The Implications of Electric Scooters as a New Technology Artifact in Urban Transportation

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Abstract: E-scooters are becoming an increasingly important component of urban transportation networks, providing a sustainable alternative for first and last-mile travel. However, if they are not managed and regulated carefully, they can become a risk to users and cities in general. In this paper, we studied the emergence of this innovative, platform-based, and shareable e-scooter, as a possible 'greener' transport alternative, from a sustainability and environmental awareness perspective. The most critical question is legislation. Urban planners need to implement laws limiting maximum speeds, requiring the use of e-scooter infrastructure, and providing dedicated parking, as well as limiting the number of licensed operators. In our exploratory research, we conducted three focus group discussions to explore the views of non-users and then built the nomological network from the key phenomenons they identified. The participants are confused about micro-mobility solutions, according to the findings, due to a lack of clarity on regulatory problems and poor infrastructure. As a result, we propose that policies should be co-developed in cooperation with various stakeholders to enable antagonistic conversation about alternative policy actions by evaluating their effectiveness in terms of behavioral change as well as their implementability.

Keywords: sustainability; electric scooter; nomological network

1 Introduction

E-scooters are a relatively new topic in transportation research. This new vehicle type originally arrived in the United States, California in 2017 and is now available all over the world. After car sharing and bike sharing, most e-scooters are organized in sharing networks, making them the newest invention of shared mobility. These schemes have become essential to most large city transportation systems in North America, Asia, Australia, and Europe (Weschke – Oostendorp & Hardinghaus). There are approximately 20 million users in Europe alone, and the adoption rate of e-scooter sharing is four times that of bike sharing (Latinopoulos – Patrier & Sivakumar).

2 Framework

To date, the scientific basis for the argument about the use and impact of e-scooters is limited. There is a lack of data from numerous studies, and it is unknown to what extent the data has been systematically obtained, examined, and interpreted. On this premise, it is unclear whether and how e-scooters can genuinely contribute to more sustainable mobility. Even though we can accurately conclude that the meaning of technology is socially constructed. Our research requires an understanding of technology as well as the organizational and individual difficulties associated with its application (Benbasat – Zmud, 2003).

The most popular statements in previous research about e-scooter are the following:

- E-scooters are seen as an important part of the evolution of cities transportation systems since they 'may be used for a considerable proportion of in-town travel' (Schellong et al., 2019, p. 2) and can be coupled with other modes, especially public transportation.
- E-scooters are promoted as a low-cost, socially inclusive means of transportation as part of micro-mobility (Semenov, 2017).
- E-scooters are marketed as a 'green solution for urban traffic' (Kopplin et al., 2021, p. 2).
- E-scooters are mostly seen as 'fun objects' (Kopplin et al., 2021, p. 1), but not as a serious mode of transportation.

The above examples of statements taken from various research studies illustrate that the conceptual network that gives meaning to electric scooters is still in its emerging stage. This paper aims to conceptualize the electric scooter as an artifact of the application of electric micro-mobility to support or complement other urban transport methods embedded within government policies that are embedded within the community's attitude towards sustainability.

3 Problems and Research Questions

E-scooters are very popular nowadays, and the story of electric scooters as a vehicle dates back more than a century. The first motorized scooter, called Autoped, was launched in 1915 and quickly became popular in the United States (Manskie, 2019). Autopeds, like their modern analogs, was accused of being a toy for the aristocratic people. Furthermore, there is evidence that the method was used for traveling and leisure uses, as well as for enterprises such as postal services, which used it to distribute letters. The main constraints limiting their commercial success were their high cost compared to bicycles and insufficient comfort compared to motorbikes. In more recent years, Go-Ped released the first manufactured motorized scooter since 1915. During the previous decade, with the invention of lithium-ion batteries

and technological advances in electric motors, the Go-Ped design began to be changed into the first e-scooter prototypes. E-scooters are significantly less expensive than their gas-powered equivalents. However, it appears that the important step in their popularity was the greater awareness that followed their introduction with the expansion of bike-sharing programs. Even though shared e-scooters have only been on the market for four years, they are quickly becoming an important factor in urban areas, changing our user behavior.

The emergence of e-scooters raises the question of whether they can become a disruptive niche innovation. According to Geels et al. (2017), any transformation of an existing transportation system necessitates changes in technologies, infrastructures, organizations, markets, legislation, and user practices. This new way of electric micro-mobility rivals cars in terms of speed, safety, and affective values. Because any innovation is generally faced with resistance in the prevailing system, its introduction must be carefully considered because it disrupts established government transportation regulations (Gössling – Cohen, 2014). While academic discussions of restrictions to e-scooter systems have focused on a lack of charging infrastructure, reduced subjective safety for other traffic participants, adverse weather conditions, or a limited capacity to transport baggage (Hardt – Bogenberger, 2019: 155), global newspaper reports (e.g., Guardian, 2019) would appear to suggest that public opinion is the most significant challenge for this mode of transportation.

As a part of this larger global trend, Hungary has seen the emergence of standing, shared, or private, rechargeable electric scooters and other micro-mobility devices. The public has replied to e-scooters with both enthusiasm and skepticism, as communities have struggled with unanticipated consequences such as irresponsible riding, cluttering, and vandalism. This new form of transportation poses challenges for all transport actors. In consideration of the possibilities and limitations of e-scooter technology, our question is whether this type of micro-mobility can launch a larger urban transportation system change. In this study, we present the results of three focus group discussions aimed at gathering the views of non-users on regulatory issues related to electric scooters and providing policy stakeholders with action-oriented guidance.

4 Research Methodology

At this early stage of our research, we focused on how this new form of electric micro-mobility is received by those stakeholders who do not use electric scooters. In this article, we present their attitudes toward e-scooters, government policies, alternative transportation modes, and sustainability. Because the electric scooter is a relatively new phenomenon in urban transportation about which we don't know much and the conceptual framework around this term has not yet been stabilized,

we used focus group interviews as a possible qualitative research method to build the nomological network to illustrate the broad public opinion and how electric scooters could be integrated into urban transportation infrastructure. This methodology allowed the researchers to examine how the participants interacted when discussing their ideas and perspectives (Liamputtong, 2012). This method of inquiry allows for the study of small groups of people who have firsthand knowledge of the subject under examination (Blumer, 1969).

According to Wilkinson (2004), the assemblement and interpretation of human experience are affected by others. Participants in the focus group discussions brought their unique stories to the meeting and worked to develop a common understanding of them (Wilkinson, 2004). As a result, we were able to observe the members in the focus group co-constructing meaning. The use of focus group methodology in this study provided a mechanism for us to improve our knowledge of the subjective meaning that participants ascribed to their behaviors and circumstances (Flick, 2006).

Respondents were selected using convenience sampling and the snowball method. The first group of participants was chosen using the contact network of the FIEK organization of the Budapest University of Technology and Economics. The FIEK is responsible for managing the relations between the university and large companies, and therefore The FIEK is responsible for managing the relations between the university and large companies, and therefore the first focus was on women working in management positions at large companies (MOL, thyssenkrupp, Bosch) or in the university sector. The second and third groups were selected based on personal acquaintance.

The very first focus group discussion took place on 4 March 2022, via a video call through the Microsoft Teams interface with 5 participants. They were all women aged between 35 and 50 working in senior management positions. The second focus group involved 5 participants, 3 boys, and 2 girls. Their ages ranged from 23-37 years, and all worked in SMEs. The interview took place face-to-face in the meeting room of one of the companies on 6 March 2022. In the third focus group interview, we interviewed people who work for a multinational company (Vodafone, Telekom, etc.), SMEs, or their businesses. The participants only knew that they would be asked about their attitudes towards urban transport and sustainability, but we did not mention scooters because we wanted to monitor how they reacted to this new phenomenon in the interview situation.

Thus, in this exploratory part of our research, we conducted a total of three focus groups in 2022, where stakeholders who do not use electric scooters were asked about their attitudes, experiences, and thoughts on the integration of these vehicles into transportation. The three groups were sufficiently demographically heterogeneous to represent public opinion. During the third focus group interview, the level of theoretical teasing was reached, and no substantially new information was presented in the discussion. The details of these interviews are shown in Table

1. The focus group titles shown in the first row of the table are only the authors' afterthoughts, based on the opinions they expressed.

Table 1
Focus groups details

The invented name of the focus group:	The empathic ladies	The skeptics	The 'open-minded'
The number of participants:	5 people (5 Female)	4 people (2 Male, 2 Female)	6 people (4 Female, 2 Male)
Ages:	25-45	28-37	35-45
City:	Budapest	Budapest	Wien, Budapest, Kecskemet, Szigetszentmiklós
Platform:	Ms Teams	Personal	Ms Teams
Duration:	60 min	45 min	80 min
Date:	March 4, 2022.	Marc 6, 2022.	March 8, 2022.

4.1. Research Questions

We used a pre-planned guideline with semi-structured open-ended questions for the focus group interviews. Table 2 shows the different types of questions. Starting with the broader topic of sustainability in general, we refined the questions down to their thoughts toward electric scooters and eventually asked them to give their suggestions on how they would integrate this new type of vehicle into urban transport.

Table 2
Research question types

Opening questions	Please briefly introduce yourself. What does sustainability mean to you? How do you do it in your everyday life?
Introductory questions	What mode of transport do you use to get to work? Why did you choose this? If it is not easily available to you, what other method of transport do you choose?
Transition questions	What types of shared electric vehicles are currently available in Hungary (car, scooter, motorbike, bicycle)? Have you used any of these? Are there any that you use regularly? If yes, why? What do you think about them?
Key questions	What do you think about electric scooters? What does an electric scooter mean to you? Have you ever tried them? Will you ever try them? What equipment and rules would you need to ever try an electric scooter? Please, don't hold yourself back!
Ending questions	Do you have anything else to say?

4.2. Coding

The data analysis method was conducted by hand rather than using a computer-assisted qualitative data analysis software tool, which allowed us to completely immerse and engage with the material (Fielding-Lee, 1995) and appreciate any subtle nuances it included. From the transcripts of the focus group interviews, we first highlighted the key concepts and narratives that were expressed during all three interviews and then used them to construct a nomological network of the phenomenon.

4.3. Ethic

Before attending the focus group, participants were asked to sign a consent form. Each participant was allowed to read the consent and ask questions once they arrived at the focus group. When they were ready, each participant signed a formal consent form.

5 Results of the Nomological Network

The results are presented in the logical order specified in the nomological network. However, the unique characteristics and typical statements are taken from the entire interview because additional comments and thoughts about a single topic were provided in numerous questions. The traits represent factors that are consistent across the three interviews.

5.1. Attitudes toward Electric Scooters

Using an electric scooter is difficult. The vast majority of people dislike it. On the one hand, they consider the risk of an accident, and the storing and charging are unpredictable. It is expected that a change will only happen when scootering becomes a part of daily life and pedestrians and motorists or car drivers become familiar with people who use this mode of transportation. The legislation is expected to include establishing the necessary driving license and protective equipment, as well as speed limits for scooters.

According to conversations, the lack of specific regulations on where scooters can and cannot be placed is a continuous challenge for all road users: Illegally parked scooters, sometimes littered and leaning against the sidewalk or bike path, are a common sight on the streets. Conflicts over space were thought to be one of the most relevant issues highlighted in the three interviews, both before and after the introduction of e-scooters, particularly in the framework of a race between e-scooter users and non-users (cyclists/pedestrians). The main point of contention was whether e-scooters should be prohibited from pedestrian areas and sidewalks. Even

though, the lack of dedicated infrastructure for e-scooters was highlighted by some interviewers as an issue of space distribution, also in comparison to the generous allocation of space to the car for both driving and parking.

Irresponsible riding, littering, and vandalism are important sources of conflict in many answers. 'Irresponsible riding' includes riding at crazy speeds, riding recklessly, and riding on sidewalks or pedestrian areas where it is not permitted. Cluttering refers to unplanned parking or e-scooters 'left' on pavements. Vandalism includes both intentional destruction, such as throwing e-scooters into lakes and rivers, and more common kinds of ransacking.

Based on the interviews we discovered that several problems appeared unexpectedly. This includes vandalism, e-scooter lifetime, and the requirement to recycle or dispose of e-scooters.

The focus group discussions made clear that the more people use micro-mobility devices, the more car traffic in city centers can be reduced; but like with any transportation system, this requires the necessary infrastructure. Another important consideration that comes from the interviews is that commuters should be able to travel from railway or bus stations not only by vehicle or public transportation but also by shared systems such as scooters and bicycles.

Many respondents noted a desire to investigate or use electric scooters, but only for short distances that could be covered on foot. For example, in office parks, between buildings, or from transportation hubs to office buildings. However, the following is required: appropriate infrastructure, secure, well-designed docking stations capable of storing several scooters and fitting in restricted spaces, using renewable energy sources to charge.

5.2. Attitudes toward Alternative Transportation Modes

All respondents from the first focus group ('emphatic ladies') use public transport to get to work because they do not have to sit in traffic jams, do not have to look for parking spaces, and can do other useful activities during the journey (e.g., reading, working, studying, etc.).

Three participants in the second group ('skeptics') go to work every day in an office complex in an outer district, so they usually drive. The fourth person has his own business but often must transport machinery and other goods, so he also mainly travels by car. They use car-sharing services for leisure activities (e.g., going to a restaurant in the evening). When asked, they said that they do not use public transport at all because it takes too long to get to work and is crowded and inconvenient.

Many of the participants in the third focus group ('open-minded') mentioned that they ride their bikes to work, not only because it saves time, but also because cycling

is a great activity. The only drawback is that it is not very practical in winter or rainy weather.

During the discussion, car-sharing networks were mentioned several times as a possible sustainable transport alternative. At the same time, respondents know that the operators of these sharing systems are also businesses, and they aim to make as much profit as possible. They are constantly expanding their fleet, often even rearranging cars/scooters at night. The question is how sustainable they are.

Based on the information presented above, we discovered that electric cars are also a popular mode of transportation among participants because they can be charged for free in the office building, they do not pollute the environment, they are very comfortable, and they are already covering more and more kilometers without needing to be charged.

5.3. Attitudes toward Government Policies

Generally, the respondents are not satisfied with the current rules. The reason for this, according to them, is that there is no clear definition of the means of transport (is this now a means of transport classified as a moped, a motorbike, or a bike?), no uniform definition of parking, and no uniform definition of the appropriate speed. In the case of electric scooters, they believe that it is essential to define where and what are the speed limits for using this device. In the interests of safety, it would also be possible to define the various specifications and protective equipment since: *'Typically, these are devices that can be used at speeds of up to 25 km/h, and in extreme cases at speeds of over 50 km/h.'* They believe that not only the issue of defining the right speed but also the issue of parking is not solved now. There are districts where the government has already started to identify so-called micro-mobility points, where it is obligatory to park electric scooters. Most of them argue that the painted micro-mobility points will not solve the chaos caused by e-scooters, they will just reduce it to a smaller area and then maybe the scooters will not be thrown away anywhere in the streets, but only around the micro-mobility points. This raises another problem, would anyone who wants to use one, pick from the hundreds of littered scooters? According to the participants, the problem of dropped scooters can be temporarily solved by the establishment of micro-mobility points, but this will make parking in the already crowded city center more difficult for local municipalities or make already narrow sidewalks even narrower. In addition, if it is not mandatory, users will not take their scooters there or, if they do, they will throw them on top of each other, which is not very aesthetically attractive and will damage the scooters and shorten their lifetime.

5.4. Attitudes toward Sustainability

We can assume from the responses from the three focus groups that sustainability and everyday goals toward sustainability are becoming increasingly significant in

the lives of consumers. Interviews revealed that respondents are aware that electric scooters also pollute the environment. E-scooters' carbon-dioxide emissions, like the other types of electromobility, are principally caused by manufacture, servicing, and daily transportation for maintenance and charging.

However, they think that any type of electric vehicle is better for the urban environment because it makes a difference whether we must breathe dusty, sooty, smokey air and live in continuous noise or live in cleaner air and quieter cities. In comparison to electric cars, the importance of energy supply for shared e-scooter charging is relatively modest.

They know that there are still bad practices that lead to unnecessary carbon-dioxide emissions, such as, for example, in districts of Budapest that take e-scooters off the streets every night even in cases where they are fully recharged. The participants proposed that more environmentally friendly methods of collecting the scooters for maintenance and charging are required. In general, they mentioned that using removable batteries and electrified vehicles for collection, as well as dispersed charging infrastructure, are operation characteristics that contribute to emissions reduction.

They know that the production of lithium-ion batteries for electric scooters and bicycles has a significant environmental impact through the mining of raw materials, so recycling battery cells can be an important milestone in minimizing or eliminating carbon emissions. The primary source of recycling could be from batteries in electric vehicles, as they are typically taken out of service when the vehicle's performance starts to fall short of the predicted range. At this point, the battery is still at 70-80% charge. The biggest challenge of recycling is that these batteries are made up of hundreds of lithium-ion battery cells, each of which ages in different ways, and like a single link in a chain, the weakest battery typically reduces the capacity of the whole system. Precisely for this reason, the major question for them is what will happen to use lithium-ion batteries.

6 Implications

In Budapest, there are districts from which e-scooters are banned until the issue of storage and maximizing top speed is resolved in a way that is satisfactory for all stakeholders. This is illustrated in Figure 1.

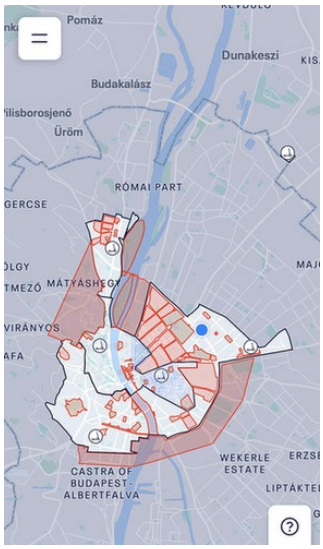

Figure 1

The districts in Budapest where you cannot stop the app and park your e-scooter

Other municipalities in Hungary, by contrast, have decided to allow scooters into their districts only if the service operators arrange charging and storage. Therefore, a network of scooter and bicycle parking, known as micro-mobility points, has been set up in the city center, first in districts V, VI, VII, VIII, and XIII of Budapest. The micro-mobility points will be designated by the local authority in the public space and will charge a fee for their use to the scooter and bicycle companies using them, at least in the frequented areas. E-scooter riders can only complete their journey and drop off their vehicles inside the parking area because the built-in GPS does not allow them to continue their journey elsewhere. Anyone who does not return it will be charged 10.000 HUF by the operator, which will be billed to the user. In many places, there will initially be virtual zones without signage, where vehicles can be parked using GPS. Using GPS, scooter operators can also set up zones where they will only allow scooters to travel at reduced speeds or switch off the electric motor.

An integrated transport service platform is also being developed, which will be a mobile phone application showing where the micro-mobility points are, how many free scooters, bikes, scooters, or public cars are available, and even how many can be booked. The app can also be used to plan a route, in principle by comparing all shared vehicles and public transport to find the optimal option. The micro-mobility points represent a major step towards the wider adoption of micro-mobility devices.

In addition, a Hungarian startup has also taken the parking and charging of electric scooters to heart. They design and manufacture electric scooter charging and docking stations that can be used to organize the devices in public areas while

reducing the charging costs and emissions for the operators. The start-up aims to build a national network of charging and docking stations in the next 2-3 years, in cooperation with local cities, municipalities, transport providers, and e-roller service providers. This would involve hundreds or even thousands of docking and charging stations, ensuring a tidy urban landscape while optimizing costs for operators.

Conclusions

While the advantages of micro-mobility and emerging flexible modes such as e-scooters are obvious, they also represent regulatory issues for municipalities. Concerns over safety, vandalism, and regulatory uncertainty have cast some doubt on the new mode's long-term feasibility. Until recently, e-scooters operated in a relative 'grey zone' in various places throughout the world since they were not included in the existing vehicle law.

In the theoretical introduction, we discussed the important factors on which the qualitative research described here was founded. The relevance of our study is not only given by the current economic situation (high petrol prices) but also by the significant social and even environmental benefits that can be derived from the decision-maker's understanding of users' expectations and attitudes towards electric scooters. The examples presented in different publications, different perspectives, and the results of our research show a wide range of attitudes of respondents towards sustainability, alternative transport, and electric scooters.

In the search for a solution, we explored the needs of our respondents regarding the infrastructure and regulation of electric scooters: we highlighted the most important measures and regulations for the target group – which, if in place, would make them willing to use electric scooters – to offer decision-makers the opportunity to integrate an ideal e-scooter ecosystem into the urban environment, contributing to a more orderly urban landscape and a positive image of electric scooters.

Our research focused on non-user perceptions of the use and limitations of shared e-scooters in Hungary. According to the interviews and our nomological network, the social construction of the meaning of electric scooter is shaped by:

- the technological affordances: such as GPS-based mobile apps and docking-charging stations in between the public transport and the free P+R stations,
- the business ecosystem: the emergence of electric scooters in urban transport has made it necessary to build new infrastructure and thus a new type of mobility solution, as the storing and the charging of scooters had to be provided,
- the government policies: the most important thing would be for the government to regulate intoxicated e-scooter riding, the age limits for using e-scooters, the number of people who can use an electric scooter at the same time, and the use of mobile phones while scootering,

- the user types/attitudes: in terms of impressions of the respondent's everyday mobility or for society and people's everyday mobility, non-users typically perceive e-scooters as harmful or wholly harmful, demonstrating significant differences in attitudes between users and non-users. The most common reason they are not using scooters is that they are satisfied with present modes of transportation and not seeing a clear necessity, as well as do not feel safe using an e-scooter in Hungary.

There are several implications for further development. First, we cannot emphasize enough how significantly the adaptation challenge relates to urban infrastructure and space allocation. As mentioned in the interviews, comprehensive policy design processes are required. These parts should be co-developed in collaboration with a variety of stakeholders, to facilitate discussion of various policy measures, recognizing their effectiveness in terms of behavioral change as well as their implementability. Based on the focus group interviews, optimal policy design would rely on national-level regulation of aspects such as drunk riding, speed, and user age, multi-stakeholder campaigns, particularly targeting non-cooperative behavior, development of education programs for all mobility system users, rules for usage/parking in specific urban areas, and further development of user recognition and verification technology in the e-scooter vehicle and associated digital platform.

On a theoretical level, several underlying questions in the governance culture have emerged, as has been typical when developing technologies deployed in a community. Higher reflection on the concept of developing technology and confrontational discussion, adaptability, and responsibility with engaging less but smartly, as well as long-term organizational learning based on experimentation and evaluation, will be required in governance culture. Simultaneously, there is an essential question about the hierarchical position of e-scooters with other modes of transportation in Hungary.

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