Economic Analysis and Impact of E-Scooter Sharing Systems

Masterarbeit

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1. Introduction

Means of transportation are an ineluctable part of everybody's daily life. The market is in constant change in order to adapt to new exigencies. Especially in the area of passenger transportation, innovations and new approaches can be seen. Sharing mobility, mobility as a service (MaaS), or mobility on demand are terms that cover innovations and developments in the this sector. Micromobility is a part of this change and wants to be a part of the answer to polluted urban areas, crowded transportation spaces, limited parking space, and the need of individual transport (Santacreu et al. 2020). It also represents an increasing market with strong investments. Since 2015 investments about $5.7 billion took place in micromobility start ups (Heineke et al. 2019). One device is attracting particular attention due to its growing presence in cities - the e-scooter. E-scooters are a part of this trend going towards micromobility in urban areas. Media coverage of e-scooters with all its highs and lows is very present since its introduction in 2017 (Fong, McDermott, and Lucchi 2019). This is a result of its accelerated expansion. As soon as e-scooters were presented as a new mode of urban mobility they seemed to cover every corner of cities that suited their requirements.

The motivation to examine this field more closely depends on different aspects. The developments in the market and the upcoming of a new transportation mode are very interesting from an economic perspective. A number of major investments in the market and high valuations can be seen since the beginning. Additionally, numerous start ups came to existence due to these circumstances and introduced various scooters. An operator, known as Bird, succeeded in being the fastest to ever reach a $1 billion valuation (Fong, McDermott, and Lucchi 2019). Simultaneously, acquisitions of some start ups are announced while the market is facing increasing issues. Besides, the environmental aspect accompanies every change and development in this sector. Each operating company has for a goal to provide sustainable, green services as well as to improve urban mobility (for instance Tier Mobility 2019; Hunter Nilsson 2020a). The transportation sector as a major driver of pollution and emissions is undergoing a change (Todts 2018). Short trip distances and private vehicle usage account for the majority of overall trips (U.S. Department of Transportation 2017). People are growing a more sustainable attitude and are getting aware that the environment plays an increasing role in all areas. Thus, innovations like e-scooters become increasingly relevant. Even though the services currently only take place in urban areas, the awareness of the topic is high. These circumstances enable the possibility for other modes, which are better suited for short trips, to be established. E-scooters can therefore be a sustainable alternative for combustion engine vehicles. This relatively new kind of transportation is still at the beginning of its development but shows

potential in every area of its business.
Companies in the market claim to offer climate neutral transportation and illustrate the e-scooter as a solution to transportation problems. The high investments and valuations of this market indicate the involvement of economically strong companies. These circumstances provide a sufficient base to take an interest in the topic. In addition, no research paper including e-scooter economics was identified which supports this approach. Little research is published on environmental evaluations of e-scooter sharing systems, including different assumptions and fundamentals. This little information still allows us to have a first look on the range of impact that e-scooter sharing systems currently have.
These observations lead to multiple questions developed and discussed in the underlying research paper:

I On what are the e-scooter economics based and how has the business developed since its introduction?

II Which part of the e-scooter life cycle has the biggest environmental impact?

III Is e-scooter sharing a sustainable transportation mode?

The following chapter presents a classification of the e-scooter in context of personal mobility and transportation market. Since literature concentrating on e-scooters is scarce, other free floating transportation modes are additionally presented. Hence, a broader view is presented in order to better understand, compare, and put in context the main topic. Chapter 3 includes fundamentals about the e-scooter market and provides economic figures of operators. Besides valuations and the market size, the e-scooter economics, with all its contributing factors, are examined. The focus lays on the unit economics and the profitability of the companies. In order to describe the impact of e-scooters on the environment chapter 4 presents the systematic literature review as the methodology on which the analysis is based. Subsequently, the e-scooter repercussions are evaluated and presented through life cycle assessments (LCA). The Environmental impacts of current e-scooters operations are put into context with other transportation modes. This approach is believed to be appropriate to provide accurate answers on the economic and environmental questions. Implications are revealed afterwards. Finally, limitations of the work are outlined before the conclusion is presented.

6. Conclusion

This paper provides an extensive literature review and presents the current state of research in the field of e-scooter sharing systems. In order to present a holistic picture of the topic, research for related modes, such as FFBS, FFCS, FFMS is included. Thus, specific characteristics and differences of FFS are exposed. E-scooters are characterized by the usage of mostly younger people for trip distances up to 3 km and an average ride time of 17 minutes (Smith and Schwieterman 2018; Heineke et al. 2019). Leisure and spontaneous trips are more common than commuting (Degele et al. 2018). The access and availability to mobility services have major impacts on pollution and customer perception. There is evidence that micromobility services tackle the first and last mile problem (Santacreu et al. 2020).

This research aimed to identify how the e-scooter business developed and on what the e-scooter economics are based. It can be concluded that the business model extended by selling scooters and a shift to in house labor takes place. The durability of the hardware increased and got adapted to the fleet usage. The economics are primarily influenced by the e-scooter lifetime and utilization as well as the distribution process and increasingly by the maintenance and repair. The unit economics, and therefore, the profitability enhanced since the beginning. Increasing prices for the costumer can be seen, resulting in more profitable margins for the companies and the chance to operate a sustainable business. The general lifetime of e-scooters is estimated to be up to 2 years for new models, increasing from around 3 month for the first consumer electronic scooters used in shared fleets. This and increasing prices will lead to quicker amortization and longer periods of profitability. However, the investor money is needed in order to operate, since companies aren't profitable at this moment (Carson 2019; Weinberg 2019).

E-scooters got adopted rather quickly compared to former mobility options, due to the familiarity of the public with previous sharing transportation devices. They represent an additional contribution to the needed change in urban mobility. The fluctuation in the market is high and first minute market players already got acquired. The valuations and funding in the market are estimated to balance on lower levels. It is conceivable that the US and Europe will be the major markets for e-scooter business. The different pricing and the higher willingness to pay for mobility services in these regions support this. The use of e-scooters is more expensive compared to other FFS. E-scooter companies need to adjust and optimize their supply in order to meet the demand and to reach the needed high utilization. This is a challenge solved via customer acquisition, pricing and a specific setup for each city.

The analysis aimed to identify the most polluting parts of the life cycle and to evaluate

whether e-scooters are a sustainable transportation mode. The results show that the MaM phase has the biggest environmental impact overall for each impact category. Inside this part the main polluters are the aluminum frame, the battery and the circuit board. This is followed by the collection and distribution, in the case that it is performed by combustion engine vehicles. The transport to the place of use, the usage and final operation in urban areas has rather small impact. This proves that the countries producing e-scooters carry the burdens coming along with it rather than the countries operating it. Air pollution of urban areas can be prevented by e-scooter usage if electrified vehicles perform the distribution. The considered lifetime and use intensity have major effects on the pollution per passenger kilometer.

Current FFSS services show a GWP range from 64.7g CO_2-eq/p·km^{-1} to 131g CO_2-eq/p·km^{-1}, excluding repair and recycling processes. Including these process steps shows that the GWP can reach a level of 34.7 g CO_2-eq/p·km^{-1}, especially if lifetime estimations prove to be correct. Not only the end of life processes contribute to this decrease, but also operational process improvements, like a sustainable-energy electric-fleet based distribution of exchangeable batteries, route optimization, and policies that allow scooters to stay on the streets are part of it.

Together, the results indicate that under current operational setups, e-scooters are only a sustainable choice if the ride displaces a car trip. Related work research for bikes, the close look on the substituted modes and the connected pollution for e-scooter, shows that free floating mobility systems have a problem with substituting the *correct* mode. In both cases high shares for PT, walking and biking displacement can be seen. In an improved operational setup e-scooters can be a more sustainable choice than established urban transportation modes. There is a high need of communication and pointing customers in the right direction. The adoption of these services increased over the last years but it is somehow not perfectly used. There is a need for substitution of more polluting modes, especially cars, and incentives that make customers use free floating mobility complementary to PT.

The results show that e-scooters won't revolutionize the urban mobility. However, they represent another approach to solve the issues in urban transportation and will survive and establish themselves in most cities. In PT rare areas and for the connection to these they can be very beneficial. E-scooters will find a place in the mobility supply and a customer base. They do not represent the single solution for urban mobility issues but they are a part of the solution and increase the awareness of the public towards mobility problems. The high media coverage is a positive factor as it also enables the view towards other mobility solutions and influence people to think about shared mobility. Companies must find a balance between profitable business, reasonable prices for end customers, and

improvements going towards e-scooters as a sustainable mode.
The analysis shows the characteristics of, and the link between, the economic and environmental aspects of FFSS. There is a need for further research in both areas. Detailed LCAs are needed to interpret different setup outcomes and to vary parameters. Analyzing market potential for untapped markets and, to therefore identify variables of e-scooter demand and pricing, represents also an area for further research.