals can be split up in groups with similar needs and desires. This division is often made based on socio-demographic factors. The locations of activities and needs and desires influence each other; an individual can change his/hers desires based on the nearby activities. At the same time based on the needs and desires of a group of individuals, locations of activities can open or close.
The locations of activities are not specifically incorporated in the system diagram because it is the authors hypothesis that that this is not a primarily relevant factor in the scheme.

Transport resistances

Making a trip comes at a cost, this is called the transport resistance. Transport resistance is often expressed as generalised cost, existing of time, money, and 'effort' (van Wee, 2013). Individuals experience a disutility of the transport resistance, that is weighed against the utility of the activity at the location. This is while assuming rational behaviour, in reality travel behaviour is not purely rational (see section X). However, transport resistance is still an important determinant in explaining travel behaviour. Transport resistance consists of the following factors:

- **Monetary costs:** These consist of a fixed and variable part. The fixed costs are independent of the kilometres travelled, like depreciation and the initial investment to buy a vehicle. Variable is dependent on kilometres travelled like energy costs.

- **Time:** The travel time from origin to destination consists of different components, depending on mode of transport. For example: waiting time, in-vehicle time, storage/parking time etc. The duration of the different parts of the total trip are valuated differently. Therefore it is not correct to simply add up al the different components for the total travel time (Van Wee, 2013). For example, Albrantes and

Wardman (2011) found that perceive travel time in a car while in congestion 34% slower then while in free flow. The perception of travel time can be expressed with the 'Value of Time', this is a measure (often in valuta/hour) for the amount individuals are willing to pay to safe on hour of travel time. This value of time is not a constant factor. It differs, as stated, between different components of the trip but also between groups of people.

- **Effort:** Effort is een verzamelnaam voor een groep factoren. Most factors of effort are difficult to measure, and are dependent on individual appreciation. Effort consists of several elements, some of them follow below(Van Wee, 2013; Elliott & Thomson, 2010):
- **(Dis)Comfort:** The comfort of a trip consists of comfort and physical needs required. The appreciation of this attribute can work in multiple ways. For example, being active while riding a bicycle can be perceived positively (because it contributes to a healthy lifestyle) or negatively (because someone gets tired) (Plazier et al., 2017).
- **Reliability:** concerns the reliability of the travel time of a trip.
- **Accident risk:** relates to the risk of getting involved in an accident by using a certain mode or route.
- **Perception of personal security:** Is about the feeling of uneasiness due to vulnerability in traffic, but also for example while waiting for public transport (Van Wee, 2013; Rietveld & Daniel, 2004).

Travel behaviour can be seen as the result of certain travel related choices to make certain trips. Individual choices are made about travel destinations, the vehicle used, the departure time, travel routes and trip frequencies. The result of all the individual decisions is a volume of traffic per mode in a division over time and space (Van Wee, 2013).

Which factors influence travel behaviour

Figure 5-2 shows different factors that influence travel behaviour. The list is not exhaustive, and many other lists could be created. This figure is based on the the 'PASTA' framework by Götschi et al. (2017). Götschi reviewed 65 publications studying factors influencing travel behaviour. They identified differences and similarities, and synthesized all these studies into a 'comprehensive' framework for active travel modes. Götshi et al.(2017) identifies three main categories of factors that influence the travel choices: Factors within the 1) social context, 2) the physical context (built and natural environment) and 3) the individual context. E-

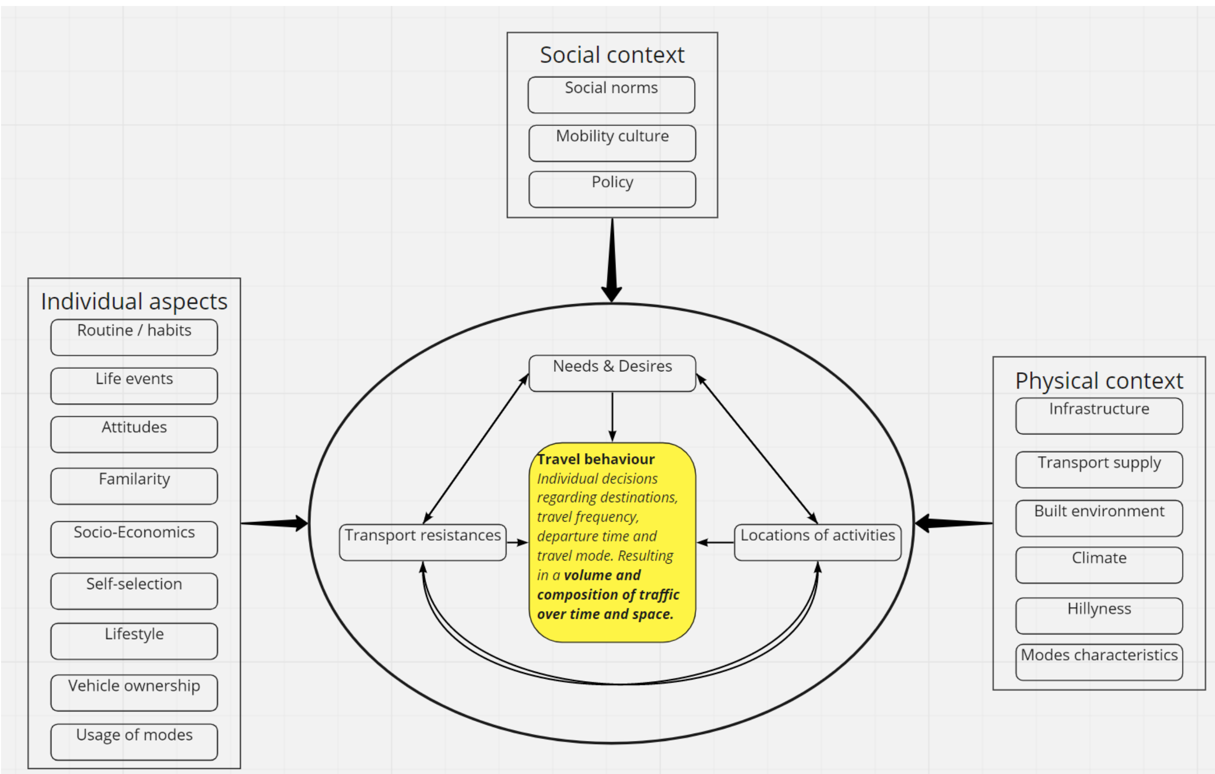


Figure 3-1: Factors influencing travel behaviour, based on the framework by (Götschi et al., 2017)

scooters have similarities with active travel modes but also differences, therefore Götschi's framework is adjusted into Figure 3-1.

1) Social context

The social context is the context of the choice process of an individual that is not tangible. Different factors are identified in literature that belong in this social context.

Mobility cultures.

'Mobility cultures' are defined as: "specific socio-cultural settings consisting of travel patterns, the built environment, and mobility-related discourses – i.e. they are defined by both the material and the socially-constructed dimensions of the transport system (Haustein & Nielsen, 2016) The concept of mobility cultures is used to understand the differences in mobility behaviour between different locations. It is an umbrella term that describes the different aspects of the social context influencing travel behaviour. For example; The car dependency in the U.S. can be explained by American settlement structures that provide less opportunities for other modes of transport, but also specific historically embedded values and beliefs in relation to the private car which are seen as key ellements of American culture (Haustein & Nielsen, 2016, p. 174). Similarly, cycling in the Netherlands is not only popular due to good cycling infrastructure and policy measures, but cycling is also part of Dutch culture (Pucher & Buehler, 2008).

Social norms

Social norms are the informal understandings that govern the behaviour of members of a society. Social norms can be seen as part of the mobility culture, but is often mentioned specifically in literature. Heinen and Hany (2012) investigated the effect of social norms on bicycle commuting. They compared travel behaviour in the cities of Davis (U.S) and Delft (NL), both 'bicycle friendly' cities. They found that, while controlling for different socio-demographics, citizens of Delft are more likely to choose the bicycle as the mode of transport for their commute. They explain this by stating that, among other things, social norms in Davis are more negative towards cycling. Also Müggenberg et al. (2015) found that the social norms influence travel behaviour. They developed a framework that analyses travel behaviour change, and conclude that socialisation (the process of behaving in a way that is acceptable by one's context in a society) influences life events and long term travel decisions, and thereby the daily travel behaviour. As an example they name the purchase of a vehicle of public transport subscription.

Policy Context:

The policy context of an individual is not tangible, but does experience tangible changes in, for example, the built environment. Müggenberg et al. (2015) found that the policy context influences the adaption of long-term mobility decisions like (as stated in the previous paragraph) vehicle possession or public transport subscriptions. These mobility decisions influence the daily travel choices and therefore the travel behaviour. Public transport is often subsidised and therefore the policy to subsidise lowers the travel resistance of trips made with public transport (Müggenburg et al. 2015)

2) Physical context

The physical context is the environment of an individual. Both the natural environment and the built environment. Different factors of the physical context influence travel behaviour.

Built environment

"The built environment refers in the broadest snse to any physicial alteration of the natural environment, … , through construction by humans "(Lawrence & Low, 1990, p. 454). Ewing and Cervero (2010) provide a meta-analysis on a large number of studies about the link between the built environment and transport behaviour, with the aim to quantify the effects. They name the '5D's of land use' that influence transport (based on Cervero and Kockelman, 1997 and Ewin and Cervero, 2001):

- **Density:** Refers to the variable of interest (for example: living, working or shopping locations) per area.

- **Diversity:** Refers to the variation in activities of an area.
- **Design:** Refers to the infrastructure network in an area. The layout of the infrastructure influences the ease or difficulty to use certain modes.
- **Destination accessibility:** Refers to the ease of accessing locations of activities in an area, see section 4.5
- **Distance to transit:** Refers to the average of the shortest route from activity locations to a public transport location.

They conclude their analysis by stating that travel behaviour behaves in generally inelastic with respect to independent changes in land use, but that combined effects of could be quite large. Literature on the relation between the built environment and transport behaviour often applies built environment measures that more or less fit in one of the 5D's, but also other measures are possible. For example, Winters et al. (2010) used (among others) hilliness (slope of roads) and greenery measures to identify mode choice choices.

Transport supply

The transport supply is the available modes and the capacity of those modes to travel between locations (Rodrigue, 2020) The transport supply influences travel behaviour as well. Naturally, if certain transport modes are not available for an individual it is impossible to choose that mode. For multimodal trips with public transport in the transport chain, an important factor that determines the transport supply is the difference between the home side and activity side of the trip (Givoni and Rietveld, 2007).
Jonkeren et al. (2018) and Nederlandse Spoorwegen [NS] (2013) confirmed this by analysing trip data of respondents in the Netherlands. Their modal split differ with each other with respect to bicycle and car share, but both publications found that the bicycle and car (as a driver) have a higher share on the home side of a trip, and walking and car (as a passenger) have a higher share at the activity side of multimodal public transport trips.

Infrastructure

The transport resistance depends on the quality and quantity of infrastructure of all types (Van Wee, 2013. Pp 8) and therefore influences travel behaviour. [iets meer over uitweiden]

Climate

The weather conditions influence the travel resistances, mainly the factor comfort of a trip (Rietveld & Daniel, 2004; Heinen et al., 2010). This is especially relevant for modes in which one is exposed to the elements, but Arana et al. (2014) found that the weather also influences public transport ridership.

Hillyness

The hilliness of an area can be an important determinant for mode choices as well. This factor is mainly relevant for active modes (Parkin et al., 2008). Heinen et al., (2010) found that the hilliness of an area correlates negatively with the bicycle mode choice.

3) Individual aspects

Next to one's context socially and physically, individual aspects play a role in the formation of travel behaviour. Also here a vast amount of factors can be determined, of which some are listed here.

Socio-demographics

The most common distinction of individual factors to explain travel behaviour is the distinction on socio-demographic factors of individuals. Socio-demographic factors include income, age, education e-scooterel, household characteristics. Based on these variables homogenous groups can be created that have similar travel patterns. For example: on average, people with higher incomes have longer commuting distances or people of a certain age group might have similar needs and desires and therefore similar travel patterns (Van Wee, 2009; Van Wee, 2013).

Habits

A large part of people's travel decisions are made based upon routines and not deliberately made (Müggenberg et al., 2015). Van Wee (2013) agrees on this, they state that in many cases behaviour is habitual. Because humans don't have the cognitive capacity to rationally consider al choices that we face during the day (pp. 34). Habitual behaviour plays an important role if one's context is constant for a amount of time. If a context changes, for example by life events (see next paragraph), habitual behvaviour may not longer function and conscious decision-making is required (Müggenberg et al., 2015, pp. 153).
Bamberg et al. (2003) showed this empirical by providing respondents with an intervention (free public transport) in a new context (moving house), they found that car using habits did not predicted travel behaviour in the new situation. However the study only looked into short term behaviour changes, it would be interesting to see if habitual car users don't fall back into old habits on the long term.

Life events

As already touched upon in the previous paragraph, changes in one's surrounding opens a ' window of opportunity' for behavioural change. If a event has has significant meaning for the individual it will activate an re-evaluation of mobility behaviour, which might result in a behavioural change (Müggenburg et al., 2015). Life events are things like; childbirth, career changes, accidents, new hobbies, divorces.

Attitudes and lifestyle

Attitudes are a way of thinking of feeling about something, for example public transport. Choo and Mokhtarian (2004) linked attitudes , lifestyle and personality factors to the mode choice of Americans. They found that these factors are important to peoples mode choices and therefore their travel behaviour. Similarly, Klinger et al. (2013) found that individual perceptions and evaluations of the local transport system are factors influencing travel behaviour. However, it can also work the other way around, Van Wee et al. (2019) showed (theoretically, based on existing literature) that attitudes can change due to positive travel experiences and changes in the built environment.

Familiarity

Familliarity, having knowledge about something, can be an important factor in travel behaviour as well.
Arendsen (2019) (student thesis, not peer reviewed), showed that the willingness to use certain shared modes as last mile in a multimodal public transport trip is strongly affected by the familiarity of a person with that mode.

Self-Selection

Self-selection is the process of the tendency of people to choose (residential) locations based on their needs, preferences and travel abilities (Mokhtarian & Cao, 2008; Van Wee, 2009). This is best explained by an example: "individuals who prefer to use the train will, on average, live closer to railway stations"(Van Wee, 2009, pp. 281). Taking into account self-selection helps to explain travel behaviour, self-selection is often related to attitudes.

Vehicle ownership

Vehicle ownership directly influences the travel abilities of individuals and households. It influences the transport supply for an individual. Giuliano and Dargay (2006) showed that, while comparing the US and the UK and controlling for a range of variables, car ownership explains daily travel patterns. They conclude that more car ownership results in more travel.

Societal effects

Environment (arrow 3a)

The environment is a broad term, it encompasses all that 'is around us'. In this research, direct transport related elements of the environment are taking into consideration: the emissions of the pollutants noise, NOx gasses and CO2 gas. These are the thee most frequent mentioned indicators of the sustainability of an urban area as mentioned in (Haghshenas & Vaziri, 2012). Indirect aspects of these emissions like the loss of biodiversity (Van Wee, 2013) or the urban sprawl (Ernst, 2011) are not taken into consideration. Impact on (liveabillity of) the built environment are considered separately.

Transport has a large impact on the environment and is therefore a large contributor to environmental related problems. The mobility sector was responsible for 23% of the total CO2 emissions within the Netherlands in 2018 and the trend is not increasing(KiM, 2019b). In addition, the mobility sector was accountable for 68% of the emissions of nitrogen oxides (NOx) in 2018 (KiM, 2019b), see figure 4-2. Lastly about 48% of the Dutch population experiences some form of noise nuisance caused by road traffic (RIVM, 2016)

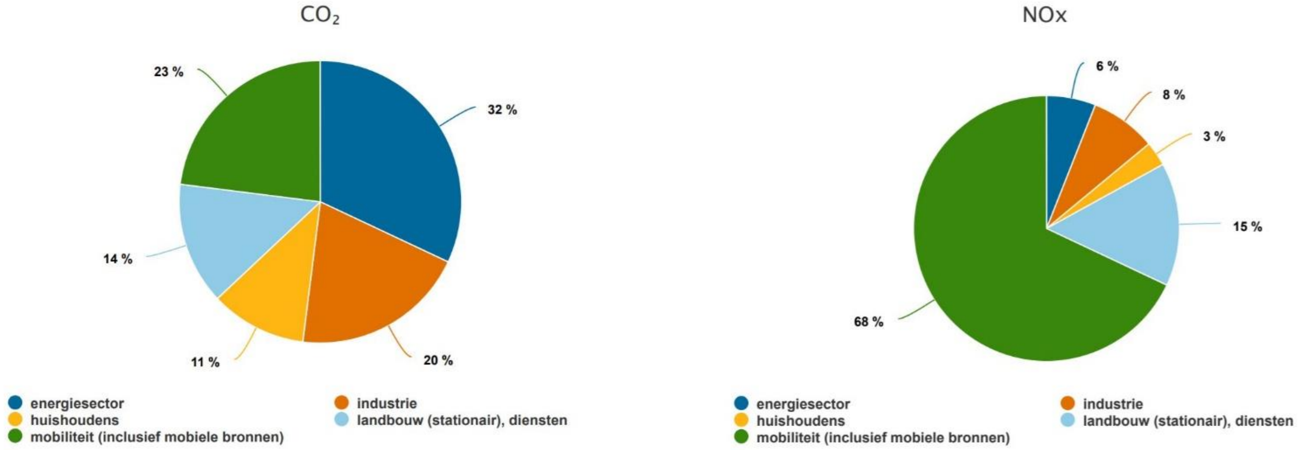


Figure 3-3: mobility sector related emissions (KiM, 2019b)

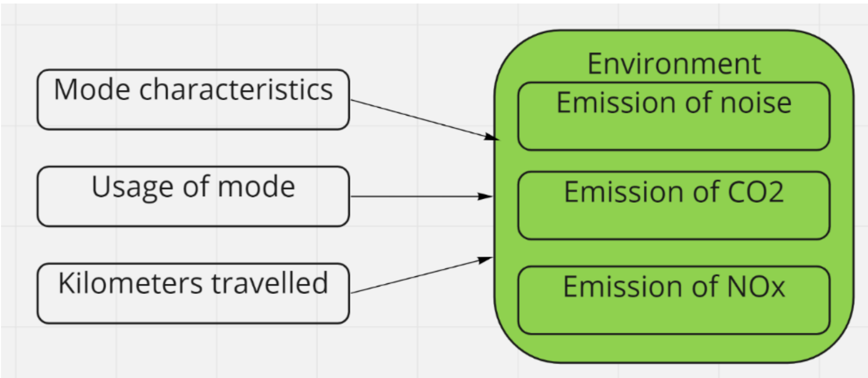


Figure 3-2: determinants of the environment and how its influenced

The emission of the mentioned pollutants are mainly caused by three factors: the kilometres travelled per vehicle, vehicle technology and the usage of vehicles. The last factor relates to the travel speed and acceleration, which influences the emissions of a vehicle (Hong & Goodchild, 2014).
In the system diagram (Figure 4-1) these factors are not specifically taken into account as factors but are assumed incorporated in respectively transport supply and use, to reduce complexity of the scheme.

Traffic safety & Health (arrow 3b + 3c)

The most dominant travel related health effects of transport for an individual are: accidents, exposure to pollutants, physical activity and well-being. Furthermore there are health effects of transport for others, mainly the exposure of pollutants. (Van Wee, 2016). These determinants are influenced by different factors, as shown in figure 4-4.

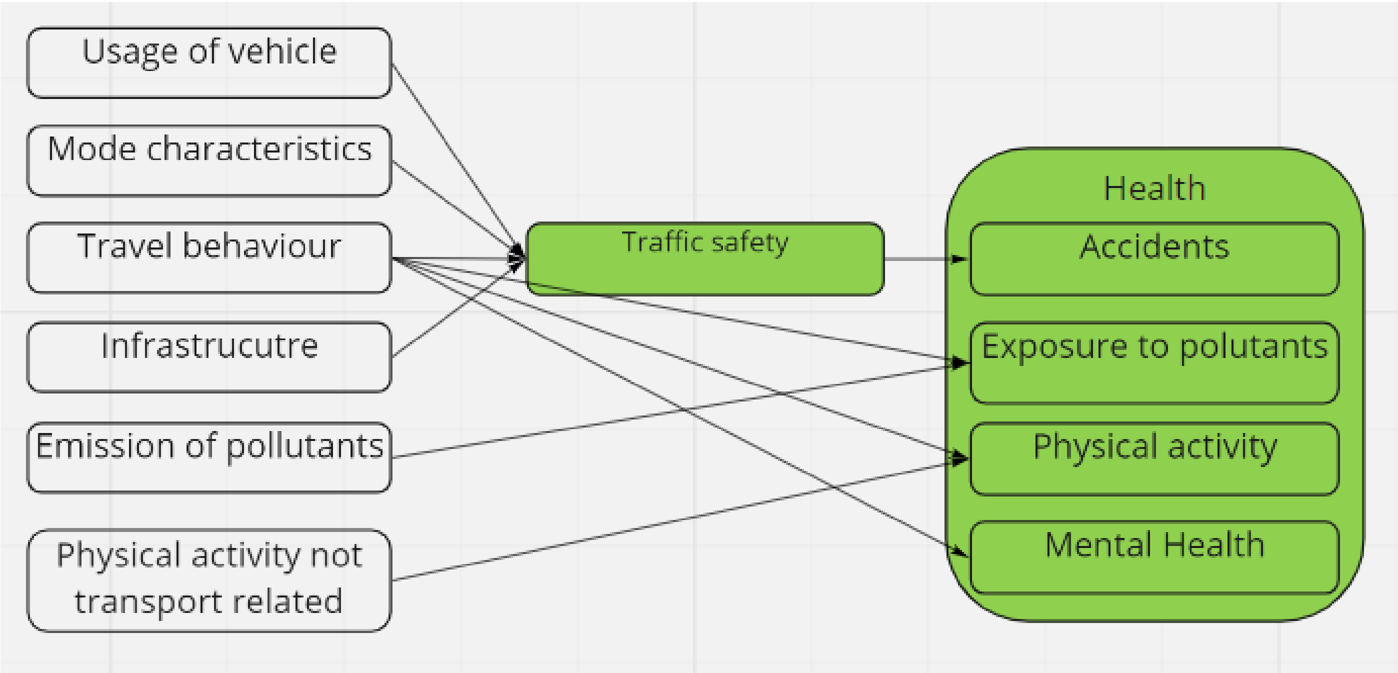


Figure 3-4: determinants of health and how its influenced

Schepers et al. (2014) developed a framework of traffic safety. In their framework the accidents are derivatives of the exposure to risk and the risk itself. The expose to risk is a dependent on the travel behaviour and the risk is related to the 'three pillars of risk': man, vehicle and infrastructure. Their framework is applied in figure 4-4 above.

Travel behaviour, specifically the mode choices walking and cycling and the travel times lead to more physical activity in combination with physical activity not transport related, like exercising (Van Wee, 2016; Mackett, 2011). The exposure to pollutants is not only dependent on the emission of pollutants, but also to the exposure to those pollutants due to travel behaviour: cycling or walking in polluted environments result in more exposure to pollutants as compared to driving a car. But in 'clean environments' this works the other way around (Van Wee, 2016).

Mental health is depending on a lot of factors, Van Wee 2016 argues the most dominant relation related to transport is through travel behaviour. Travel exposes an individual to a physical and social environment. And travel indirectly enables a person to participate in out-of-home activities.

In the system diagram (Figure 4-1), health and traffic safety are taken as sperate factors. Traffic safety is dependent of the infrastructure (arrow 4a) and the composistion of traffic volumes (arrow 3c). The characteristics of the transport modes (in relation to safety) and the usage of the transport modes are incorporated in arrow 3c. Health is dependent of the composition of traffic volumes (arrow 3b), physical activity per mode is not taken as a separate factor. The emission of pollutants is already incorporated in arrow 3a. Mental health is neglected, since it is the authors hypothesis that the importance of this factor is nil in this study

Public land use & liveability

Transport influences land use and land use influences transport, their interaction is described by the transport land use feedback cycle (see figure 4-5). The transport networks (and the corresponding transport resistances) determine the accessibility of locations (see also next paragraph), and therefore what is attractive for land use developments (Bertolini, 2017). Consequently, land use determines the location of activities and thus the urge to move between locations, which generates transport (Soteropoulus et al., 2019). However, figure (4-5) is a simplified version of reality. The interactions are open-enden and its development co-determined by other factors (Soteropoulus et al., 2019).

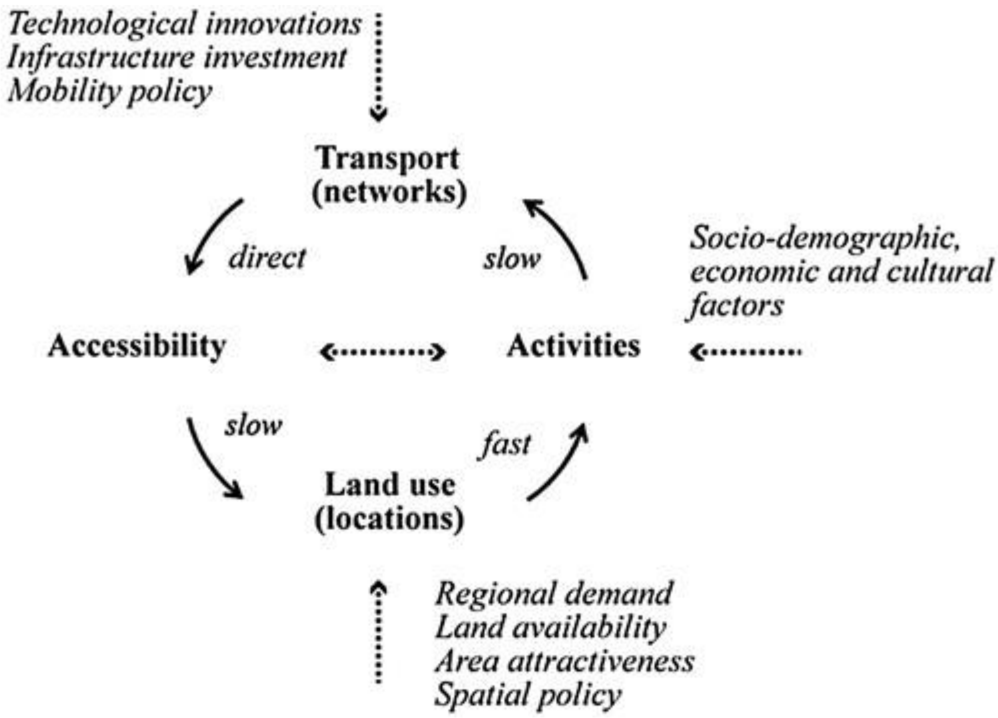


Figure 3-5: Land use transportation feedback cycle, (Soteropoulus et al., 2019, who addapted it from Wegener & Furst, 1999)

Transport uses public lands and therefore affects the public land use. Transport also affects the liveability of a place. In certain aspects this is clear and tangible, for example: the infrastructure required to accommodate transport volumes takes up public space (Ernst, 2011). Liveability however is a less tangible term. It is a broad term that indicates if an area is attractive ‘ to be’ (work/live) in. It also encompasses factors that are seen as individual societal effects in this report, like the environment or safety. Also the transportation system itself is an indicator of the liveabillity of an urban area (Higgs et al., 2019).

In the context of this report, the societal effect ‘liveability’ is used in the same way as Van Wee (2013) refers to the term ‘non-emissions-related liveability’: assuming that transport would not emit any pollutants and would not use any energy, even then transport has negative impacts, “as a result of land take (e.g. for parking) and community severance and by preventing streets being used for non- transport- related activities (e.g. for play).” (Van Wee, 2013, pp. 229). In general, a shift away from the car towards walking and cycling should make urban areas more attractive (Mackett, 2011, pp.100).

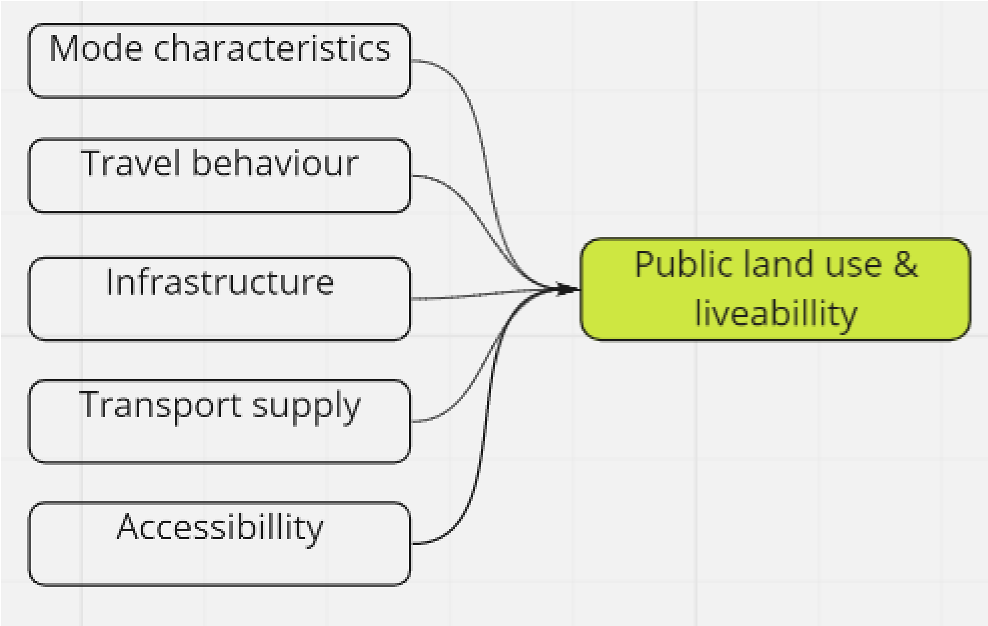


Figure 3-6: factors influencing public land use & liveabillity

The public land use and the liveability is mainly influenced by the travel behaviour, the infrastructure (required and used), and mode characteristics (mostly relating to the size of modes). On the long term developments are also influenced by accessibility situation, as can be seen in figure 4-5, however this is not taken into consideration in this study.
In the system diagram, (Figure 4-1) the liveability is affected by the infrastructure use and supply (arrow 4b & d4d) and the composition of traffic. Accessibility is taken as a separate factor, see next paragraph.

Accessibility

Accessibility, from a persons perspective, is defined as "The extent to which land- use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s) at various times of the day" (Van Wee, 2013, pp.5) ' The extent' is determined by the transport resistance. Accessibility can also be looked at from a location perspective, but since this research focusses on the mobility of persons that is not taken into account here.
Accessibility is an important outcome of the transportation system, it is a measurement of the advantage of the location of something (eg: house, workplace) as compared to other locations.
Van Wee (2013) distinguishes four components of accessibility:

- the land-use component ,
- the transportation component,
- the temporal component
- the individual component.

The land use component consists of the amount and quality of activity locations at a destination. The transportation component consists of the transport resistance (eg: time, cost, effort) required to reach those locations of activities. Time constraints of these activities (eg; opening times) the temporal component of the accessibility of a location. Lastly, the individual component of accessibility is the needs, abilities and opportunities of an individual. For example; having a driver's license and owning a car changes a persons accessibility to activity locations.

Summarizing, accessibility is dependent on the following main factors: location of activities, transport resistances, land use and individual capabilities, see figure 4-7. **In the system diagram, (Figure 4-1),** infrastructure supply influences the location of activities and therefore the accessibility. Besides that, the transport resistances influence the accessibility. Individual capabilities (not included as a separate factor) are relevant for the accessibility as well. As stated shown in Figure 3-5, accessibility influences land use and therefore infrastructure supply in his turn as well, this relation has been neglected in this system diagram because of the time scope of the diagram. The temporal component of accessibility is neglected in this system diagram.

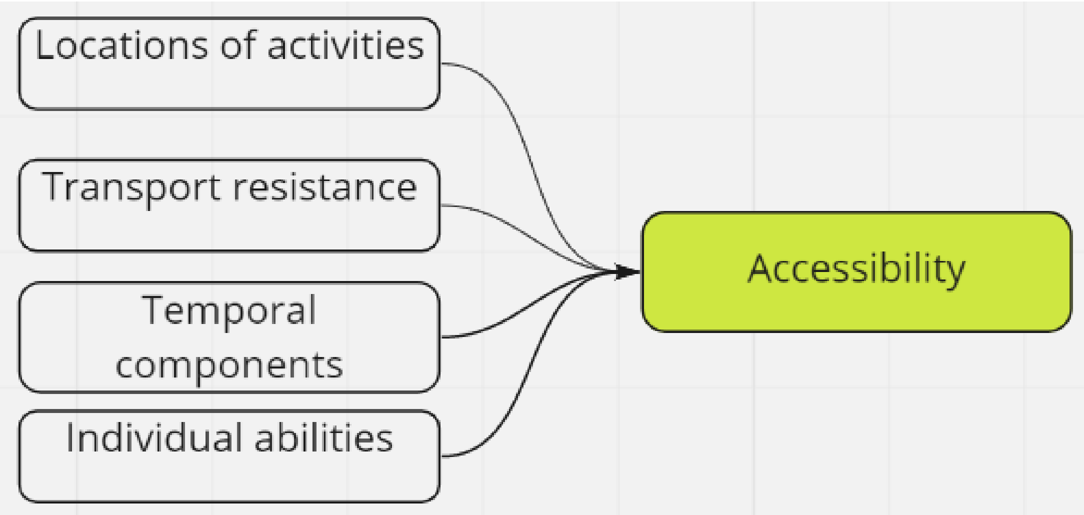


Figure 3-7: determinants influencing accessibility

Inclusion / equity

In/exclusion of transport relates to social equity; it is about the distribution of the benefits and costs of transportation, the access to transportation and accessibility of transportation (CROW congres, 2020 appendix 4). A widely used (Lucas, 2012, pp 108) definition of transport related social exclusion is: " The process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities , services and social networks, due in whole or part to insufficient mobility in a society and environment built around the assumption of high mobility'

Church et al. (2000) identified seven factors of the transport system and the built environment that are related to the inclusion of the transport system:

- physical exclusion: relates to physical barriers such as vehicle design.
- geographic exclusion: relates to the home specific access to transport services (eg: rural areas)
- exclusion from facilities: relates to the distances to activity locations
- economic exclusion: relates to the cost of transport that can limit an individual to access employment and therefore impact incomes.
- time-based exclusion; or: 'time poverty' (Lucas, 2012): relates to certain duties (like informal care) limit time available for transportation.
- fear based exclusion: relates to fear for personal safety that limits the use of transportation services
- space exclusion: where space management prevent certain groups access to public spaces, like in 'gated communities'.

The exclusion from facilities, economic facilities and time based exclusion can be seen as accessibility. A inclusive transportation system is one in which the differences in accessibility are small. The author assumes that fear based is not a main relevant factor in the Netherlands. Space based exclusion, although it is a trend in the Netherlands to live in more protected neighbourhoods (Planbureau voor de Leefomgeving [PBL], 2007). Schuilenburg and van Steden (2015) concluded that those neighbourhoods do not have the same characteristics as the 'gated communities' and its (transportation) benefits as related to by (Church et al., 2000).

The main determinants that influence the inclusivity of the transportation system are shown in figure 4-8. **In the system diagram, (Figure 4-1),** inclusion is incorporated as the factor 'equity in accessibility' and depends on the accessibility (including differences in-) and the access to transportation (arrow 5-7).

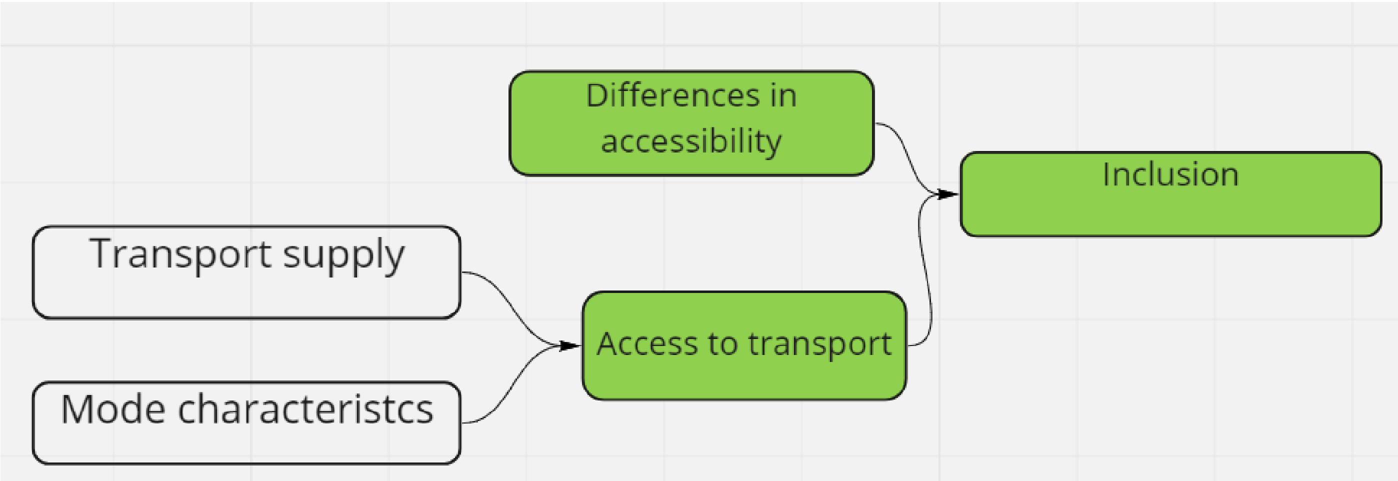


Figure 3-8: determinants influencing inclusion

Appendix 4.: Mobility expert interviews responses per interviewee

This appendix contains the mobility expert interviews responses per interviewee. This responses are used in the content analysis in Appendix 5.

Responses per interviewee

Coming tables (Table 4-1 - Table 4-11) show an overview of the responses for each interviewee. Right column are the (grouped) factors, if between brackets it's a specification of the factors.

Expert: 1 (TU Delft)	
Travel resistances, needs and desires	Convenience / comfort (due to size and foldability), image, novelty, availability (-reliability of-)
Travel choices	In general no large effect expected, mode choice and as a consequence route choice affected,
Users & purpose	Younger people. Leisure purpose, almost no commuting.
Traffic volumes & modal shift	Highest potential shared, small share private, mostly multimodal use. Shift from: bicycle, walk, BTM. Virtually no shift from car.
Environment	Overal negative effect, whole life cycle important
Health	Overal negative effect, whole life cycle important
Safety	Decrease (small), obstacles on footpath, new people don't know how to use it
Liveability	Parking, limit space required positive, regulations important (also for drive behaviour)
Accessibility	Digital accessibility relevant, increase for a small group, not accessible for elder
General comments on system diagram	No further comments

Table 4-1: Responses of expert 1

Expert: 6 (Studio Bereikbaar)	
Travel resistances, needs and desires	Convenience/comfort, availability (at ports of city), precise set-up shared system (part of 'waaier', parking system), imago, price, availability of infrastructure
Travel choices	Effects on activity side (behave more like inhabitant instead of visitor), mode and route choice affected and destination choice on activity side
Users & purpose	Younger people, visitors, non-cyclists, purpose not so relevant.
Traffic volumes & modal shift	Sharing highest potential, small part private, largest share activity side, multimodal use (train & car), modal shift: bicycle &walk. Small shift from car (unimodal E-SCOOTER use in city no replacement for car).
Environment	Overall negative effect
Health	No idear
Safety	No idear
Liveability	If on cycle lanes impact is fine, parking, regulations
Accessibility	Plus for a small group, increase of 'vervoersarmoede' places, increase of PT networks (easy to install close to stations)
General comments on system diagram	No further comments

Table 4-2: Responses of expert 6

4 (Ministery of Infrastructure and Water Management)	
Travel resistances, needs and desires	Convenience/comfort (size, weight, flexibility), not healthy (cause no physical effort required), availability, set-up shared system (parking), price (bicycle cheaper), quantity&quality of infra, uncomfortable longer distances
Travel choices	In general not a large effect, effect of covid larger (could be E-scooters facilitate in that),
Users & purpose	Younger. Purpose not so relevant
Traffic volumes & modal shift	First hype, then small amount of users left. Sharing highest potential, small part private (same target group as vouwfiets). Multimodal use (of existing ketenverplaatsers), also unimodal use .(small part, similar to shared mopeds). modal shift: bicycle, walk. Virtually no shift from car.
Environment	Virtually no effect
Health	Virtually no effect
Safety	Perception of safety decreases, already busy on bicycle lanes, diversity of vehicles on bicycle paths (unpredictable and invisible),
Liveability	-
Accessibility	Plus for a small group, not accessible for elder, increase accessibility of PT networks.
General comments on system diagram	No further comments

Table 4-3: Responses of expert 4

11 (TNO)	
Travel resistances, needs and desires	Convenience/comfort (how it seems to be), availability (reliability of), image, novelty, price (but people wont let it because of price), quantity and quality infra, copying behaviour, bicycle culture (unsure if positive or negative)
Travel choices	In general not a large effect, mode choice and as a consequence route choice affected,
Users & purpose	-
Traffic volumes & modal shift	Highest potential shared system, multimodal use (train & car). Modal shift: bicycle & walk. Small shift from car (if PT is more attractive some people will switch)
Environment	Potential for positive effect,
Health	No idear
Safety	In time not so much influence on safety, new people don’t know how to use it, pricing promotes speeding, regulations important
Liveability	Regulations important, parking, quiet catch people by surprise,
Accessibility	Increase of accessibility
General comments on System Diagram	No further comments

Table 4-4: responses of expert 11

9 (AT Osborne)	
Travel resistances, needs and desires	Availability, precise set up shared system (part of range of alternatives), Comfort (low entry barrier, no physical effort), image/lifestyle, novelty, copying behaviour.
Travel choices	Increase in frequency of pleasure trips
Users & purpose	Leisure, commuting, visitors, younger
Traffic volumes & modal shift	Sharing highest potential, also part private. Multi modal use (train & car), unimodal use. Modal shift: bicycle, walk, small shift car (due to new ketenverplaatsers)
Environment	Overall negative effect. Potential if shared systems and technology advances (more green energy), whole life cycle important,
Health	Overall negative effect
Safety	Safety decreases also in time (not a second nature), perception of safety decreases, new people don't know how to use it, already busy on cycling lanes (separated bicycle infra)
Liveability	Regulations important, way they are parked, contribute to cluttering of public space
Accessibility	Not really high impact, increase in accessibility of PT (and flexibility), digital accessibility relevant (in combination with Maas),
General comments on System Diagram	Feedback health > resistances (negative)

Table 4-5: Responses of expert 9

8 (AT Osborne)	
Travel resistances, needs and desires	Comfort (application, no physical effort required), image, price (lease), hygiene situation, uncomfortable on longer distances
Travel choices	Increase in frequency trips
Users & purpose	Leisure, commuting, visitors, younger, non-cyclists, lower educated
Traffic volumes & modal shift	Equally divided shared (visitors) & private (commuters) use. Multimodal use (train for commuters & visitors). Unimodal use (for visitors). Modal shift; bicycle and moped. Small amount of car (for people who are already positively orientated regarding PT).
Environment	Small positive effect in time, impact on whole SC has to be considered
Health	Overall negative effect (very small)
Safety	Low influence on traffic safety
Liveability	Regulations important, way they are parked
Accessibility	Digital accessibility relevant, plus for a small group, increase accessibility ot PT, not really high impact
General comments on System Diagram	No further comments

Table 4-6: Responses of expert 8

7 (AT Osborne)	
Travel resistances, needs and desires	Availability, reliability of the availability, precise set-up shared system, comfort (ease of use, parking), novelty, price (stimulated by employers), quality and quantity infrastructure, Dutch bicycle culture (negative), speed (Time)
Travel choices	In general no large effect, increase frequency leisure trips,
Users & purpose	Younger, lower educated,
Traffic volumes & modal shift	Largest share shared, also small part private (for commuters). Multimodal use (train). Also unimodal use. Modal shift: bicycle and BTM. Very small shift from car (as part of waaier).
Environment	Small positive effect in time (with more green energy)
Health	Virtually no effect
Safety	Negative impact, also in time, diversity of vehicles on bicycle lanes (visibility)
Liveability	Regulations, way they are parked, cluttering of public space
Accessibility	Plus for a small group, increase in accessibility of public transportation
General comments on System Diagram	F2b important

Table 4-7: Responses of expert 7

10 (Dutch Cycling Ambassy)	
Travel resistances, needs and desires	Convenience/comfort due to size, low entry barrier. Low physical activity not relevant. Set-up shared system, familiarity (in the beginning not so familiar). Dutch cycling culture (positive), quality&quantity bicycle infra
Travel choices	In general no large effect, mode choice and as a consequence route choices
Users & purpose	Younger individuals, visitors
Traffic volumes & modal shift	Equal share of private & shared, multimodal use (train (not a lot of space to carry with you) & car) but also large share of unimodal use. Modal shift: walk & bicycle. No shift from car
Environment	Potential if shared systems and technology advances
Health	Overal negative effect
Safety	Slight negative impact. Already busy on bicycle lanes
Liveability	Negative impact on space in PT, limit space required positive, regulations important, way they are parked
Accessibility	Plus for a small group (people without access to cars), not really high impact.
General comments on System Diagram	F1 very important, F3 important, number of visitors in a city

Table 4-8: Responses of expert 10

Expert: 3 Eurovia & Ecole Des Ponts ParisTech	
Travel resistances, needs and desires	Availability, novelty, price/costs, climate, speed
Travel choices	Mode choice and therefore route choice,
Users & purpose	Leisure, commuting, younger (men)
Traffic volumes & modal shift	unimodal use. Shift: walk and PT(small), small shift from car
Environment	Overall negative effect, whole life cycle important,
Health	No idear
Safety	No idear
Liveability	Way they are parked
Accessibility	`not really high impact
General comments on System Diagram	No further comments

Table 4-10: Responses of expert 3

Expert: 2 TU Delft	
Travel resistances, needs and desires	Comfort (size), availability, image/lifestyle, familiarity, price (to expensive for private), quality of bicycle infra (F4), supply of parking infra (F4)
Travel choices	In general no large effects,
Users & purpose	Leisure, younger, non cyclists
Traffic volumes & modal shift	Sharing highest potential, small part private. Multimodal use (with the train). Largest share activity side. Modal shift: walk & Bicycle, no shift from car
Environment	No idear
Health	No idear
Safety	Perception of safety decreases, new people don't know how to use it, already busy on cycling lanes, conflict fast vs slow users of bicycle lanes
Liveability	Regulations important
Accessibility	Plus for a small group (non-cyclists), increase in accessibility of PT
General comments on system diagram	F2b very Relevant

Table 4-9: Responses of expert 2

Expert: 5 (Ministery of Infrastructure and Environment)	
Travel resistances, needs and desires	Availabillity, set up shared system (part of range of alternatives and with handing in), Comfort (application, parking rules), copying behaviour, speed, Supply parking infrastructure
Travel choices	In general no large effect
Users & purpose	Younger, non-cyclists, lower educated
Traffic volumes & modal shift	Sharing highest potential, small part private. Equall distribtution of multimodal and unimodal use. Shift: bicycle, walk, PT. Small shift from car.
Environment	Small positive effect in time. Impact on whole SC has to be conisdered
Health	Small positive effect in time,
Safety	Not a large impact on real traffic safety, perception of safety decreases. New people don't know how to use it. Already busy on cycling lanes. Diversity of vehicles on bicycle paths.
Liveability	Limited space required positive, regulations important, way they are parked,
Accessibility	Plus for a small group (non cyclists), increase in accessibility of PT (small effect)
General comments on system diagram	F1 very important,

Table 4-11: Responses of expert 5

Appendix 5. Content analysis: grouped codes responses per arrow

In this appendix the content analysis is presented. The results are sorted by response rate or by category (eg: effect, underlying factors). The results as presented in this appendix are used as input for Chapter 5. The numbers between the brackets correspond to the interviewee that named the factor.

Travel resistances, needs & desires (arrow 1)

Responses on the most important factors of the transport supply that influence the travel resistances.

Factor	**Named by number of experts (out of 11 in total)**	**Specifications (if applicable)**
Convenience/comfort	10 [1, 6, 11, 10, 2, 5, 9, 4, 8, 7]	• Due to its size (4) [1, 10, 2, 4] • Where do you keep your own e-scooter? (2) [5, 7] • Digital application important aspect of convenience of e-scooter (2) [5, 8] • Physical effort 3 [9,4,8]
Availability of shared e-scooters	9 [1, 6, 11, 2, 3, 5, 9, 4, 7]	• Reliabillity of the availbillity (3) [1, 11, 7] • At ports of cities (1) [6]
Price	8 [6, 11, 10, 2, 3, 4, 8, 7]	• Stimulation by work providers (2) • Private use to expensive as compared to bicycles (2) • Cheaper then folding bike (1)
Precise set-up of shared e-scooter system	7 [6, 11, 10, 5, 9, 4, 7]	• Part of range of transport options (4) [6, 10, 5, 9] • Where can you park shared e-scooters (4) [6, 5, 4, 7]
Image / lifestyle	7 [1, 6, 11, 2, 9, 4, 8]	
Novelty	5 [1, 11, 3, 9, 7]	
Quantity and quality of e-scooter infra (F4)	7 [6, 11, 10, 2, 4, 7, 9]	
Copying behaviour	3 [11, 5, 9]	
Dutch Bicycle Culture	3 [11, 10, 7]	• Negative for uptake (2) • Positive for uptake (2)
Speed of vehicle / Time savings	3 [3, 5, 7]	
Familiarity (F1)	2 [10, 2]	
Uncomfortable for longer distances	2 [4, 8]	
Climate	1 [3]	
Hygiene situation	1 [8]	• Also after the covid crisis

Table 5-1: Content analysis of arrow 1

Travel choices (arrow 2a-2e)

Responses on the influence of the changing travel resistances on the travel behaviour choices. In this table the factors are mentioned that deviate from the idea that in general no major effects are expected here, except for mode choice.

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
In general no large effects expected	8 [1, 11, 10, 2, 5, 9, 4, 7]	
Route choice	5 [1, 6, 11, 10, 3]	• As result of mode choice (5) [[1, 6, 11, 10, 3] • Finer meshed routes (1)
Increase in trip frequency	3 [9, 8, 7]	• Increase in leisure trips (2)
In general most effects expected on activity side	2 [6, 2]	• Behave more like an inhabitant instead of visitor. (1) [6]
Destination choices affected	1 [6]	• On activity side only (1) [6]
Changing travel behaviour due to covid much larger	1 [5]	

Table 5-2: Content analysis of arrow 2a-2e

Traffic volumes and modal shift effects (e-scooter usage)

Responses on the experts expectations of the most promising uses of E-SCOOTER and modal shift effects, are shown in table x.

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Largest volume potential for use in shared system	8 [1, 6, 11, 2, 5, 9, 4, 7]	
Also part of private e-scooter use	7 [1, 6, 2, 5, 9, 4, 7]	
Use of E-scooters in multimodal trips	10 [1, 6, 11, 10, 2, 5, 9, 4, 8, 7]	• In combination with the train (7) [6, 11, 10, 2, 9, 8, 7] • In combination with the car (4) [6, 11, 10, 9] – small part (1) • Highest share on activity side of trip (2)
Equal share of shared and private E-scooters usage	2 [10, 8]	
Largest share activity side	2	
Use of E-scooters in unimodal trips	7 [10, 3, 5, 9, 4, 8, 7]	• Small part (1) • Large part (2) • Mostly visitors (1)
Modal shift from walking	8 [1, 6, 10, 2, 5, 9, 4, 3]	• Multimodal trips (7) [1, 6, 10, 2, 5, 9, 4] • Unimodal trips (6) [1, 10, 3, 5, 9, 4]
Modal shift from cycling	10 [1, 6, 11, 10, 2, 5, 9, 4, 8, 7]	• Multimodal trips (9) [1, 11, 10, 2, 5, 9, 4, 8, 7] • Unimodal trips (8) [6, 11, 10, 5, 9, 4, 8, 7]
Modal shift from Public Transportation (BTM)	4 [1, 3, 5, 7]	• Multimodal trips (2) [5, 7] • Unimodal trips (4) [1, 3, 5, 7]
Modal shift from moped	1 [8]	
(very) Small modal shift from car	7 [6, 11, 3, 5, 9, 8, 7]	• Verry small part (2) • Cause PT system is improved (4)
(Almost) no shift from car	4 [1, 10, 2, 4]	• There is a slight possibility to attract new chain trip users, then small shift from car (1)
First there will be relative large quantities, afterwards a small amount of users remains	1 [4]	

Table 5-3: Content analysis of traffic volumes

Users & travel purpose

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Users: Younger individuals	10 [1, 6, 10, 2, 3, 5, 9, 4, 8, 7]	• Eager to try new things (2) • Less interested in car possession (1)
Leisure purpose	5 [1, 2, 3, 9, 8]	

Users: visitors of a city	4 [6, 10, 9, 8]	
Users: non cyclist	4 [6, 2, 5, 8]	
Commuting purpose	3 [3, 9, 8]	
Users: lower educated	3 [5, 8, 7]	
Purpose not relevant	2 [6, 4]	

Table 5-4: Content analysis of users

Societal effects

Responses of the experts about their expectations of resulting societal effects, and important factors that also account for those effects. Considering their expectations on the traffic volumes.

Environment (arrow 3a)

One expert stated he expect an overall negative effect, but he also sees a potential for positive effect. This explains the the total number of responses of 12.

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Overal negative effect	4 [1, 6, 3, 9]	
Slightly positive effect, in time	3 [5, 8, 7]	• Because higher share of green energy (1))
Potential for positive effect	3 [11, 10, 9]	• If technology advances (2) • If higher share of green energy (1)
Virtually no effect	1 [4]	
No idear	1 [2]	
Whole life cycle is important	6 [1, 3, 5, 9, 4, 8]	

Table 5-5: Content analysis of arrow 3a

Health (arrow 3b)

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Overall negative effect	4 [1, 10, 9, 8]	• Very small (1)
Small positive effect, in time	1 [5]	
Virtually no effect	2 [4, 7]	
No idear	4 [6, 11, 2, 3]	

Table 5-6: Content analysis of arrow 3b

Traffic safety (arrow 3c)

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Virtually no influence on traffic safety, if vehicles are no longer a novelty	3 [11, 5, 8]	
Traffic safety decreases	4 [1, 10, 9, 7]	• Because its not our second nature (1) [9] • Decreases a little (2) [1, 10]
No idear	2 [6, 3]	
Perception of safety decreases	4 [2, 5, 9, 4]	

Table 5-7: Conent analysis of arrow 3c

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)

Busy on cycling lanes	6 [10, 2, 3, 5, 9, 4]	• Diversity of transport modes on cycling lanes (3) [5, 4, 7] • unpredictability and invisibility of E-scooters (2) • Conflict of fast vs slow users (1) [2]
New, people don't know how to use it	5 [1, 11, 2, 5, 9]	
Obstacles on footpath	2 [1, 3]	
Separation of bicycle lanes	2 [10, 3]	
Pricing system of shared E-scooters promotes speeding	1 [11]	
Regulations are important	1 [11]	

Table 5-8: Content analysis of arrow 3c

Liveabillity (arrow 4b + 3e + 4d)

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Way of parking	9 [1, 6, 11, 10, 3, 5, 9, 8, 7]	• Mainly of shared E-scooters (3)
Regulations are important	8 [1, 11, 10, 2, 5, 9, 8, 7]	• Driving behaviour regulations (1)
Limited space required is positive	4 [1, 6, 10, 5]	
E-scooters contribute to cluttering of public space	2 [9, 7]	
Not a large impact if on cycling lanes	1 [6]	
People can be catched by surprise	1 [11]	
Negative impact on space inside PT	1 [10]	

Table 5-9: content analysis of arrow 4b + 3e + 4d

Accessibility, access and inclusivity (arrow 5 + 6)

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Increase in accessibility for small group of people	8 [1, 6, 10, 2, 5, 4, 8, 7]	• For non-cyclists (4) • For people without a car (1) • Only if the shared systems reach areas with transportation poverty (1)
In general: increases accessibility of PT	8 [6, 11, 2, 5, 9, 4, 8, 7]	
Not really high impact	4 [10, 3, 9, 8]	
Digital accessibility relevant	3 [1, 9, 8]	• In combination with MaaS (1)
E-scooters not accessible for elderly	2 [1, 4]	
Increase in accessibility of some places with transportation poverty	1 [6]	

Table 5-10: Content analysis of arrow 5 + 6

Feedback loops:

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
F2 all feedbacks to resistances are relevant	3	
F2A Not large effect	3	• Gelegenheids argument
F3: more car congestion, more other vehicle usage	5	
F4: parking places for E-scooters relevant	2 [1, 5]	
F4: if less options for car parking> more other vehicles	4	

Table 5-11: Content analysis of the feedback loops

General statements

Factor	Named by number of experts (out of 11 in total)	Specifications (if applicable)
Feedback health > resistances	3 [9, 4, 8]	
Regulations 'on front' very important	2 [5, 7]	
All feedbacks to resistances not so relevant	3 [10, 2, 3]	
All feedbacks relevant	3 [9, 8, 7]	

Table 5-12: content analysis of the validation

Appendix 6. Report CROW webinar micromobility

In this appendix a report on the CROW webinar on micromobility is provided, since there is no report available online. If information from this conference is used in the main text, reference is made to this appendix. The webinair was organised by CROW-KpVV and Connekt on 25-11-2020.

1. *Information*

Around 200 participants with a diverse selection of stakeholders from the Netherlands participated in this congress; micromobility suppliers, policymakers, consultants, road authorities, vehicle authorities etc.
The scope of the congress was broader then the scope of this research, all vehicle categories except the blue categories were in scope of the webinar, see Figure 6-1. The blue category of vehicles are regulated through the EU en therefore out of scope. In the rest of this report is scope refers mostly to contents of this webinar that refers to vehicles that fit in the definition of e-scooters as used in this research. The webinar started with two plenary sessions followed by breakout sessions with specific subjects.

Figure 6-1: light electric vehicles in traffic, source: Ministery of Infrastructure and Water Management , 2020 10 november, Nationaal Toelatingskader Lichte elektrische voertuigen. Rovert Hulshof

2. *Plenary session 1: Robert Hulshof Ministery of Infrastructure and Water Management*

In this session Robert Hulshof of the Ministery of I&W explained the current state of -to be newly made- admission framework for light electric vehicles. All information is still subject to debate at time of the webinar. The admission framework consists of four steps:

- **Assigning vehicles to a category, or making new one(s)**
    - The ministery is planning to categorise vehicles based on vehicle weight.
- **Determining the process of road admission**
    - Heavier E-scooters will probably be subject to inspection and admission by the RDW (the Dutch vehicle authorities), lighter E-scooters will probably be subject to self-certification with the responsibility of the manufacturer

- **Determining the place on the road**
    - This will be determined based on weight and speed.
- **Determining the usage requirements**
    - This is about driving skills, helmet obligation, etc. Not elaborated yet. The Ministry probably wants to draw up risk profiles.

The planning of the framework is (at time of the congress) as follows:

- Dec 2020: outline admission to the parliament
- 2021: start legislative process for admission
- 2022: entry into force of the admission framework
- 202x: new EU rules E-scooters

3. Plenary session 2: Roxy Tacq ANWB

The ANWB (The Royal Dutch Touring Club) (offers a wide range of services related to transport on the road) made a 'perspective on micromobility'. They see promising opportunities for micromobility. They came with a suggestion for regulating E-scooters:

- Regulate small and light E-scooters similar tot the bicycle/e-bicycle. Use the bicycle path, no license required, no obligation to wear a helmet, insure through AVP (reliability private individuals)
- Regulate heavier E-scooters similar to mopeds. Driving license, insured.

In the rest of this session they explained where these suggestions come from.

4. Break out session: public space

In this session Netty Baartman (secretary G4), Nick Knoester (Over Morgen) and Kristina Nilsson (VOI) elaborated on the changes and dangers of the impact of micromobility in urban public spaces.
Netty Baartman talked about which role municipalities can play in micromobility and stimulating the switch from vehicle possession to vehicle use. However she warned that, from her experience in London municipalities have to be cautious to avoid negative effects on liveability and cluttering of public space. She stated that the healthy claims should be take with some healthy sceptics. Londen is using Pilot project and evaluate each time. She emphasizes that municipalities should know that micromobility has a large impact on public space. She sees potential for taking E-scooters in PT.
Nick Knoester talked about embracing innovation of people. If the goal is to stimulate a transition away from the car, he suggests getting people to try micromobility out. Behaviour change takes usually about four to seven weeks.
Kristina Hunternilsson acknowledges that micromobility can have a large impact, but she puts it the other way around: cars have a much larger impact. An independent survey in Stockholm found that 80% of the inhabitants were in favor of e-scooters (75% of the respondents weren`t users). She suggest to make clear appointments between municipalities and suppliers of micromobility. There are multiple policy options to 'control' the impact: trials/pilots, geofencing etc.
Question on modal shift: early adapters will probably be cyclist. People have to get used to micromobility, and product gets more attractive with more users. Supply has to grow till also car users are convinced. In Sweden there is an upwards trend that more people switch from car to E-SCOOTER.

The participants of the session (two sessions in total) were asked to name the most important factors that influence the impact of micromobility in public space. The named factors were: ease of use, behaviour, safety, speed

5. Break out session: Inclusivity

Tom van Dam (Connekt), Jeroen (donkey republic) and Christiaan Zandstra (Vervoerregio DH) talked about the inclusivity and accessibility potential of micromobility. Micromobility has the potential for accessibility. However there are currently not a lot of initiatives for less abled people. There is division with regard to the countryside. Some think that there are only opportunities for micro-mobility from nodes and centers, thus linked to public transport. Others see that micro-mobility (shared scooters) are useful in rural areas, especially for the last mile. Parking (free floating) is still a major challenge. For example, sidewalks must remain accessible, also for people with disabilities.

6. Break out session: Sustainabillity

Frieso Metz (ADVIER) talked about sustainability aspects of micromobility with the focus on shared bicycle, shared e-bike, shared e scooter and shared e-moped. His statements however are also for a large part based on the opinions and expectations of the ADVIER researchers.
Aspects that are relevant for effects on the environment: Modal shift, redistribution, life cycle, changing battery. Modal shift and life cylce problematic for E-scooters. Redistribution and battery changing depends on shared system.
E-scooters as independent mode not really big effect on the environment, but can make total shared mobility more interesting, therefore leading ultimately to less car usage. In general there is a lot of uncertainty regarding the impact on the environment of E-scooters.
The participants of the session (two sessions in total) were asked to name the most important factors that influence the impact of micromobility on the environment. The named experts were: circulair, regulations, ease of use, laws, availability, life cycle,

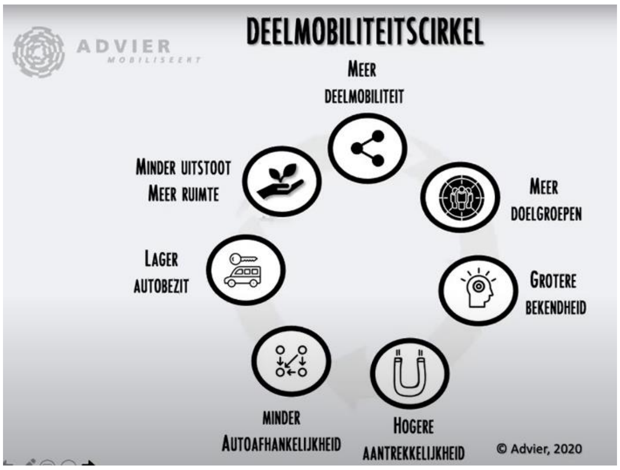


Figure 6-2: shared mobility circle

Aspects that are relevant for total uptakee: More shared mobility leads to Figure 6-2. More shared mobility leads to more choice freedom which leads to more choice assides from the car which leads to less reliance on cars.

7. Session traffic safety

Maartje de Goede (SWOV) talked about traffic safety. She stated that there is currently not yet a lot of data available on the subject. She states that it is even harder to use data from abroad cause of the unique bycicle situation in the Netherlands. The participants of the session were asked to name the most important factors that influence the impact of micromobility in public space. The named factors were: behaviour, speed, mass, infrastructure, place on the road, driver and width.

Appendix 7. Report VOI webinar

In this appendix a report on the VOI webinar on micromobility is provided, since there is no report available online. If information from this conference is used in the main text, reference is made to this appendix. The webinair was organised by VOI on 11-12-2020

About 20 people from different organisations participated in this congress. The webinar was of an interactive base and consisted of an introduction of VOI and two sessions:

Presentation Jelbi & Berliner Verkehrsbetriebe

Jelbi is a MaaS app that is currently operating successfully in Berlin, see infographics (Figure 7-1 and Figure 7-2).

Figure 7-2: Infographic by Jelbi, source Jelbi 2020

Figure 7-1: Infographic by Jelbi

Presentation CoMuUK

CoMuUK is an organisation that promotes shared mobility in the UK. The presentation was about how e-scooters (e-scooters in this report) can be utilized optimally as mode of transport to achieve a mode shift from cars. His main conclusion is that: ""if you want to get people out of their cars, you need a range of options". So e-scooters can be a (necessary) complement to the existing range of non car vehicles. He already sees a lot of promising modal shift results in a range of countries, see Figure 7-1.

Figure 7-3: modal shift from car, source: CoMuUK (2020)

Appendix 8. Report policymaker interviews

In this appendix a report of the three policymaker interviews is provided. The interviews were used as unput for Chapter 6 in the report. The interviews were conducted with: the municipality of Eindhoven, the municipality of Utrecht and the municipality of Amsterdam. The full transcription of the interviews can be requested at the author of this report.

The municipality of Eindhoven

Current goal and objective of the mobility policy

Increasing density ('verdichtingsopgave') in the city (mainly center). Besides that decreasing car usage in the city center. Not completely banning the car, but decreasing reliance on car by making other modalities more attractive and simultaneously decreasing car infrastructure.

Desirable outputs of the mobility system

Liveability and the environment are on top of the list, while maintaining and increasing accessibility of the city. However goal is to improve *all* societal effects of the transport system.

Policy strategy to reach those goals

The municipality is simultaneously making the car less attractive and filling those gaps with other transport options. The municipality acknowledges that probably trade offs have to be made between societal effects. Regarding the societal effects of (shared) micro mobility this is a process of trial and error. There is a lot collaboration between mobility suppliers.

Instruments that are currently being used are mainly aimed at shared mobility. Instruments like: regulations regarding safety, number of vehicles, parking rules etc. in the permits for suppliers. They require all the suppliers to be available in one network (MaaS application).

The municipality runs pilot projects and examines each pilot and each rule the effects of the pilot and adjusts accordingly.

Do e-scooters fit within that policy?

The municipality is open to this type of new means of transport. looks at what the effects will be through pilots.

The municipality of Utrecht

Current goal and objective of the mobility policy

Objective: Healthy mobility for everybody. Focus on active mobility forms and PT, and realizing that for everybody. This includes a less prominent role for the car. People need mobility options, but this should be less about the car. Utrecht also wants to be the first city where sharing is more normal than owning (vehicles)

Desirable outputs of the mobility system

Environment, health and accessibility for everyone.

Policy strategy to reach those goals

Making the car less attractive and at the same time stimulating walking, cycling and PT. This includes: P+R at borders of city. Less parking spaces for cars. More roads not accessible for cars, more 30km roads. Regarding LEV instruments: permits for suppliers with limit of vehicles. most permits (in number of vehicles) bicycles and cargo bikes, also small amount of permits for mopeds. Requirements to serve certain areas with a certain availability percentage. They don't know yet what works best so they are planning to pilots (trial and error).

Do e-scooters fit within that policy? E-scooters might fit in policy, but currently no specific policy is being made. Wont be a 'golden bullit'.

The municipality of Amsterdam

Current goal and objective of the mobility policy

The main pillars of the mobility policy of the municipality of Amsterdam are: less pollutants (also noise pollution important!), increase in traffic safety and inclusivity of the transport system. These pillars are included in two major plans currently underway at the municipality: Amsterdam clean air and Amsterdam low-traffic.

Desirable outputs of the mobility system

This depends on the local situation. At every location is examined which effects are not that bad and which are the most desirable. Of course with the main goal as mentioned above.

Policy strategy to reach those goals

Many different measures and instruments are used simultaneously to implement the mentioned plans. For each measure a thorough (local) research is done. The municipality uses a trial and error strategy; they try things out step by step and look locally for the effects.
The municipality mainly has influence on shared LEVs that operate in the public space. Private LEVs and 'private shared LEVs' (eg: in possession of hotels) are less within control of the municipality. As the local road manager the municipality is in control of, for example, parking regulations of all LEVs. The municipality is very happy with the announcement that LEVs (probably) will recuire a license plate. This makes enforcement a lot easier.
If LEVs fall within the current vehicle classifications then the current instruments are sufficient. If they form a completely new category, an adjustment of the ADV ('Algemene Plaatselijke Verordering') is necessary.

Do e-scooters fit within that policy?

The municipality is not immediately enthusiastic, they know the problems from other large cities. The centre of Amsterdam is already busy. They are especially curious about the modal shift effects and how tourists (who are often present in the city) deal with it. Ragarding private LEVs the municipallity forsees two scenarios: if the LEVs are parked outside in the bicycle parking facilities this is a problem. If they are brought inside then parking of private LEVs is not such a problem.

Appendix 9. Report and content analysis of the focus group

In this appendix a report of the focus group is provided. Seven experts who also participated in the expert interviews participated in the focus group. The attendees were: 11 (TNO), 6 (Studio Bereikbaar), 7 (AT Osborne), 1 (TU Delft), 9 (AT Osborne), 8 (AT Osborne) and 4 (Ministry of Infrastructure and Water Management). See for the expertise per attendee Appendix 2. The focus group was hosted and moderated by the author of this report.

The focus group session was held digital via MS teams due to Covid-19 restrictions. The focus group consisted of 2 parts: **i)** in the first part insight was provided in the research results of research question 1 & 2, related to the expected effects of e-scooters in the Netherlands. Consequently, a report was provided on the results of the policymaker interviews and literature, related to research question 3. **ii)** the second part contained the interactive session of the focus group. A case was provided, which was the background of 6 discussion points.

In order to guarantee the involvement of all participants in the digital set-up, a digital 'white board' was used. All participants were asked to respond to the discussion points on this white board. Subsequently, those responses were discussed by the group.

The case

The following background situation was outlined in the case:

Role of the attendees:

The attendees of the focus group are transport policymakers in the fictive city ‘Lutjedam’. For each discussion point the focus of the policymaker changes: eg: ‘policymaker environment’ or ‘policymaker traffic safety’. With the exception of discussion point 6, the goal of the policymaker is to focus solely on the corresponding goal of their job. E.g.; the policymaker environment has only one goal: to make sure the the transportation system in Lutjedam is as beneficial to the environment as possible.

In the last discussion point, discussion point 6 the role of the attendees changes: they are promoted to ‘Transportation Councilor’, and have to formulate a final conclusion of the regulations regarding e-scooters in Lutjedam.

National e-scooter regulations:

There is an admission framework for e-scooters in the Netherlands with the following rules: inspection by the manufacturer, number plate, place on the road: cycle path, no helmet requirement.

The city of Lutjedam:

Lutjedam is a city what one could call a very ‘average’ G5 city, with the following characteristics: 400.000 inhabitants and an average yearly number of tourists/visitors in the city.Furthermore, there is quite a lot of use of private e-scooters in the city. The regulations of shared e-scooters are dependent on the rules made by ‘the policymakers’.

Discussion points:

Discussion point 1	As policymaker accessibility: With which policy instruments do you stimulate the contribution of e-scooters to the accessibility, for everyone?
Discussion point 2	As policymaker environment: With which policy instruments do you stimulate the contribution of e-scooters to the environment?
Discussion point 3	As policymaker traffic safety: With which policy instruments do you guarantee safety with e-scooters usage?
Discussion point 4	As policymaker liveability, with which policy instruments do you guarantee the effect on the liveability of e-scooters?
Discussion point 5	As policymaker public health, with which instruments do you guarantee the effect on public health of e-scooters?

Discussion point 6	As transportation councillor, what is you conclusion: What kind of policy are you going to formulate regarding e-scooters, to make sure the transportation system in Lutjedam functions optimally?

Results

This section describes the results of the discussion points of the focus group in Table 9-1 - Table 9-6.

Discussion point 1

The summarized results on discussion point 1: accessibility are presented in table x below. This table includes the information on the digital whiteboard and the accompanying discussions.

Expert	Response
(11)	-Take into account the whole transportation system, with all its modalities. -Ensure there are enough e-scooters available and/or enough parking places -Ensure you also consider the spatial design of the city that fits with the e-scooter policy -Ensure also LEVs for disabled
(6)	-Make hubs at PT points and P+R on edge of cities -Less stops for BTM (=faster), last mile with e-scooters -pricing for everyone -Improve bicycle infra> broaden bicycle paths (=more comfort on e-scooters). -Parking is allowed everywhere, at the cost of parking places for cars.
(7)	-Organise data and match question & demand -Investigate witch accessibility effects you want where and for which target group, set guide lines for suppliers on base of the location specific goals of the municipality. -Then make location specific e-scooter policy -Ensure inclusion by setingi norms for price and access for *all* users
(1)	-Ensure 'soft accessibility'; make sure people know how it works. -Link e-scooters to the PT network, thereby reaching the group of non cyclist to use PT. -Analyse the transportation market: who what which
(9)	-Parking is everywhere allowed, thus supplier needs to relocate vehicles at night. -Connect e-scooter to PT and car points -Focus as well on suburbs
(8)	-Regulate suppliers the less as possible -Focus also on suburbs -Think of goals you want to pursue related to accessibility
(4)	-Ensure accessibility on relevant spots: shopping centers, PT point etc. (location policy) -Location specific policy: make sure the e-scooters are available there where they are needed the most. And thereby coupling to PT. Make framework for distance to e-scooters and availability of e-scooters for suppliers -Only place a framework for suppliers, the rest is up to the market

Table 9-1: Results of discussion point 1

Discussion point 2

Summarized results on discussion point 2: the environment.

Expert	Response
(11)	-Think of recharge policy: eg: solar panels on hubs -Focus on modal shift from car: connect to PT -Geofencing or special parking locks (to ensure the e-scooters are not being dumped in the environment)
(6)	-Only charge with green energy - Steven: make the tradeoff: how many car switchers are worth bicycle and walk switchers? -Stimulate shift from car, by: hub on P+R on edge of city -If that doesn't work: don't allow e-scooters - 'autolow' policy required, e-scooters are more a solution to the gap that arises then.
(7)	-Set requirements for the production and charging (life cycle) -Work together with other governmental institutions -More e-scooters = less parking places needed for cars = more room for green -Combine charging points for all modalities
(1)	-Set requirements for life cycle impact of e-scooters -shift from car by connecting to PT -'flank policy with regards to uber'
(9)	-Green energy, facilitate charging in public space -low parking norms (car), couple e-scooters to hubs. Focus also on the facilitating services for the e-scooters. (reposistioning etc). That can be added to permits for suppliers.
(8)	-Fully focus on e-scooters by making parking for cars as unattractive as possible -spread charging facilities over space with the focus on PT points
(4)	Focus on charging points, and more specifically the availability of those points on userlocations - set national rules for life cycle requirements suppliers, if suppliers then go to other countries so be it. These questions should be national coordinated. If local policy is made, then there is a big change of inequality between cities and corresponding inequality in price etc.

Table 9-2: Results of discussion point 2

Discussion point 3: public health

Expert	Response
(11)	- users are not always able to guarantee their own safety. That is why we try to do that with rules like government. Protect the user with rules: age, instructions etc -Accessibility
(6)	-If it stimulates cyclist and walkers to not being active; not allow shared LEVs -e-scooters are not your favorite thing in this role.
(7)	-Stimulate active forms above passive forms, so don't focus on e-scooters -
(1)	- E-scooters don't fit in the public health is health is you focus -Frame e-scooters as part of the 'no-car options', to ensure switch from car. Accepting also part of switch from active modes
(9)	Don't allow if active modes are replaced
(8)	
(4)	

Table 9-3: results of discussion point 3

Discussion point 4: liveability

Expert	Response
(11)	-Analyse per location where they are allowed to being stalled -Also allow/or don't! inside shopping areas. -Help in the layout of public space
(6)	-Only parking allowed on car parking places -Geofencing, deny parking and driving in certain areas
(7)	-See accessibility -scooters could replace taxis etc, but cheaper. Thereby increasing liveabillity for everyone. As a municipality you can then set requirements, but that naturally affects the business case. Maybe as municipality you can be creative with budgets and shifting money from certain jars to lev stimulation
(1)	-Don't allow driving on footpaths -Make sure they are being stalled while folded in a storage rack to ensure effective use of space
(9)	-E-scooters can contribute to liveabillity for visitors and inhabitants by stimulating pleasure trips
(8)	
(4)	

Table 9-4: Results of discussion point 4

Discussion point 5: traffic safety

Expert	Response
(11)	-Focus on interaction with other traffic -Introduce step by step and monitor usage -monitor on long term to correct for 'newabillity-people don't know how to use it' effects -Involve enforcers
(6)	-Only allow 'light LEVs' -Monitor
(7)	-Arrange safety by national law: standards for vehicle design and road design
(1)	-Ensure clear rules, make sure users have to read them before able to use e-scooters -Age requirements -Not allowed to ride on footpaths
(9)	-Set requirements for min. age, driveabillity license, helmet -Prevent self build of LEVs -Focus also on infra (sperate traffic streams)
(8)	-Only allow shared e-scooters to be opened with a car license. (also ensuring shift from car)
(4)	-Regulate national - In the Netherlands often the tendency to regulate everything. How feasible is that? You have to be able to maintain it. Let people also do their thing. It is still too early to regulate everything. As a government, primarily guarantee public values. (individual) safety is mainly your own business. It happens often that rules are to strict in the beginning and once they are in place it is difficult to get rid of them.

Table 9-5: results of discussion point 5

Discussion point 6: conclusion

Expert	Response
(11)	Allow, don't be to afraid regulate up front (making adjustments can be difficult and dangerous)
(6)	-Allow, with certain requirements: geofence at hubs -Stimulate on certain spots: at PT and P+R, also by ensuring PT companies involve e-scooters actively
(7)	Make rules and regulations up front and then start with pilots
(1)	Start with pilots. With some requirements up front: amount of vehicles + suppliers, parking locations etc
(9)	Allow under certain requirements - first reaction would be don't allow. But if you know there are negative side effect, but your city becomes cool then it can be worth it.
(8)	Allow with requirements for parking and number of vehicles and suppliers
(4)	

Table 9-6: results of discussion point 6

Content analysis

Policy instruments that focus on the accessibility and inclusivity:

- Instruments that focus on connection to other modalities (PT & Car) (4x) [6, 1, 9, 4]
  - Hubs on PT and P+R points
- Ensuring enough parking options (3x) [11, 6, 9]
  - Ensure enough places (1x) [11
    - At the cost of car parking places
  - By allowing e-scooters to be parked everywhere (2x) [6, 9]
- Also focus on suburbs, making sure suppliers facilitate those areas as well (3x) [6, 9, 8]
- Ensure access for disabled [11]
- Making other PT faster (=better accessibility) by skiping stops. [6]
- Improve bicycle infrastructure [6]
- Match supply & demand with the use of data (2x) [7,
- Set norms for prices and access options for everybody [7]
- Ensure soft accessibility, make sure people know how to use it [1]

Policy instruments that focus on the environment

- Focus on shift from car: (5x) [11, 6, 1, 9, 8]
  - Connect to PT (3x) [11, 1, 9]
  - Connect to car [6]
  - Policy aimed at making car les attractive (3x) [6,9,8]
- Recharge with green energy (4x) [11, 6, 7, 9]
- Focus on charging points, making them available a lot (2x) [8, 4]
- Set requirements for production proces>whole life cycle pollutants (3x) [7, 1, 4]
  - Do this nationally [4]
- Focus also on facilitating services like repositioning [9]
- Geofencing or special locks to avoid dumping [11]
- If , 'a' shift from car is not achieved> don't allow [6]
- Less car parking places is more room for green [7]
- Combine charging points for all modalities [7]

Policy instruments that focus on public health

- Protect users from themselves [11]
  - With rules for minimum age [11]
  - Instructions [11]
- Do not allow if shift is from active modes (4x) [6, 7, 1, 9]
- Frame e-scooters as part of car alternative options [1]

Policy instruments for liveability

- Parking restrictions (4x) [11, 6, 1,4]:
  - Only in parking places [6,
  - Geofencing [6,
  - Analyse required restrictions per area [11,
- Restrict driving in certain areas [11, 6, 1]
  - Using geofencing [6]
  - Don't allow driving on footpaths [1]
- Fold them in storage to optimally use public space [1]

Traffic safety

- Monitor safety situation (2x) [11, 6]
  - By introduce e-scooters step by step [11]
- Involve enforcers (police etc.) [11]
- Arrange safety by national law with standards for design (road+vehicle) 2x [6, 7]

    - Only light e-scooters [6]
- Ensure clear rules, make sure users have to read them before able to use e-scooters [1]
- Requirements for drivers: (3x) [1, 9,8]
    - Age requirements (2x) [1, 9]
    - Helmet [9]
    - Driving license (2x) [9,8]
- Prevent self build of e-scooters [9]
- Interaction with other traffic flows by separating infra (2x) [11, 9]
- Regulate national, don't over regulate [4]

Conclusion

- Allow, don't be to afraid regulate up front (making adjustments can be difficult and dangerous)
- Allow, with certain requirements: geofence at hubs
- Stimulate on certain spots: at PT and P+R, also by ensuring PT companies involve e-scooters actively
- Make rules and regulations up front and then start with pilots
- Start with pilots. With some requirements up front: amount of vehicles + suppliers, parking locations etc
- Allow under certain requirements
- First reaction would be don't allow. But if you know there are negative side effect, but your city becomes cool then it can be worth it.
- Allow with requirements for parking and number of vehicles and suppliers

Appendix 10. Synergy of information sources

In this chapter the synergy of information is provided, that leads to the final conclusions as provided in Chapter 7. The conclusions are formulated in the following manner:

- If all information sources align (majority + literature) = There is a sufficient basis for this expectation
- If the sources align a bit (minority + literature OR majority + not researched literature) = There is a reasonable basis for the expectation, but more research would provide a stronger basis
- If the sources don't agree = There is not yet a sufficiently founded basis for this expectation, this must be further investigated

The synergy of information is provided in Table 10-1till Table 10-10. The first column shows the factor or effect. The second column states if a factor is found in literature and or the congresses or not. The third column shows how many experts named the factors. The fourth column shows the conclusion, named in colours.

Effects and factors

Travel resistances, needs & desires and transport supply

Factor	Literature / congresses	Experts	Conclusion
Availability of shared LEVs	Mentioned in 1 paper	9	Green
Set-up of shared system	Not specific one factors but factors that fall within are mentioned	7	Green
Convenience/comfort	Mentioned in multiple papers	10	Green
Price	Mentioned in multiple papers	8	Green
Operating speed / travel time savings	Mentioned in multiple papers	3	Orange
Lifestyle	Not mentioned or researched in literature	7	Orange
Novelty	Not mentioned or researched in literature	5	red
Dutch bicycle culture	Not mentioned or researched in literature	3	red
Portable in PT	Mentioned by a few papers	4	Orange
Hygiene situation	Not mentioned in literature	1	Red
Copying behaviour (trans sup)	Not mentioned in literature	3	Red
Familiarity (trans sup)	Mentioned in one paper	2	Orange/red
Quality & quantity infra	Mentioned in multiple sources	7	Green
If les infra for cars other modes more attractive	Not mentioned in literature, mentioned in congresses	minority	orange
More congestion=more attractive other modes	Mentioned in literature	minority	orange

Table 10-1: synergy of information on travel resistances, needs & desires

Users

Factor	Literature/congress	Experts	Conclusion
younger	Mentioned by multiple sources	10	Green
Visitors	Not mentioned in literature	4	red
Leisure purpose	Mentioned in multiple studies	5	Orange
Commuting purpose	Mentioned in multiple studies	3	Orange
Lower educated	Not outcomes of studies	3	Red
Higher educated	Mentioned in multiple studies	-	Red
Non-cyclists	Opinion	4	Red

Table 10-2: Synergy of information on the users

Travel choices

Factor	Literature/congress	Experts	Conclusion
No large effects	Not researched	8	Orange
Route choices	Not researched	5	Red
Increase (leisure trip freq)	Found in multiple studies	3	Orange
Activity side	Not researched	2	red
Mode choices	Found	11	green

Table 10-3: Synergy of information on travel choices

E-scooter usage

Factor	Literature/congress	Experts	Conclusion
Sharing highest potential	Mentioned in some sources	8	Green
Also part private	Almost not researched	7	Orange
Multimodal use	Almost not researched	10	Orange
Unimodal use	Researched	7	Green
First hype, then small amount of users	Not researched	1	Red
Most users activity side	Not researched		Red

Table 10-4: Synergy of information on e-scooter usage

Modal shift effects

Factor	Literature/congresses	Experts	Conclusion
Walking	Confirmed In multiple sources	8	Green
Cycling	Confirmed in multiple sources	10	Green
BTM		10	Green
Moped	Confirmed in one source but in Taiwan, not touched upon in other literature	1	red
(very) small shift car	Confirmed in multiple sources	7	green
Virtually no shift car	Not found in literature	4	red

Table 10-5: Synergy of information on modal shift effects

Environment

Factor	Literature/congresses	Experts	Conclusion
Negative effect	Two sources (who state it is heavily location dependent)	4	Orange
Slightly pos, in time		3	Red
Potential	Mentioned in multiple sources (potential is a broad definition)	3	Orange
Whole life cycle important	Mentioned in multiple sources	6	Green
redistribution	Mentioned in multiple sources	0	red
Power generation	Mentioned in multiple sources	11	green

Table 10-6: Synergy of information on the environment

Public Health

Factor	Literature/congresses	Experts	Conclusion
Negative effect	Mentioned	4	Orange / green

Table 10-7: synergy of information on public health

Traffic safety

Factor	Literature/congresses	Experts	Conclusion
No influence	Indication in literature (qualitative statements)	3	Red (because of qualitative statements)
Decreases	Not researched	4	Red
No idear	-	2	Red
Perception of decreases	Not researched	4	red
Busy on cycling	mentioned	6	Green
Diversitity on cycling lanes	Not researched	3	red
Obstacles on footpath	Mentioned multiple	2	orange
New people don't know	Not researched	5	red
Pricing promotes speeding	Not researched	1	red

Table 10-8: Synergy of information on traffic safety

Liveability

Factor	Literature/congresses	Experts	Conclusion
Way of parking	Mentioned in multiple sources	9	green
Regulations	Mentioned in multiple sources	8	Green
Limited space req positive	Mentioned in one source	4	Orange
Cluttering	Not researched	2	Red
Catch by surprise	Not researched	1	Red
Neg impact space in pt	Not researched	1	Red

Table 10-9: Synergy of information on liveability

Accessibility and inclusivity

Factor	Literature/congresses	Experts	Conclusion
Increase access small group	Mentioned even for a larger group	8	green
Increase access PT	Menttioned in multiple sources	8	Green
Potential to increase poverty places	Mentioned in some sources	4	orange
Not high impact		4	Orange/red
Digit access rel	Not mentioned	3	red
Not access by disabled	Mentioned in multiple sources	4	green

Table 10-10: Synergy of information on accessibility and inclusivity

Policy strategies and instruments

- If an strategy / instrument is named by a majority or minority and named in literature or the congresses, the conclusion is made that there is *sufficient* basis to conclude that the policy strategy or instrument can contribute positively to the societal effect. The label green is then given
- If an strategy / instrument is named by mobility experts but not mentioned anywhere in literature or vice versa, concluded is that there is a *reasonable* basis to conclude that the policy strategy or instrument can contribute positively to a societal effect. The label orange is then given.

The synergy of information is provided in Table 10-11 till Table 10-15. The first column shows the policy strategy or instrument. The second column states if a factor is found in literature and or the congresses or not. The third column shows how many experts named the factors. The fourth column shows the conclusion, named in colours.

Environment

Policy	Literature	Focus group	Conclusion
Focus on shift from car	Mentioned in multiple sources	Majority	Green
Connect to PT & Car	Mentioned in conferences	Minority	Green
Set requirements for recharge	Mentioned in multiple sources	Majority	Green
Ensure enough charging point capactity	Not mentioned	Minority	Orange
Set requirements for prod process	Mentioned in multiple sources	Minority	Green
Don't allow if shift is not achieved	Mentioned in multiple sources	Small minority	Orange
Use geofencing to avoid dumping	Not mentioned	Small minority	Orange
Only allow driving with car license	Not mentioned	Small minority	Orange

Table 10-11: Synergy of information of policy on environment

Public health

Policy	Literature	Focus group	Conclusion
Don't allow	Mentioned	Majority	green
Protect users: min age	(related to traffic safety)	Small minority	Moved to traffic safety
Protect users: instructions	(related to traffic safety)	Small minority	Moved to traffic safety

Table 10-12: Synergy of information on policy on public health

Traffic safety

Policy	Literature	Focus group	Conclusion
Requirements for users	Mentioned	Minority	Green
-Age	Mentioned	Minority	Green
-Driving license	Not mentioned	Minority	Green
-Helmet	Mentioned	Small minority	Green
Safety design standards for e-scooters	Mentioned	Minority	Green
Separate traffic flows	Mentioned	Minority	Green
Safety campaign	Mentioned	Not named	Orange

Table 10-13: Synergy of information on policy on traffic safety

Liveability

Policy	Literature	Focus group	Conclusion
Focus on parking regulations:	Mentioned	Majority	Green
-By assigning designated parameters	Mentioned	Minority	Green
-By using geofencing	Mentioned	Small minority	Green
-Specify per area	Mentioned	Small minority	Orange
Restrict driving certain areas	Mentioned	Minority	Green
-Using geofencing	Mentioned in congresses	Small minority	Orange
Focus on cluttering:	Mentioned in congresses	Not Mentioned	Orange
-Fold in storage	Not Mentioned	Small minority	Orange
-Report broken e-scooters	Mentioned	Not Mentioned	Orange

Table 10-14: Synergy of information on policy on liveability

Accessibility and inclusivity

Policy	Literature	Focus group	Conclusion
Connect to other modalities	Mentioned in congresses	Majority	Green
Ensure enough parking places	Not mentioned	Minority	Orange
-At cost of car	Not mentioned	Small minority	Orange
-Allow everywhere	Mentioned	Small minority	Green
Focus on accessi suburbs	Mentioned	Minority	Green
-By service req	Mentioned	Minority	Green
Requirements for cost of use	Mentioned	Minority	Green
Skip BTM stops	Not mentioned	Small minority	Orange

Table 10-15: Synergy of information on policy on accessibility and inclusivity