Activity Deliverable

MOBY - Living lab e-micromobility

Description of business models

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1. Executive Summary

The innovation dynamics of the development of e-micromobility is fast and investments tend to be driven more by expectations on business growth and future values, rather than short term profits, or even business models geared towards profitable businesses in a medium or long term time horizon. Thus, to identify requirements for business models on this market that are economically, socially and environmentally (i.e., enable and encourage modal shift towards low impact options) sustainable needs a thorough investigation. To this extent, activity A2004 of the MOBY project included 1) the mapping and qualitative analysis of existing qualitative business models of shared e-micromobility service operators in four cities Stockholm, Tel Aviv, Barcelona and Munich and 2) the analysis of quantitative macroscopic models and information sources for the estimation of service demand and usage and business attractiveness indicators.

The table of the document information gives the names, affiliation, and roles of the participating partners who has developed the deliverable. After the initial phases of the MOBY in Q1 of 2020, the information for the deliverable was gathered and analyzed under Q2 and Q3. The methodology, results, conclusions of the qualitative and quantitative business model analysis are as follows.

The qualitative business model analysis generally fulfilled the objectives of the subtask (see Section 2.1). The business models of the most significant providers in respective cities with respect to their value propositions, value creation processes, and value capture mechanisms have been mapped and analyzed. The analyzed cities constitute very different business settings, where Stockholm and Munich (so far) have a liberal policy towards, e-scooters; Tel Aviv has a strictly regulated market; while Barcelona, so far, applies juridical barriers that hinders a market to develop. Beneath the regulative regime, however, all e-scooter providers included in the study are applying one and the same generic business model (with small variations).

The e-kickscooter business seems, so far, to be a venture capital driven market where various scooter providers try to position themselves, in order to become market leaders and gain advantages for, e.g. public procurements, in the future. Many of the scooter providers still experiment with different kind of pricing models, number of scooters, scooter designs, and to collaborate with other type of actors in order to expand their value propositions and services offered.

In the qualitative business model analysis of the four cities, three types of policy regimes were identified, each creating specific business conditions for the e-scooter providers: (1) the liberal “Wild west”, (2) “The opportunistic-exploitive”, and (3) “The protective-conservative”. Under these three regimes, various trends affecting the business models and strategies of the providers were identified (see section 7.1)

In addition, one experience from the empirical studies behind the qualitative analysis is that the e-scooter market is a vague and dynamic research object. The e-scooter providers are in general difficult to approach and are hesitant to provide access to researchers. Something that has been even more problematic during the Covid-19 period. Thus, the mapping had to a large extent been based on public, written material. However, the current empirical material provides a rich resource for deeper analysis, e.g. concerning comparisons with other transport services.

The results of the quantitative business model analysis reached the objectives that were set out for the subtask (see Section 2.2). In particular, an extensive literature review of quantitative (macroscopic) demand models for shared e-micromobility services has been performed (see Section 6.1) according the methodology that was in line with what was proposed in BP2020 and is explained in Section 5. As part of the literature review, an inventory of information and data sources and methods have been created (see supplementary material DEL04-SUPP1_DemandModel.xls). A deep analysis of the reviewed models' structure, input data, variables and results (see Section 6.2) reveals that one can construct models that estimate realistic shared e-micromobility service demand in the context of the larger transport system (including public transit), and some models can even adequately model service integration with public transport services via incentives or restrictions. However, as it is summarized in Section 7.2, while such models can be applied to different geographies to estimate service demand, they are data and computationally intensive.

Also, there is no obvious choice for a universal model and data sources that would allow to quantify the business opportunity in terms of estimated service demand and hence business profitability (under some cost assumptions) for different service deployment scenarios, which was aimed to be built as part of BP2021. Nonetheless, the value of such a universal model and a simple web-based decisions support tool for shared e-micromobility service planning is enormous. Such tool would allow operators to evaluate market opportunities for deployment scenarios with positive unit economics at the tactical / strategic level. Thus it could have similar disruptive effects on the shared e-micromobility market as the emerging services that provide improve vehicle utilization and unit economics via supply-demand balancing and dynamic pricing at the operational level (Section 7.1.4).

As a good understanding of current qualitative and quantitative business models is an important component in the roadmaps for successfully integrating e-micromobility devices into the existing mobility infrastructure of the pilot cities. Thus, this deliverable contributes to the MOBY project output OUT06 "Guidance material". As this guidance material could be a main component of a possible commercialization strategy but is not part of the current final commercialization agreement, this deliverable also contributes to a possible future commercialization strategy.

2. Introduction

This deliverable details the work performed and the results obtained in the Activity A2004 - Definition of business areas and business models of the MOBY project.

The innovation dynamics of the development of e-micromobility is fast and investments tend to be driven more by expectations on business growth and future values, rather than short term profits, or even business models geared towards profitable businesses in a medium or long term time horizon. Thus, to identify requirements for business models on this market that are economically, socially and environmentally (i.e., enable and encourage modal shift towards low impact options) sustainable needs a thorough investigation. To this extent, activity A2004 included 1) the mapping and analysis of existing qualitative business models of shared e-micromobility service operators in four cities Stockholm, Tel Aviv, Barcelona and Munich and 2) the analysis of quantitative macroscopic models and information sources for the estimation of service demand and usage and business attractiveness indicators. The respective qualitative and quantitative business model analysis objectives are outlined below.

2.1. Qualitative Business Model Analysis Objectives

1. Empirically map the most significant providers of e-micromobile fleets in the addressed cities:
   - Who are the providers?
   - What kind of vehicles do they provide?
   - What technologies?
   - What are their business strategies?
   - And if possible; who are their owners?
2. With this background data, an analysis of the business models of the most significant companies is conducted with respect to the three components:
   - The value propositions
   - The value deliveries
   - The value capture (revenue models applied)
3. Comparisons with other mobility services (taxi, Uber, rental bikes, car sharing, etc.) and other kinds of digital, or semi-digital, services.

2.2. Quantitative Business Model Analysis Objectives

1. Review literature of quantitative macroscopic demand models for shared e-micromobility services

2. Create and inventory of over information and data sources and methods

The rest of this document is structured as follows. Sections 3 and 4 respectively detail the methodology and results of the qualitative business model analysis. Whereas, sections 5 and 6 respectively detail the methodology and results of the quantitative business model analysis. Finally, Section 7 presents the conclusions and lessons learned from the two type of analyses.

3. Methodology for Qualitative Business Model Analysis

3.1. The Business Model Concept

There are a number of definitions of the concept "business model", each with a different emphasis and different levels of details and sophistication (c.f. Amit and Zott, 2001; Osterwalder and Pigneur, 2010). However, despite the academic disagreements, there is an emerging, general consensus that the core of a business model comprises three basic elements (see for example. Birkinshaw & Ansari, 2015; DaSilva & Trkman 2014; Tongur & Engwall, 2014; Jovanovic, 2018).:

- Value proposition, i.e. the organization offers its products and services to its customers.
- Value creation, i.e. how this value is created, delivered, and provided to the organization's customers.
- Value capture, i.e. how the firm appropriates parts of the value created for its customers.

Thus, a business model directs attention towards the backbone of any successful business, i.e. the activities connecting the firm's technological core to the fulfilment of its customers' needs. As an analytical concept, a business model constitutes a unit of analysis that explicitly spans the traditional, legal boundaries of the focal firm and relates the firm's internal value-creation activities to activities and structures of the firm's business environment. A business model does always have a focal organizational point, such as a firm, a product, or a business unit, constituting its point of departure and what it encompasses. However, as an analytical tool, it is a boundary-spanning device addressing how the business of a focal organization is intertwined with the business models of its surrounding organizations.

Consequently, a business model perspective on e-kick scooter operations requires the scrutinization of how the value proposition, creation, and capture of the actors involved. In addition, it encompasses how the business model of each actor interacts with other business models of the system.

3.2. Method

The qualitative business model analysis has consequently focused on mapping and analyzing the current e-kickscooter operations in the cities of Stockholm, Tel Aviv, Madrid and Munich. Data has primarily been gathered by public reports, documents and new paper articles, webpages and other corporate information. In some occasions, this data has also been complemented with “reality-tests” of the services provided by actually using the apps and vehicles for test rides.

The original intention was to complement the public sources with interviews with representatives of the most important scooter providers. This idea had however to be abandoned. We experienced significant difficulties in getting access and contacts with providers (and several of them do also provide limited information through public sources). The market is driven by venture capital and many of the scooter sharing companies do not want to reveal information concerning their business models, revenues, and financial status to the public. In addition, the lock-downs following the covid-19 pandemic during the time of the data gathering (spring-summer 2020), made it even more difficult to get access. Thus, such a more in-depth analysis of e-kick scooter operations, is a project for future research.

The exact sources have varied slightly between the cities. They are specified in a reference list for each respective city (see Section 8).

One important disclaimer has to be yielded. Presently, the markets of micromobility, e-kick scooters, and other vehicle sharing services, are fluid. During the period of the study there were significant changes in several cities concerning the number of scooters provided, the number of operators, payment schemes, etc. It is still an emerging market, which has not stabilized. In addition, the regulation of scooter operations is currently a matter of political debate in several cities. Thus, the report analyses the situation during the Summer 2020, this might change quickly, due to how the market evolves.

4. Results of Qualitative Business Model Analysis

The qualitative business model analysis generally fulfilled the objectives of the subtask (see Section 2.1). The business models of the most significant providers in respective cities with respect to their value propositions, value creation processes, and value capture mechanisms have been mapped and analyzed. The analyzed cities constitute very different business settings, where Stockholm and Munich (so far) have a liberal policy towards, e-scooters; Tel Aviv has a strictly regulated market; while Barcelona, so far, applies juridical barriers that hinders a market to develop. Beneath the regulative regime, however, all e-scooter providers included in the study are applying one and the same generic business model (with small variations).

One experience is that the e-scooter market is a vague and dynamic research object. The e-scooter providers are in general difficult to approach and are hesitant to provide access to researchers. Something that has been even more problematic during the Covid-19 period. Thus, the mapping had to a large extent been based on public, written material. However, the current empirical material provides a rich resource for deeper analysis, e.g. concerning comparisons with other transport services.

4.1. e-Micromobility in Stockholm

There are currently many companies providing shared e-micro mobility in Stockholm. During the time when the study was conducted, there were nine mobility providers that were actively in operation. However, there are signs that the industry might be heading towards a consolidation. The signs of consolidation are that smaller companies are being acquired by larger firms (e.g. Circ being acquired by Bird (Lejonhufvud, 2020)) and also, there are other smaller companies that have fallen out of business (e.g. Glyde removed their electric kick scooters late 2019 (Blixt, 2019a)). Since November 2019, no new competitors have entered the Stockholm market for micro mobility. If this is due to a market saturation or due to the current economic recession starting in spring 2020, making companies acting more restrictively, is yet uncertain. Furthermore, just during the finalizing stage of the study made in Stockholm, two more companies seem to have terminated their e-micro mobility services. In late July 2020, the Vosh scooters quietly seem to have been taken off the streets. If it is a temporary action or a permanent move from the providers is yet unknown. Then, short thereafter, Aimo declared that their scooter service will cease the 1st of August.

4.1.1 Most significant fleet providers

The companies providing micro mobility services in Stockholm in June 2020 are Aimo, Bird, Bolt, Lime, Moow, Tier, Voi, Vosh and Wheels. These are reviewed below, staring with a short introduction of the companies.

Aimo - Aimo Solution is owned by the Japanese corporation Sumitomo Corporation (Aimo Solution, [n.d.]), which are operating a number of industries, including mobility. In Sweden, Aimo Solution was originally only providing a car sharing service, which was enabled using a mobile application (Lejonhufvud, 2019). In August 2019, the company made a lateral move to introduce their own electric kick scooter service, which was made available through the same mobile application as the car sharing service (Lejonhufvud, 2019). Aimo has since a few years back acquired the parking company Q-park to further expand the business (Lejonhufvud, 2019). Aimo’s strategic aim is to first become the leading mobility company in Sweden, and then expand their business out in the rest of Europe (Lejonhufvud, 2019).

During the time of the study, the scooter service was still in operation. However, in the finalizing stages the service was declared to be shut down to leave room for only the car sharing service in their mobile application. However, the analysis which is presented in this report is written as if Aimo’s electric kick scooter services was still in operation. There is no information provided from the company about the reason behind this move.

Bird- Bird was originally one of the first electric kick scooter service providers, and the company originates from California, US. In the beginning of their operation, they introduced their services in public areas within cities without permission from the authorities (SLL, 2019). The situation that followed was rather problematic and the authorities responded by enacting restrictions on the services (SLL, 2019). Now Bird has changed their strategy to be less aggressive, and have started to work together with cities instead. Now they operate in over a hundred cities in Europe, North America and Asia (Goldmann, 2019a). In the beginning of 2020, they acquired the German company Circ, including their 300 employees (Lejonhufvud, 2020)

Bolt - Bolt was first established in Tallin 2013 as a regular taxi application under the name Taxify (Satariano, 2019). It grew to be one of the major competitors in taxi services across the world. They have operations in over 100 countries. In 2019 the name Taxify was replaced by Bolt and the value proposition was extended to also include electric kick scooters (Adeshokan, 2019). The electric kick scooter service will be the area of focus when analyzing Bolt's mobility services in this study. Therefore, the taxi service is not analyzed in any particular detail.

Lime - Lime was first introduced in the United States, and where then some of the early pioneers of providing electric kick scooters (SLL, 2019). However, they raised concerns through their initially controversial market strategy. They used public spaces for distributing their electric kick scooters, without permission from the authorities (SLL, 2019). Many of the authorities' response to the strategy was harsh restrictions to handle the situations that emerged (SLL, 2019). Now, the company strategy seems to have changed, to better cooperate with cities and authorities, driving a more responsible development. Lime was early on the Nordic market, being the second electric kick scooter provider in Stockholm (Kristoffersson & Wallin 2019). Now they are established in more than a hundred cities worldwide (Lime, [n.d.]a).

Moow - Moow is a quiet market player in e-micro mobility, with very limited external communication. They launched their electric kick scooter service in May 2019. Previously they operated a car rental service (Wisterberg, 2019a). Moow only operates in Stockholm.

Tier - Tier originates from Germany, and has been one of the fastest growing micro mobility companies in Europe. After one year they had 11.5 million rides through their electric kick scooter service, and now claim to be the European leader in micro mobility (Tier Mobility, [n.d.]b). The company operates in over 60 cities in 9 countries and have 180 employees (Tier Mobility, [n.d.]a).

Voi - Voi is a Swedish company. It was the first company to provide an electric kick scooter service in Stockholm. They grew fast, and during the first year they reached over a million trips (Kristoffersson & Wallin 2019). Now they are operating in 35 cities and have 4 million users (EY, 2020). They also have over 400 employees (EY, 2020).

Vosh - Nusvar is the company behind the mobility brand Vosh, which now provide an electric kick scooter service in Stockholm. Nusvar is originally the company behind the website MrKoll, which provides services for searching people's personal details and information (Blixt, 2019b). Vosh have a rather anonymous profile, they only operate in Stockholm and have one of the smallest fleets there.

In the finalizing stages of the study of micro mobility providers in Stockholm, the Vosh vehicles were quietly removed from the streets, and it is unclear what this means for the future of the Vosh kick scooter service. However, the study of Vosh is presented as if the operation is still in a normal stage, before the withdrawal of the vehicles.

Wheels - Wheels was first founded in California, US to provide a shared electric bicycle service as an alternative to the shared electric kick scooter services. Shortly thereafter the company expanded their business to be launched in other cities around the US (Los Angeles, San Diego, Miami, Dallas, Austin, Scottsdale, and Cleveland) (Hawkins, 2019). Following the national expansion, the first international move was made to launch the service in Stockholm late 2019 (Hawkins, 2019), where a couple of hundred vehicles were introduced initially (Wilhelmsson, 2019).

4.1.2 Products and services provided

When studying the micro mobility companies in Stockholm, there are some differences and similarities across the different products and services. Moow, Vosh and Aimo currently use the same scooter model from Segway-Ninebot, which is one of the simplest models on the Stockholm market concerning vehicle design and robustness. Voi and Bolt also use a Segway model, though both models are slightly more advanced than the simplest model used by Moow, Vosh and Aimo. Looking at Bird, Tier, Lime and Wheels, they all design their own models, with varying performance levels.

Not all the companies choose to be transparent about the country where the vehicles are manufactured, but the ones that do, all declare that China is the country where the vehicles are manufactured. Segway have manufacturing spots in China and the USA (Segway-Ninebot, [n.d.]).

The mobile applications that are used to provide the services have more or less the same features, and they all seem to have a high performance and are easy to use. They all enable users to start, pause and close journeys, book a scooter and follow up on previous usage. It seems rather clear that the services aim to attract a younger user segment. According to studies of user behavior, the majority of the Swedish users are men, and also that the majority of all users are younger than 35 years old.

Aimo - Aimo provides a mobility service in the form of a combined electric car share and electric scooter service in the same mobile platform. The combination of both a scooter and a car share service in the same platform creates a wider value proposition, so that both shorter trips within the city center can be made using scooter, and also longer trips outside the city (up to two-day rental). The idea is to provide a complete mobility solution that can be used the whole way, from “door-to-door”.

The scooter fleet is rather small (about 70 vehicles) compared to the other kick scooter providers in Stockholm (Lundell, 2019). The scooter service is presented rather like an accessory to the core product which is the electric car share service that operates about 300 cars (Lundell, 2019).

The scooter riding experience from using an Aimo is rather plain compared to some of the other competitors (Strand, 2019). The model is a Segway SNSC1.0. with a 300W engine (according to the label on the vehicle). The negative features are that the wheels are rather small (Ø19 cm), and the shock absorber is single shafted and there is only a single hand break (see Appendix 1 for images). The top speed is 20 km/h and the range in a full charge is 35-45 km (Goldmann, 2019d). There is a protection against uncareful usage as the vehicle is equipped with an alarm that is triggered if the vehicle is not maintained in an upright position after parking.

Bird - Bird provides an electric kick scooter service with their own design and software. Minimalistic design and modern appearance make them stand out from the other competitors. The mobile application is powerful, simple to use and any malfunctions are very rare (Strand, 2019). Bird also offer simple registration for apple users by connecting to Apple pay.

The scooters are molded into one unit to make them more rigid against wearing and rough usage. Their first model was Bird One, now Bird Two has also been introduced in Stockholm with a battery range from 20-25 km and a top speed around 20 km/h (Goldmann, 2019a). Bird One is simpler in design and performance (see Appendix 1 for images) while the second model, Bird Two, is more stable, offer a smoother ride and is designed with a new modern look and more powerful engine. Still, the features are rather slimmed down, with no mobile phone holder, no installed shock absorber and only one hand break. The wheels on Bird Two are Ø22 cm, slightly larger than Bird One which are Ø20 cm.

Apart from providing their own electric kick scooter service for users, they also offer packages for companies that want to start managing their own fleet (Bird, [n.d.]a). This is further explained in section 4.1.6.

Bolt - Bolt uses the advantage of having a combined taxi service and kick scooter service in the same mobile platform as a way to differentiate their value proposition from other electric kick scooter competitors. Thus, they make the scooter service simpler and more accessible, especially for already established Bolt taxi users (Petzinger, 2018).

Their mobile application is well designed and easy to use, even though the combined service with the taxi service makes it slightly more difficult to navigate the app. The application is compatible with apple pay, making registration fast and simple for apple users. Their scooters do not stand out in design, or performance. The model is a Segway SNSC 2.2 with a power of 350W and a maximum speed of 25km/h (according to the label on the vehicle). It is not equipped with shock absorbers, but still offer a stable ride due to the frame design and a wheel size off Ø24 cm (see Appendix 1 for images).

Lime - Lime provides an electric kick scooter service with a high availability. They provide simple and fast transportation within cities and the users claim that the primary reason for using a lime scooter is because of its convenience (SLL, 2019). The scooters are the model Lime-S SZ2.5 (see Appendix 1 for images) and have a range just above 30 km within a full charge (Lime, [n.d.]c). The top speed is 24 km/h according to the label on the scooters. The application is easy to use, and offers fast and easy registration for apple users through apple pay. Nevertheless, there are some features that are unique for Lime: it is possible to make trips in group, by registering guest users and scanning several scooters individually.

The comfort and user experience from riding a Lime is rather plain compared to the other industry competitors. The vehicles provide good sturdiness and stability, however, the negative aspects affecting user experience is that the scooters often are worn down and slow (Strand, 2019). The wheels are also one of the smaller ones available on the market, Ø19 cm, and there is only a single shaft shock absorber and a single hand break. The engine power is 300W.

Moow - The mobile application is an important part of the user experience. However, Moow's application is less advanced than the competitor's, though it still provides the same features. Most prominently, the appearance in the application is rather stale. The vehicles are a Segway SNSC1.0 according to the label on the vehicles (see Appendix 1 for images) with a 300W engine and a battery range of 40 km for a full charge (Goldmann, 2019c). The top speed seems to vary between 22 km/h to 27 km/h (Goldmann, 2019c). The scooters have smaller wheels than the other competitors, Ø18 cm, and they also only have a single shaft shock absorber. There is a single hand break and there are no particular features that makes the scooter stand out. The driver experience is rather plain (Strand, 2019).

Tier - Tier offers micro mobility with high environmental standards and progressive technology development. Tier was the first micro mobility company to provide scooters with a swappable battery and the first-ever integrated helmet solution (Tier Mobility, [n.d.]c). Tier provides their own in-house vehicles, and their kick scooter fleet have been updated to only contain the latest model (see Appendix 1 for images). However, the helmet solution has not yet been introduced in Stockholm. The range within a full charge is not communicated, but estimated to be about 50 kilometers (Goldmann, 2019b). The top speed is 20 km/h, and the scooter have been equipped with large wheels, double hand breaks and robust shock-absorbers for a smoother and safer ride (Goldmann, 2019b). The scooters also have a phone holder and a sturdy kickstand. The wheels are Ø27 cm, which is the largest amongst the electric kick scooter providers. The scooters are equipped with a dual shaft suspension, which increases stability and promotes a smoother ride.

Tier's core value proposition builds on their shared electric kick scooters service, which is described above. Nevertheless, a recently introduced extension to the original service is that Tier offer *electric scooters* in some selected cities. However, the scooter service has not yet been introduced in Stockholm. Tier also offers a product called "My Tier", which are electric kick scooters sold for private ownership. They are private premium scooters and they are equipped with a keyless solution so that the vehicle is unlocked and managed through the complementary mobile application instead of traditional keys (Tier Mobility, [n.d.]d).

Voi - Voi provides electric kick scooters, for transportation within cities. The idea is to offer a faster option instead of walking, easier option instead of biking and a more sustainable option instead of fossil fuel based public transport, taxies or ownership of scooters or cars (Kristoffersson & Wallin 2019).

The mobile application is designed for high performance and simple use (Goldmann, 2018a). The scooters have developed from being rather simple in design and performance, to becoming equipped with more features in later models. Voiager1 was the first model, equipped with one hand break, a simple kickstand, an alarm bell and lights (Voi, [n.d.]b). The shock absorber is built on one shaft, making it less adapted to ride a rough surface (Voi, [n.d.]b). The second model already have a dual shaft shock absorber and an increased stability, improving the user experience (Voi, [n.d.]b). The third model, Segway SNSC 2.3 according to the label of the vehicles (see Appendix 1 for images), is said to be revolutionizing in its features and performance (Voi, [n.d.]b) and is the current model used for the Stockholm market. It is equipped with an improved dual shaft shock absorber for a smoother journey, a hanger for bags, a phone holder, 4G connection for faster unlocking, and a display showing the different zones a user travels through (Voi, [n.d.]b). The top speed is about 20km/h (Goldmann, 2018a) and the vehicle power is 250W. The wheels are Ø22 cm, which is making it more stable to ride than the vehicles with smaller wheels. All the competitors have chosen to present the battery level in distance range, though Voi is presenting the battery charge level in percentage of a full charge. This may be a disadvantage as it makes it harder for a user to decide if there is enough charge for the planned trip.

Vosh - Vosh electric kick scooter service does not stand out in any particular matter except for the fact that they are the only kick scooter service that provides a feature of the scooter that enables a 10% power boost for the engine, for a more powerful acceleration (Strand, 2019). This additional service is provided at an extra cost through the mobile application. Even without the power boost activated, the scooters are one of the fastest compared to the competitors, about 24 km/h (Strand, 2019). The vehicles are a Segway model, same as Moow and Aimo (see Appendix 1 for images). The mobile application is not very advanced and looks the same as Moow's mobile application, though it provides the same basic features as the competitors.

Vosh do not only operate vehicle fleets, but also provide management systems for fleet managers (Vosh, n.d.) and this is further explained in section 4.1.6. According to Moow's mobile application, they use Vosh software as management system.

Wheels - The way Wheels stand out amongst micro mobility companies is through their vehicles. Instead of providing electric kick scooters like their competitors, they provide electric *bicycles* with pegs for the feet instead of pedals (see Appendix 1 for images). The business is provided according to the same basic model as the other micro mobility competitors in Stockholm; using a mobile application that provides access to the bicycles in public areas within Stockholm city. The product is marketed to address a premium user segment and thus also comes with a higher price than the other e-micro mobility services (Wisterberg, 2019b). To extend the value proposition the bikes are also equipped with a Bluetooth-connected music speaker (Wheels, [n.d.]a).

The mobile application is simple to use and easy to navigate. The advantage of riding a bike in comparison to a kick scooter is that the wheels are larger (Ø31 cm), making riding smoother and more stable (Wisterberg, 2019b). Also, the center of gravity is lower and it is possible to use the feet for extra support to make a safer ride (Wisterberg, 2019b). The bicycles have a full battery range just over 40 km (Wheels, [n.d.]b), a top speed at 20 km/h and engine power set to 250W (Wisterberg, 2019b). Wheels have come up with a smart, shareable helmet system. The helmet is accessed through the mobile app, and for hygienic reasons, it comes with a removable hygienic liner (Dickney, 2019). The service is however not yet introduced for the vehicles in Stockholm.

Apart from their basic value proposition, they also provide a private bike rental service with a weekly or monthly plan (Wheels, [n.d.]b). The bicycles provided for private rental are now equipped with self-cleansing handlebars and breaks to limit the risk of infections during the Covid-19 pandemic. The handlebar innovation is provided by NanoSeptic, and it uses an oxidation process to continuously break down microscopic organic contamination (Denbratt & Lindnér, 2020). Furthermore, prior to delivery, the bikes are cleaned, to limit spread of possible infections. The bike is delivered to the doorstep along with a home charging cable, and then the user has access to unlimited rides during the entire period of rental. When the subscription is cancelled, the bicycle is picked up by someone from the Wheels Crew.

4.1.3 Distributing and marketing to customers

The basic model for providing the micro mobility services in Stockholm is through the use of a mobile application. Users are then enabled to select vehicles and book and pay for trips. A user may operate a vehicle using the mobile application, where an account is created by registering personal details and a credit card. The price is displayed in the mobile application and a user may select a vehicle on an interactive map, which shows all the available vehicles in the area and their battery level. The selected vehicle is unlocked by scanning the bar code placed on the particular unit.

The companies provide electric micro mobility vehicles to their users by placing them in public areas within the zone of operation which is controlled by geo-fencing. In Stockholm they are all placed in the city center, though the exact geographic boundaries differ slightly between different providers. New users are exposed to the services by seeing vehicles and other users in their daily city environment, thus this makes out the primary channel for marketing. Some use e-mails for information and promotion campaigns directed to already established customers.

As an additional access channel to the mobility services in Stockholm, there are also external mobile applications where users may overlook the locations of the vehicles from several micro mobility fleets, in order to find the closest, most suitable vehicle independently from a specific fleet operator. The primary mobile application for this type of service is eScoot, showing vehicles from Voi, Tier, Lime and Bolt.

Many of the companies in Stockholm use social and environmental sustainability aspects to promote themselves in their marketing communication. The environmental aspects are often referred to in terms of reduced climate impact and improved life span of the vehicles. Social aspects include safe and accessible mobility, and there is a general willingness to create an image of being a responsible company with responsible services. A part of the reason to this marketing strategy is because companies in Stockholm in micro mobility previously have received extensive criticism in the local public debate (SLL, 2019; Micu, 2019). As a result, it has become industry standard to provide clear safety instructions when a trip is initiated in order to promote safe and responsible usage. Furthermore, it has also become an industry standard to request a photograph of the selected parking spot before a user is able to finalize a trip, to ensure that the parked vehicle is not disturbing other traffic or is at risk being damaged. The standard age limit for using micro mobility services in Stockholm is 18 years old.

The sustainability aspect has also been under debate, especially since the services in Stockholm primarily is said to replace trips that otherwise would be made by foot, and the short life span is seen as a problem towards limiting emissions (SLL, 2020). This is probably one of the reasons to why many promote their services to be more environmentally sustainable.

Aimo - Aimo's company motto is to "rethink mobility", so that mobility becomes less dependent on car ownership (Aimo Solution, [n.d.]). The social and environmental aspects are described as important, but is not gaining much attention in Aimo's marketing communication.

They use frequent e-mail send-outs as way of communicating with already established customers, thus promoting usage. The age limit for driving an Aimo kick scooter is 19 years old, which is one year older than all the other competitors. There is also need to have a valid driver's license registered in the application. This is a result from having a combined car sharing service and an electric kick scooter service in the same mobile application, but still may seem to be a disadvantage for scooter users especially since many micro mobility users come from the younger user segment (SLL, 2019). The accessibility is low seeing that they operate one of the smallest fleets in Stockholm.

Bird - Bird's mission is "to make cities more livable by reducing car usage, traffic, and carbon emissions" (Bird, [n.d.]d). Moving away from their original expansion strategy which was considered too aggressive by many, Bird is now partnering with cities around the world, to find models to reduce emissions and maximizing the positive impact from micro mobility (according to the Bird mobile application). Now they are gaining respect as a more conscious company in micro mobility.

Environmental sustainability is an element of their business which is not very central in their marketing communication. However, they promote safety by for example introducing low speed zones through the operating system. Furthermore, the application makes it easy to find instructions and rules of usage (for example parking in designated areas, not to ride faster than 6 km/h on sidewalks, not to drive under the effects of alcohol etc.). Bird operates one of the largest fleets in Stockholm (based on the number of vehicles seen in the city and the number of vehicles in the mobile application), making accessibility high.

Bolt - The social and environmental aspects are not highly prioritized in Bolt's marketing strategy. They instead emphasize the simplicity, accessibility and how fast it is to use their scooter services for shorter trips that do not require a taxi (Bolt, [n.d.]a). Bolt in Sweden use e-mails to communicate discounts and campaigns to already existing customers, thus promoting usage. The fleet size is large, which makes a good accessibility.

Lime - Lime has the largest geographic area covered in the Stockholm region compared to the other micro mobility providers (based on the geographic area presented in the mobile applications), increasing flexibility and usability. The general aim of the organization is to increase sustainability and responsible usage of their scooters, and thus have started campaigns and partnerships with this purpose. Despite the turbulent initial launch of the company, they now seem to have earned a more serious profile as a business, improving the value proposition towards conscious users.

Social and environmental gains are presented in Lime's communication as part of their branding strategy. Their aim is to "connect communities" and to" reinvent multimodal transportation, helping people get where they need to go quicker, easier and more affordably than ever before" (Lime, [n.d.]b). They especially communicate that they aim for improving mobility for the poorer segment, thus introducing low prices (Goldmann, 2018b). Lime work to improve safety in traffic. For example, they use geofencing to reduce speeds in certain risk areas. They have also claimed that they take social responsibility as 40% of their users are women, more than bike share services, which show a potential that micro mobility may serve to mend gender inequalities (SLL, 2019).

Accessibility is a great advantage in Lime's value proposition. Apart from being accessible in a larger geographic area than the competitors, lime has one of the largest fleets in Stockholm (based on the number of vehicles that can be seen in the city). Furthermore, Lime has established a partnership with Uber which makes them accessible through their mobile application for taxi services. Thus, users may benefit from a combined taxi and shared electric kick scooter service, which is strengthening the value proposition.

Moow - The way that Moow stand out amongst the other competitors is that they are the only kick scooter company to operate an eco-labelled fleet. They have been assigned the label "Good Environmental Choice" from Swedish Society for Nature Conservation (Naturskyddsföreningen) which is strengthening the value proposition and company profile.

Moow operates one of the smaller kick scooter fleets in Stockholm (based on the number of vehicles seen on the streets and the mobile application), which makes a low accessibility. However, to improve this, Moow and Vosh have initiated a cooperation. Both their individual apps enable the user to choose from both of the companies' scooter fleets. Thus, Moow can offer access to a larger fleet without offering more scooters, and also gain a second channel to provide access to their scooters.

Tier - Tier take a holistic approach in their company vision, and communicate that they wish to rethink urban transportation and reshape city landscapes for a more seamless and sustainable mobility that is joyful for everyone (Tier Mobility, [n.d.]c). They aim to responsively provide affordable services with high quality across all markets. Safety is also a high priority, and thus they aim to design scooters that are more stable and sturdy to ride (Tier Mobility, [n.d.]b). The kick scooter accessibility is high due to the fact that they operate a large fleet in Stockholm (based on the number of vehicles displayed in the application and seen on the streets).

Sustainability is a central aspect for Tier. They claim to be climate neutral since January 2020 (Tier Mobility, [n.d.]b), and also provide transparency on how they work to make their products and services more environmentally friendly. They have an ambitious climate agenda and use UN's Sustainable Development Goals as a guiding framework, which is effectively used for their external communication (Tier Mobility, 2019). Thus, Tier provide transparency, so that users may make a decision to use their services with good conscience. Transparency is otherwise unusual amongst micro mobility entities, and this is an important part of the value which Tier provides.

Voi - Voi aims to provide a sustainable option for their users, and their internal surveys show that 12% of the trips replace cars (EY, 2020). It also seems like the usage is becoming a part of people's daily commute to school and work, and less as leisure activities. Voi's surveys further show that 63% of all the users combine the Voi service with public transport (EY, 2020), and thus is supporting a sustainable user pattern. As the market matures, Voi shows that the usage is becoming increasingly more responsible and sustainable.

An important part of the value proposition is to prove sustainability and manage responsible operations and activities. As part of their work for improved sustainability, Voi is partnering with Fortum for lifecycle management and sustainable energy (Hunter, 2020). They also try to promote responsible usage by introducing geofencing which indicate safe parking areas. This solution is called Incentivized Parking Zones (IPZ), which gives users a ride discount if parked at these specific spots. This has later become an industry leading practice (EY, 2020). There are also zones that are accepted for parking, zones where parking is forbidden, zones with lower speed and zones where riding is forbidden (Voi, [n.d.]a). They also promote cooperation with cities to support and strengthen both entities' shared values (EY, 2020).

The exact number of Voi scooters in operation in Stockholm is not communicated, but it seems to be one of the largest available fleets compared to the other micro mobility providers (Strand, 2019) which is making a high accessibility. Travis is a mobile application which is used for planning trips with different means of travel; both public transport and private actors. Voi's scooter fleet is the only micro mobility provider that is included within the service, thus making Voi's service more compatible with public transport and other means of travel. This increases the accessibility, and it enables users to combine several means of transport more easily to get from one place to another within the city.

Vosh - The scooters have low accessibility due to a low number of vehicles in the Stockholm region. Never the less, accessibility is improved with the cooperation with Moow, which operates a larger fleet. The cooperation with Moow is making it possible for users to access Moow vehicles through the Vosh mobile application, and vice versa, extending the value proposition through more channels. There are low speed zones for safe usage, but otherwise social and environmental aspects are not presented in their marketing strategy.

Wheels - The service provided by Wheels is presented as a premium product. However, the same kind of marketing and access channels are used by Wheels as the other competitors for approaching users. Wheels do not use campaigns providing discounts and price reductions, as it is not a primary means of competition for them. Wheels claims to have a better environmental performance than the competing micro mobility services (Wisterberg, 2019b), though they provide little transparency about internal operations to support that claim. The swappable batteries are said to be a contributing element of their operation to improve sustainability, though they are not the only micro mobility company providing that kind of feature. The vehicle fleet is medium sized, compared to the other competitors', based on the number of vehicles seen in the city and the mobile application. This makes accessibility quite average.

4.1.4 Revenue models

The basic model for all e-micro mobility providers in Sweden is pay per use, which applies a starting fee with an additional minute fee. Alternatively, some companies have chosen just a simple minute fee. Figure 1 displays the different pay per use strategies depending on the length of the ride in minutes, which shows that Tier is generally cheapest and Wheels is generally most expensive. The different prices presented in this section are all retrieved from the different provider's mobile applications if not claimed otherwise.

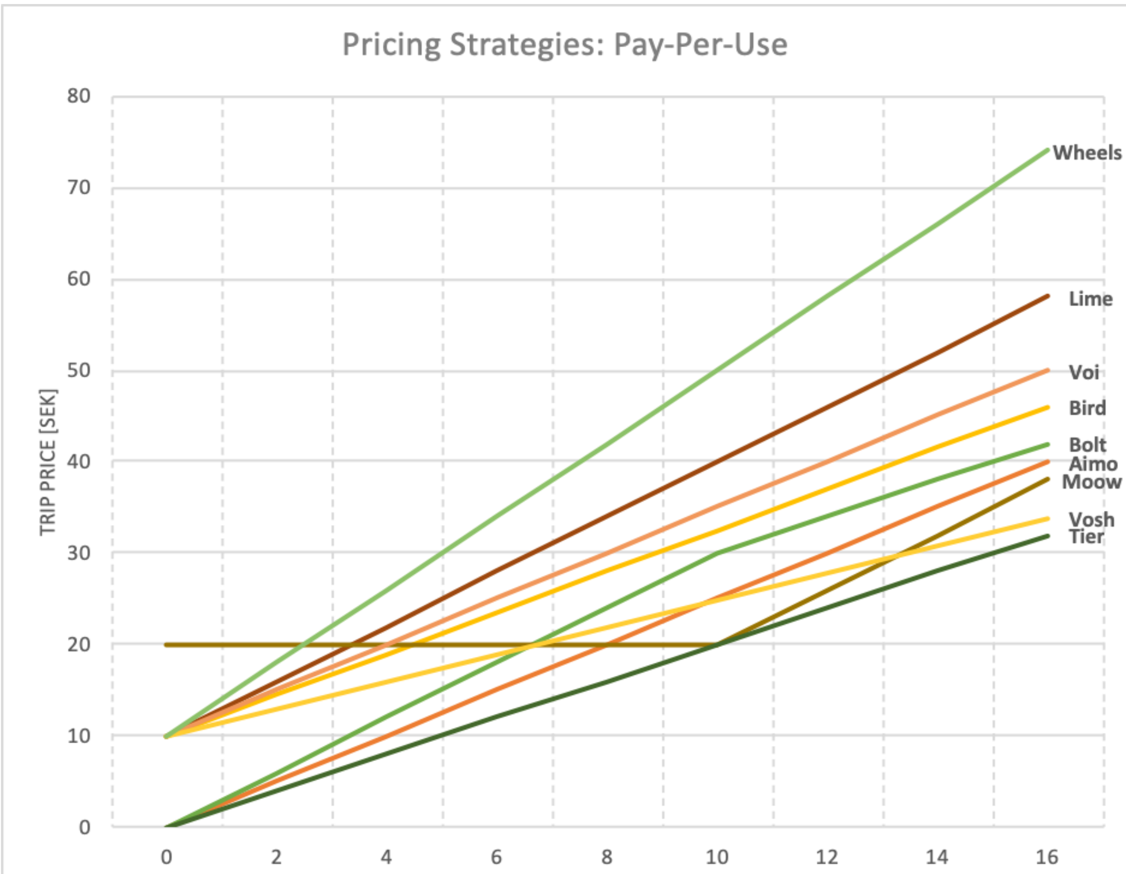


Figure 1: Price of share e-micromobility services in Stockholm as a function of trip time.

Some e-micro mobility providers also offer daily, weekly or monthly passes as an extension to their basic pricing model. Many offer occasional discounts, and some use discounts to promote responsible usage. Most of the providers offer a stable fee, that only changes to match demand on long term market development. Thus, users do not have to consider time of the day or day of the week to know the price of the different services. However, the price is always displayed in the mobile application before booking a vehicle or initiating a trip.

Aimo - Aimo offers their electric kick scooter service at a constant minute fee of SEK 2.50/min (€0.25/min). Their competitiveness seems to build upon their low price strategy.

Bird - Bird's pricing strategy is a starting fee of SEK 10 (€1) to unlock the vehicle followed by an additional fee SEK 2.25/min (€0.23/min). Previously, Bird offered a discount in a pre-pay solution (Goldmann, 2019a) but this has been removed for the current service offering.

Bolt - The fee for using a Bolt kick scooter is SEK 3.00/min (€0.30/min) the first 10 minutes of each trip. After 10 minutes the minute fee is reduced to SEK 2.00 (€0.20). There are frequent discounts handed out for already established users. For example, there is a 50% discount if a user invites a friend.

Lime - The basic fee is SEK 10 (€1) to unlock with an additional minute fee of SEK 3/min (€0.30/min). Lime also offers Lime Pass as a recent development of the service, with daily, weekly or monthly packages. A daily pass is valid for 24 hours and is offered at a fee of SEK 70 (€7) which includes an unlimited number of 30-minute-long trips. A lock up pass for seven days offers the user to save SEK 10 (€1) per trip at a fee of SEK 30 (€3). Monthly passes are offered to include a set number of pre payed trips: 5 trips for SEK 125 (€12.5), 10 trips for SEK 200 (€20) and 25 trips for SEK 400 (€40).

Moow - Moow offers their electric kick scooter service at a fee of SEK 20 (€2) for 10 minutes, followed by a fee of SEK 3/min (€0.30/min).

Tier - Tier aims to have a pricing strategy which is making micro-mobility financially accessible for everyone. The price setting is currently demand driven across all markets. (Tier Mobility, 2019). The different markets that Tier operates differ due to GDP per capita, price sensitivity in the area and other socio-economic factors, therefore Tier needs to be aware and adapt to these variations. They aim to use technology development to streamline the operations and thus achieve both high profitability and high cost efficiency within the organization (Tier Mobility, 2019).

The price is based on a starting fee of SEK 0 (€0) followed by a fee of SEK 2/min (€0.20/min). There is also a new payment model which is to be launched which offers monthly packages for cheaper rides according to the mobile application. However, the service is not yet available in Stockholm.

Voi - The starting fee is SEK 10 (€1), followed by a minute fee on SEK 2.50 (€2.50). Recently, Voi launched a fixed price service, Voi Pass, with a monthly (30 days) price of SEK 599 (€60) and a 24 h price of SEK 129 (€13). Then the user is given an unlimited number of trips during the assigned period of time, and each trip may run up to 45 minutes. Lastly, if a user parks in designated parking areas (i.e. Incentivized Parking Zones, IPZ), a discount of SEK 5 (€0.50) is given to the user.

Vosh - Price varies based on day, time and weather. The lock-up fee is SEK 10 (€1), followed by a minute fee of SEK 1.49-2.00/min (€0.15-0.20/min). An extra power boost is offered each new trip with a fee of SEK 10 (€1), to make a more powerful driving experience.

Wheels - The price to unlock a Wheels bicycle is SEK 10 (€1), followed by a minute fee SEK 4/min (€0.40/min), making Wheels the most expensive e-micro mobility provider in Stockholm (Wisterberg, 2019b).

4.1.5 Business strategy

Many of the micro mobility companies in Stockholm build upon very similar standard operations, and thus a standard model to create value has been identified. The mobile application and the vehicles are central elements that need to be provided to the customers. There is also need for a management system that binds everything together so that the service is provided to customers effectively. The vehicles are equipped with a GPS-tracker and smart IT-technology that can communicate with the management system for a simple fleet management operation.

The vehicles that are low on battery need to be collected and recharged continuously. The standard operation for doing this is to use cars or vans to transport them to a work shop. When fully charged, the vehicles are retrieved to the public areas. Traditionally it was common to use gig-workers or “hunters” for this process. It is a type of shared economy model so that private users may collect scooters and provide charging as a service, while getting paid accordingly. Now many instead enter partnerships with logistic companies for the charging operation. One of these companies that operate in Stockholm are The Green Charging Company. They operate charging services for Bird, Bolt, Lime, Tier and Voi (The Green Charging Company, [n.d.]). The Green Company offers 100% emission free operation to their partners, and operates in several cities (The Green Charging Company, [n.d.]). At any given time, they charge over 7000 micro mobility vehicles (The Green Charging Company, [n.d.]) which gives an indication of the size of the company.

The micro mobility companies differ in internal operations, some are highly vertically integrated to also include vehicle production and software programming, while some only manage fleet operations. The degree of vertical integration is displayed in figure 2. In-house operations mean that the company themselves are managing the specific element of the value chain, and is shaded grey in the table. Some of the companies also offer services to other fleet managers, such as fleet management systems, which is also communicated in the table. The operations managed by external suppliers or partners are displayed in non-shaded boxes, and the specific supplier is also named if it is known.

	Scooter design/ manufacturing	**Fleet management System (Software)**	**User platform (Mobile application Software)**	**Fleet management operations**	**Charging of vehicles**	**External business partners**	**Additional offerings**
Aimo	Segway	Inhouse	Inhouse	Inhouse	Inhouse		Car parking, electric car rental
Bird	Inhouse.	Inhouse.	Inhouse.	Inhouse	Gig-workers		Scooters; fleet management and user platform software
Bolt	Segway	Inhouse	Inhouse	Inhouse	*Unknown*		Taxi service
Lime	Inhouse	Inhouse	Inhouse	Inhouse	Gig-workers	Uber	
Moow	Segway	Vosh	Vosh	Inhouse	*Unknown*	Vosh, Wunder Mobility	
Tier	Inhouse	Inhouse	Inhouse	Inhouse	Inhouse/ Logistic partners	Deutsche Recycling	
Voi	Inhouse/ Segway	Inhouse	Inhouse	Inhouse	Gig-workers, shifting towards logistic partners	Fortum	
Vosh	Segway	Inhouse	Inhouse	Inhouse	*Unknown*	Moow	Fleet management and user platform software
Wheels	Inhouse	Inhouse	Inhouse	Inhouse	*Unknown*		Electric bike rental

Figure 2: In-house / External Supply of Basic Elements of the Value Chain.

Aimo - It is unclear what internal processes Aimo has and thus the way they create value for its customers. However, what is known is that they choose to hire staff in-house for charging scooters with renewable electricity (Goldmann, 2019d), thus not using gig-workers for the process. Aimo's vehicle supplier is Segway, thus their strategy is to operate the downstream industry value chain and software programming, and do not manufacture their own vehicles.

Bird - Vehicle design is carried out in-house and also programming of software for fleet management system and user platform. The upstream production (vehicle, management system and user platform) is also provided to other mobility providers as a product offering. This is further described in section 4.1.6.

In-house technical knowledge and expertise is one of the ways which Bird is differentiating from other businesses that operates only the downstream value chain. They have chosen to integrate the entire upstream value chain into the organization, all the way from the vehicle design to fleet management and software programming. The vehicle manufacturing is located in China according to the label on the vehicles. For the down-stream vehicle recharging process they are not operating in-house activities. Instead, they use gig-workers or "hunters" to charge their scooters in Stockholm, called the Bird Flyer community (Bird, [n.d.]c). There is an app that the gig-workers use to manage the process, making it more effective and standardized. Bird also hire The Green Charging company as a logistics partner, that perform the charging operations (The Green Charging Company, [n.d.]).

Bird takes an environmental standpoint to make cities more livable. However, there is little transparency about how they work to reduce their own climate impact and operate internal processes, globally or locally.

Bolt - Bolt benefits from the advantage of having long experience within the mobility sector, operating their taxi services. Thus, the lateral moves to introduce a Bolt scooter service comes with competitive advantages as Bolt already have access to data from previous operations to help identify patterns of mobility within the city (Petzinger, 2018). Thus, scooters may be placed in areas optimal for usage (Petzinger, 2018).

Bolt's strategy is to be conscious about all costs, and do not make extra expenditures on marketing campaigns and R&D projects etc. (Shead, 2019). They instead slim down the organization, and keep the costs at a minimum. Furthermore, they have most of their top management operations located in Estonia and Romania, with low salaries (Satariano, 2019). Their research department is slimmed down, and market analyses are mostly made through reaching out to people through Facebook (Satariano, 2019). Their vehicles are provided by Segway, which means that they are not including any vehicle manufacturing processes in the internal organization. In order to expand to new markets, they allow organizations to reach out to Bolt, which then supplies management system, mobile application support, vehicles etc., which then is integrated into the Bolt organization (Bolt, [n.d.]b). This is further explained in Section 4.1.6. The charging operation is performed by The Green Charging Company (The Green Charging Company, [n.d.]).

Bolt has introduced a new sustainability strategy to drive the company development in a more responsible direction, called the "Green Plan" (Höök, 2019). Though it is not a central aspect of their value proposition, they realize the advantages of becoming more climate friendly. Their decision to introduce an electric kick scooter service is a part of that strategic move (Höök, 2019).

Lime - There is little transparency about Lime's internal processes, and it is hard to distinguish how vertically integrated the company is. However, according to the label on the kick-scooters, the model is designed in-house, and also the software seems to be provided in-house. Furthermore, vehicle manufacturing is located in China according to the label. Lime have traditionally used "hunters" or gig-workers for recharging operations in Stockholm, and they did not have any preferences on the fuel type of the vehicle used for the pick-up/drop-off operation in relation to charging (SLL, 2019). Now they use The Green Charging Company for the recharging operation (The Green Charging Company, [n.d.]). Another important partnership is the one with Uber in Stockholm, which increases the accessibility for users, as described in section 4.1.3.

Lime has established partnerships to improve their operations and their social impact. They partner with Allianz to improve awareness about road safety (Allianz, 2020) and with Cosmo Connected to provide helmets for Lime users with a discount, thus increasing safety (2nd Street, 2020). These services are not offered in Stockholm, however.

Environmental performance is also an important aspect for Lime. After 1 million lime trips made in Stockholm with Lime Scooters, they declared that 31 000 kg CO2 had been saved due to the switch from use of fossil fuel to micro mobility, enabled by their services (SLL, 2020). However, they do not communicate how they aim to decrease the environmental impact from their own internal processes.

Moow -There is very limited information about the internal processes of Moow. Based on information from the fleet management provider, Wonder Mobility, Moow are partnering with them for some part of their business. Wonder mobility offers a fleet management service with an all-in-one solution for scooter sharing, with management system, mobile application, vehicles, financial support etc. (Wunder mobility, [n.d.]). It is unclear what kind of partnership which has been established between the two companies, but it is imaginable that some part of Moow's internal operation is supported by Wunder Mobility's services.

Moow also partner with Vosh, as explained in section 4.1.3. The partnership with Vosh extends beyond sharing fleets in the mobile application, they also use the management system provided by Vosh, the Vosh KickFleet system. The software is an all-in one solution for scooter sharing services (Vosh, n.d.). Moow do not have any vehicle design or manufacturing processes in the internal organization seeing that their vehicle supply is provided by Segway. The charging operation is unknown, but since Moow does not reach out in the public with job openings for gig-workers, this may be an indication that it is managed in-house or by external logistic partners.

Due to the fact that Moow has been assigned the eco label "Good Environmental Choice", some conclusions can be made about their internal processes. This is due to the fact that they need to follow certain frameworks to gain the label. The label is adapted for electric kick scooter services and the criteria to be fulfilled are (SLL, 2019):

- To charge scooters with energy marked "Good Environmental Choice"
- Use climate friendly service and maintenance vehicles
- Actively work to extend the life-span of the scooters

Tier - The way in which Tier's value delivery differs from other competitors is that they have been operating all processes in-house from the start and have never used gig-workers or "hunters" (Tier Mobility, [n.d.]e) as is otherwise is quite common in the industry. They have integrated in-house processes for design and manufacturing, with major focus on high technical performance and innovation. Tier now also use swappable batteries for their electric scooters in Stockholm, which reduces their climate impact and makes recharging much more simple (Tier Mobility, [n.d.]b). Swappable batteries enable recharging without transporting the entire scooter, and thus more scooters may be recharged using less vehicles for transportation. A new fleet of cargo bikes is used for recharging operations to further reduce climate impact in Stockholm (Tier Mobility, [n.d.]b). Tier also seem to service and maintain their scooters in the area without bringing them to a service facility which reduces unnecessary transportation. Furthermore, Tier's Swedish warehouses and operations are powered by clean and renewable energy (Tier Mobility, [n.d.]b), thus decreasing their environmental impact further.

Tier's in-house competence seems to be a major advantage to enhance competitiveness on all their European markets. This enables progressive technological development, better control of processes and business development, and also confidence in providing transparency. Instead of using gig workers for charging operations, Tier globally chooses to charge or collect the scooters exclusively with salaried employees, either on a part-time or full-time basis as well as with local logistics companies (Tier Mobility, [n.d.]e). In Stockholm the charging operations are partly or fully operated by The Green Charging Company (The Green Charging Company, [n.d.]).

Tier has established partnerships with municipalities, public and private organizations as well as other transportation providers (Tier Mobility, [n.d.]c). For example, the partnership with Deutsche Recycling and other local recycling companies enables a circular economy. Tier recycle and reuse parts of the scooters to a very high extent, especially batteries and aluminum parts which drives the majority of the climate impact from the scooters (Tier Mobility, [n.d.]b). Tier also communicate that if a scooter is in need of full replacement, it is often due to vandalism (Tier Mobility, [n.d.]b). The problem of irresponsible parking is solved the same way as many competitors do, by introducing "no parking zones" enabled through geofencing.

Voi - Voi does not stand out much from the competitor's in terms of internal processes, except for the fact that they were pioneers on the Swedish market and that they aim for a high technical performance. It is unfortunately rather uncertain to what extent Voi is vertically integrated. The design process is said to be made in-house (Voi, [n.d.]b) though the scooters are made by Segway. The software programming is assumed to be made in-house due to the fact that they post job offerings for software developers. Voi use external actors, called "hunters" for recharging the scooters (SLL, 2019). Voi prefers non-fossil vehicles to be used for charging purposes in Stockholm (SLL, 2019). It seems like the usage of private hunters is fading for Voi and they instead make use of logistics partners for charging scooters (Voi, [n.d.]c). This makes a safer and more stable working environment for the employees while it creates greater control over quality and sustainability for the company. The most recent scooter model, which now is the only model provided in Stockholm, are equipped with swappable batteries for a more efficient charging procedure (Voi, [n.d.]b). The company that manage the charging operation is The Green Charging Company (The Green Charging Company, [n.d.]).

The sustainability aspect has been discussed in relation to Voi's service. Previous information from Voi indicates a life span of 2-3 months for the early scooter models (Kristoffersson & Wallin 2019). Voi has attempted to lengthen the life span to improve the sustainability aspects. Now, "Voi's latest Voiager 3 scooter is estimated to have an average operational lifespan of 24 months" (EY, 2020). This new version also has swappable batteries, improving the scooter performance from a lifecycle perspective.

In order to responsibly develop their services and expand their business, Voi is working along with cities and other private companies. This is important from a sustainability perspective, and to build valuable partnerships. Fortum is one of these companies which enables an improved environmental performance as described in section 4.1.3.

Vosh - One of the least transparent companies in Stockholm is Vosh, and thus it is very challenging to distinguish their business strategy and internal daily operations. What is known however, is that they use Segway as vehicle supplier. It is also known that they operate their own software for fleet management and mobile application, since it is communicated in the mobile application. This software system is also provided as a service to other fleet operators (Vosh, n.d.). One known customer is Moow as explained previously in this chapter. The charging process is unknown, though there are no job openings for gig-workers, which indicates that the process is managed in-house or that it is managed by logistic partners.

Wheels -Despite the fact that the vehicles are much different from the other mobility providers' in design, the way that the bicycles are distributed and accessed is according to the same standard model for micro mobility services in Stockholm. The vehicle design and manufacturing process is made in-house. Due to the fact that the bicycles have swappable batteries, the recharging process is simpler. Instead of bringing the entire bicycles to the service station, the bikes are brought to a service hub by company employees to swap the batteries (Wisterberg, 2019b). At the hub, there are recharged batteries which have been dropped off for replacement of the discharged batteries in the bicycles (Wheels, [n.d.]a). The service and maintenance processes are made in-house to improve reliability (Wheels, [n.d.]a).

Wheels works to improve sustainability. They are working together with cities to provide easier and more environmentally friendly transportation for people. They also adjust their internal processes to improve vehicle life span and thus reducing climate impact. Due to the fact that the vehicles are modularized, selected parts may be replaced to expand the life of the bicycle. The components of the vehicles are custom made for wheels (Wisterberg, 2019b), making the products unique. The company claims that the life span of Wheels' bicycles are longer than the kick scooters and that they have a lower cost of operation than the other micro mobility competitors (Wisterberg, 2019b).

4.1.6 Fleet providers

Apart from the e-micro mobility service providers, there are also businesses that supply fleets with a full package of user software, management software and vehicle fleet. With these services, it is easier to start a business in e-micro mobility. There are a couple of known market players relevant for the services provided in Stockholm; Wundermobility and Bird.

- Wundermobility is a German company, and seems to have established some kind of business or partnership with Moow. Apart from offering a complete package to companies wanting to start a micro mobility business, they also offer solutions for financing, warehousing etc.

- Bird operates its own fleet, while also providing a service to other mobility providers, enabled for their own branding. Value capturing is made by taking a service fee for every scooter ride.

Vosh does not supply a complete package for other companies wanting to start operating a fleet. However, they do supply the management system and the user platform.

There are also e-micro mobility service providers that expands their business to new markets by offering to support new business with a fleet and operating systems. Bolt is such an example. The difference is that this strategy builds on expanding the own brand and it makes a new filial which is integrated into the Bolt organization. The difference to fleet providers is that they provide the necessary equipment to independently start and operate an e-micro mobility fleet without being an integrated filial. Bolt offers novel fleet operators market exposure, kick scooters, customer support with local language adaptation, software for administrative and operative operations, payment solutions and business support (Bolt, [n.d.]b).

4.1.7 Comparison with other mobility services in Stockholm

The supply for mobility services in Stockholm is diverse, and there are many mobility providers fighting for market shares. The region's public transport system is well developed and highly accessible and there are also traditional mobility services such as taxi services. Never the less, there are also novel businesses emerging within mobility, which to a high extent is enabled through the recent development in IoT and smart phones. These services are primarily: bicycle or scooter rentals, car sharing services and multi modal transport services. Within each mobility type, some examples are given below. These examples are given as a comparison for the e-micro mobility service providers in Stockholm and to give an overview of the market landscape which the micro mobility companies operate in.

Public transport

Public transport in Stockholm is well developed, and includes subway, train lines, busses, and ferry traffic. It is operated by SL which is controlled by the local public unit, Region Stockholm. Their mission is to provide accessible and reliable transportation to people in the Stockholm region, and each day almost 800 000 people use public transport provided by SL (SL, [n.d.]).

Taxi services

Taxi Stockholm - Taxi Stockholm is a conglomerate, consisting of individual taxi companies under the same brand, and thus users experience the service as if it would be one single company (Taxi Stockholm, [n.d.]). In practice the individual taxi companies are all part of the same organization, though each individual business is more or less responsible for their own daily operation. Taxi Stockholm provide a traditional taxi service and is a well-established market player in Stockholm. This makes a stable position, and high accessibility for users. The taxies are accessible in a number of ways; through the mobile application, on the internet based web page, through hotel receptions, by phone or simply getting an available taxi in traffic (Taxi Stockholm, [n.d.]). Taxi Stockholm provides 1600 cars, and operates 22 000 trips each day (Taxi Stockholm, [n.d.]).

Uber - Uber has been established in Stockholm since 2014. The initial launch was problematic as the business was disregarding existing laws and regulations concerning taxi operations (Lindahl, 2020). After some time, the business developed more responsibly and Swedish laws and regulations was updated to match the new technical development which Uber was pushing for (Lindahl, 2020). The basic business model of Uber is that the cars are owned and operated by the drivers (Lindahl, 2020), which means that the company costs are reduced significantly. This means that they can push the prices down to a minimum. The company provides the mobile platform and manages payments and administration while the drivers are managing the transport operations. Lately the company has expanded to also include food delivery and transportation of goods (Lindahl, 2020). The company has had major influence on the taxi industry, due to their low prices and innovative business model.

Bicycle or scooter rental

Weelo -There are some scooter rental services available in the city, though there is need to make a booking well in time before usage, and they must be returned in the same location as they are picked up. Therefore, these services are much different from the electric kick scooter services and electric bicycle service. Weelo is an electric scooter rental provider and they also offer electric bicycle rentals (Weelo, [n.d.]). The service is offered to tourists that wish to explore Stockholm in a flexible way, with day tours with locations in the city. The tours are guided through a mobile application that also is provided (Weelo, [n.d.]). There is a selection of different themes to choose from: City & Djurgården, Island hopping or Seaside (Weelo, [n.d.]). Insurance and helmets are included (Weelo, [n.d.]). There are 6 available pick-up/drop-off locations that all are located within the city center.

EU-Bike - EU-bike provides access to a number of bicycles, which are placed in public areas around Stockholm. The bike service is accessible through a mobile application, where the user may find and select a bike, start a trip, and pay for the usage (Blixt, 2018). There have been some complaints about the equipment not functioning properly, and the payment is said not very effective (Blixt, 2018). However, the service is very cheap compared to the other mobility providers, which is a strong element of competition.

City Bikes - Similar to EU-bike, City Bikes provides bicycles for rental around the city. However, the difference is that City Bikes use bicycle stations, where users may pick up and drop off the vehicle instead of just placing them on the streets. City Bikes is a cooperation between the private company Clear Channel and the Stockholm City (View Stockholm, [n.d.]). The bikes are accessed using an access-card, used for public transport (SL-kortret) (View Stockholm, [n.d.]). The service is accessible from 06.00 to 01.00 (View Stockholm, [n.d.]). The time limit for each use is 3 hours. In total, there are 140 bicycle stations around the city (View Stockholm, [n.d.]).

Car sharing services

Snappcar - Snappcar offers a platform which is matching people for rental of private cars. Snappcar has 2000 registered private cars in Sweden (Rabe, 2016). Users are able to access the registered vehicles through the website booking page. The car key is handed over in a meeting between the vehicle owner and the user. Snapper also offers a keyless solution, which is enabled by a reconfiguration of the car's locking system (Snappcar, [n.d.]). The entire rental time is fully insured by IF insurance and Snappcar is cooperating with the Swedish Transport Agency for any road related legal concerns for car owners or users.

Sunfleet and M Sunfleet has been available for over 20 years. They offer a traditional car sharing solution, where the company takes the responsibility for the car ownership. Sunfleet is owned by Volvo Car Mobility. Recently, Volvo Car Mobility have initiated a new car sharing service called M (Sunfleet, [n.d.]). The older service by Sunfleet is to be gradually integrated into the new M service. Both Sunfleet and M offer Volvo Cars, which are often no older than 1.5 years. The cars are cleaned before usage, and fuel, insurance and road fees are included in the rental service. The advantage of car share system compared to a car rental service is that the subscription is designed to be advantageous for short trips and occasional usage. Thus, it is provided closer to where the user lives and is designed for fast and simple pick up and drop off. Parking is also included in the service. Sunfleet's rental deal is based on a monthly fee for continuous usage or alternatively a deal for occasional usage that holds no basic fee. The fee differs depending on which car is chosen for rental. M's rental deal offers a similar solution, except it is independent of which car is chosen for rental (M, [n.d.]).

Mobility as a Service (MaaS)

UbiGo - UbiGo offers a single mobile application to access public transport, carpooling, rental cars and taxi services (UbiGo, [n.d.]). The idea is to address the user segment that are not in need of car ownership, yet sometimes need to make transportation in a flexible way (for example to occasionally get out of town over the weekend). The user may choose any of the available services in a flexible and easily accessible way, without locking in on expensive investments in car ownership. Everything is controlled from the mobile application. Payment is made either through the application or by invoice according to usage (UbiGo, [n.d.]).

The UbiGo service is depending entirely on the partners which provides the actual mobility service, and the partners are SL for public transport, Move About for car-pooling, Hertz for rental cars and Caboline for taxi service (UbiGo, [n.d.]). UbiGo is merely a way of accessing the services through a combined platform.

Pricing Strategies for Mobility Services

Services provided	Pricing principles	Comments
Public transport	75 minutes cost SEK 37.00 (€3.70) for adults and SEK 25.00 (€2.50) for children, students and seniors	The service is available for 24h/day, and includes all transportation within the region except some of the outer ferry traffic which comes at an extra fee
Taxi Stockholm	The basic pricing is from SEK 45.00 (€4.50) as a starting fee with additional SEK 520.00/h (€52/h) and SEK 12.80/km (€1.28/km). A trip of 10 km in 15 min comes with a fee SEK 303 (€30).	
Uber	The basic pricing is from SEK 36.00 (€3.60) starting fee with an additional fee SEK 5.09/min and SEK 6.71/km (€0.67/km). Minimum price per trip is SEK 90.00 ((€9)). A trip of 10 km in 15 min comes with a fee of SEK 179,45 (€17.90).	Flexible pricing depending on supply and demand.
Weelo	SEK 450 (€45) for 5 hours or SEK 590 (€59) for 1 day	
EU-Bikes	SEK 5.00/30 min (€0.50/30 min)	

City Bikes	Three day pass SEK 165.00 (€16), Season pass from SEK 250.00 (€25)	
Snapper	Depending on time, car and location.	
Sunfleet	Deal One: from SEK 0/month (€0/month) with additional SEK 105.00/h (€10/h) and SEK 2.50/km (€0.25/km) Deal Small: from SEK 199.00/month (€20/month) with additional SEK 65.00/h (€6.5/h) and SEK 2.50/km (€0.25/km) Deal Medium: SEK 499.00/month (€50/month) with additional SEK 60.00/h (€6.50/h) and SEK 1.75/km (€0.17/km)	Depending on the car and the selected monthly deal.
M	Deal Lilla: SEK 0 (€0) monthly fee, and additional SEK 110.00/h (€11/h) and SEK 2.00/km (€0.20/km) Deal Lagom: SEK 195.00 (€19) monthly fee, and additional SEK 85.00/h (€8.50/h) and SEK 2.00/km (€0.20/km) Deal Stora: SEK 895.00 (€90) monthly fee, and additional SEK 60.00/h (€6/h) and SEK 2.00/km (€0.2/km)	Also daily, weekend, weekly offers in each deal
UbiGo	Public transport from SEK 525.00/month (€52/month) Carpool from SEK 330.00/month (€33/month) Rental car and Taxi according to provider's pricing	The price is depending on usage for car pool and public transport. For rental car and taxi, the price is depending on the price from the service providers.

Figure 3: Pricing strategies for mobility services in Stockholm.

4.2. E-Micromobility in Tel Aviv Jaffa

4.2.1 The most significant providers

The mapping of the e-micromobility providers in Tel Aviv indicated that three large companies offer e-scooters for rent in the city. However, it turns out that today there are no e-bike rental companies in Tel Aviv, only regular bike rental companies.

The three e-kickscooter providers operating in Tel Aviv are:

Bird - a micromobility company based in Santa Monica, California, founded in September 2017 by Travis VanderZanden, formerly an executive at Lyft and at Uber. Bird operates shared e-kickscooters in over 100 cities in Europe, the Middle East, and North America with 10 million rides in its first year of operation. Bird was the first company to start operating in Tel Aviv in August 2018. Its fleet includes 2,500 e-kickscooters.

Lime - founded in January 2017 as LimeBike by Brad Bao and Toby Sun, two former executives of Fosun International's venture capital arm. The company was first located at the University of North Carolina, in Greensboro. In May 2018, the company announced that it would rebrand as "Lime" and partner with Segway to produce new e-kickscooters. The company began operating in Tel Aviv in February 2019. Its fleet includes 2,500 e-kickscooters [Kol17].

Wind - Wind Mobility was founded by Eric Wang in 2017 with locations in Berlin and Barcelona. The company operates shared e-kickscooters in Europe, Israel, and Asia in more than 20 cities. Among the three companies operating in Tel-Aviv, Wind is the smallest with a fleet of 1,000 e-kickscooters. The company began operations in the city in early 2019.

4.2.2 The products and services provided

The three companies only offer shared e-kickscooters in Tel Aviv. Wind operated a pilot with 20 electric bikes that did not work and did not continue.

Bird - In Tel Aviv, the company initially launched Chinese Xiaomi scooters. In May 2019, Bird launched Bird One, the first Bird e-kickscooter made available for purchase as well as for sharing purposes. Starting from August 2019, Bird upgraded its scooter fleet in Tel Aviv and replaced it with the Bird One model. Improvements incorporated into this model include a longer battery life (up to 48 km on a single charge); the battery charge time is 4-6 hours and the maximum speed it can reach is 29 km/h. The One model comes with a steel-reinforced aluminum frame that, according to Bird, makes it more durable over the years. New features include a more responsive brake system, improved lighting, and stability features (9-inch semi-solid wheels) [Hai19].

When the company launched the One Model in Tel Aviv, the second generation of the e-kickscooter, the Bird Two, was already available. This upgraded version includes a new battery system with a double capacity, and sensors so that broken e-kickscooters are removed from the sidewalks until they are repaired. Bird in Israel has announced that the plan is to replace all the fleet of e-kickscooters in Tel Aviv soon, starting with Bird One instead of Xiaomi scooters and later with the second version of Bird scooter [Hai19].

Lime - The company manufactures its cooperative e-kickscooters together with Segway-Ninebot's Xiaomi subsidiary. The third and latest generation of the Lime Scooter emphasizes rider safety, as it is much larger and comes with 10-inch wheels and improved shock absorbers. The model features a 20% larger battery, improved water resistance, greater legroom and a color display equipped with a GPS unit and G3 connectivity. This allows GPS navigation to the destination so that users don't have to deal with their phone at all during use. All the Lime scooter models can reach speeds of up to 25 km/h and a range of about 20–40 km [BenT19].

Wind - The German company has recently launched a new, third e-kickscooter model with significant improvements when compared to its predecessors [Sha20]. The most notable aspect is the upgrade of the braking system that makes it easier to climb over sidewalks. Braking, which is almost impossible in some of the other cooperative e-kickscooter models, has improved wonderfully in Wind's third generation, becoming more stable and more comfortable.

The battery capacity is enough for trips up to 80 km between charges. Moreover, the ability to retrieve and recharge it remotely, without physically connecting the scooter to an electrical outlet, should increase the supply of devices located at the pickup stations across cities. Therefore, on the hand, more scooters remain in circulation at any given time, potentially increasing the revenue per scooter, and, on the other hand, the costs of dead batteries collection for recharging are reduced as they are decoupled from the scooter itself. Another advantage in terms of urban space is the reduction in traffic interruption when collecting the batteries for recharging, as opposed to the other companies' models where the scooters themselves do need to be collected for recharging. The old-fashioned bell has been replaced with a horn that produces a higher quality sound for pedestrian warning and additional mobile phone holding facilities that make it very easy to navigate in the city.

Wind also claims its new e-kickscooter has the highest waterproofing with IP67 standard, and that its increased durability should make it last over 12 months when it is continuously used and shared. This puts the startup on a better unit economic footing, as flimsy frequently replaced hardware has been a fiscal drag for e-scooter companies that use off-the-shelf e-scooters designed primarily for single ownership and not for commercial use [Sha20].

4.2.3 Distribution and marketing to customers

The customer 'use of the companies' products are carried out in the three companies through an app they each developed, through which the e-kickscooter can be rented and paid for its use. In addition, some of the companies also provide the users with different guidelines, some of them being related to the municipality regulations. On 1.8.2019, the Tel Aviv-Jaffa Municipality issued regulations for the use of e-scooters in the city. Accordingly, companies are required to obtain a temporary operating permit for six months. The number of e-kickscooters is limited to 2,500 per operator. It is forbidden to block sidewalks or driveways as well as setting off an alarm at night from 11pm to 7am. Companies are required to give data to the municipality, that will be used for research and analysis of the use of the vehicles and for further regulation.

Recently, the Tel Aviv municipality imposed additional restrictions, some already in effect while others expected to be in effect within a few months. They include parking in designated locations, with the municipality creating dedicated parking areas for scooters and bicycles, first in the city center and later in the rest of the city. These parking areas should also be spotted in the companies' apps. Any rented vehicles left outside of said parking areas may result in confiscation. Sanctions will be imposed on the riders who violate the riding laws but also on the riders who violate the speed limits in crowded areas. These are pedestrian-laden streets and the definition of "traffic-controlled areas" where the scooters will automatically be limited to only up to 15 km/h. These areas are usually main streets that are crowded with pedestrians and are in constant danger because of the e-kickscooter riders. The municipality also requires a helmet supply. While most restrictions are enforceable by technology and field supervision, the helmet supply limit is still considered unsolvable [Pos20].

Ordering Bird's e-kickscooters is done through the company app. On the Bird app, the user can see the operating area of the service and also view a tutorial on how to use the scooter. Lime e-kickscooters are equipped with a GPS system that can detect the location of the vehicle, an operating and locking system, as well as an interface that links the mobile phone with the e-kickscooter. When the user arrives, he/she unlocks and starts traveling [Cas2020]. Ordering Wind scooter is done through the company app, as well as locating and renting the near scooters, by scanning the QR code on the handlebars, releasing the lock, and traveling.

Bird and Lime set the minimum age for the use of the e-kickscooters to the age of 18 (although according to the traffic laws the minimum age is 16). Bird requires the users to upload a photo of their ID card to make sure they are over 18. In addition, the company sends to its users a full version of the riding regulations in Israel and in Tel Aviv in particular. This includes the obligation to ride on the road or bicycle pathways, wearing a helmet, prohibiting riding under the age of 18, prohibiting the use of cell phones or headphones, and providing the rules for parking scooters in public spaces. The company also urges its users to report illegally parked scooters to the company [Had19].

4.2.4 Revenue models

Bird - The company charges NIS 5 (€1.2) for the unlocking of the vehicle and NIS 0.5 (€0.12) per minute. From October 2019, the company began charging NIS 0.60 (€0.15) per minute on days and hours when there is no public transport services [Cas20]. In addition, it is also possible to book a scooter nearby up to half an hour in advance. The service inviter can choose the "time" option which will remove the scooter from the available tools map up to half an hour in advance. Accordingly, the e-kickscooter cannot be released from its lock on the spot by anyone other than the ordering person. The cost of this service is NIS 0.20 (€0.05) per minute "lock" [Pos19].

Lime – The same as Bird, Lime charges NIS 5 (€1.2) for the unlocking of the e-kickscooter and NIS 0.5 (€0.12) per minute. The company also offers a coupon of NIS 11 (€2.6) to users who are able to invite a member to travel. In 2020, Lime launched a dynamic pricing model based on variables such as the scooter location and the rush hours in Tel Aviv. Accordingly, the price in some cases rises to NIS 0.6 (€0.15) per minute but in other cases drops to NIS 0.4 (€0.10) per minute [Cas20].

Wind - At the beginning of the company's operation in Tel Aviv, the rental cost was the same as Bird, NIS 5 (€1.2) for the release of the scooter lock and NIS 0.5 (€0.12) per minute, but the first trip is free [BenT18].

4.2.5 Business strategy

Bird - Bird's strategy is not to flood the market with a large supply of e-kickscooters, but to maintain a measured growth rate so that the supply is smaller than the demand to avoid a situation where the vehicles would stand on the streets without use [Raz-H19]. Initially, the company was not providing the service at night to use these hours for the recharging operations. However, in May 2019, it was decided to expand the operations to 24 hours a day. The company is also considering the possibility of a monthly rental of the vehicles. Bird Global has also started running a scooter ordering service to be delivered to the place to which they will be ordered, by the company staff. This service will be provided in different markets for a monthly subscription [Pos19].

Bird also maintains a collaborative model where app users can recharge the e-kickscooters closest to their home. The company pays NIS 20-70 (€5-€17) per recharge depending on the location and battery condition [Cas20]. However, Bird scooters are mostly charged by gig workers, private contractors who sign up to become Chargers. The company sends approved Chargers to get the vehicles, pays them to charge the e-kickscooters overnight, and then place them at designated "nests" throughout the company's service area in the morning. Charging can become competitive with Chargers using vans and other creative means to pick up scooters all over the city. Becoming a Charger is done by clicking on the charging button in the application. Personal information is transferred, along with tax information and the account number to which the payment will be transferred for the charger. The Charger will also have a telephone call with the company representative. The charger must, at least, be 18 years old, have one vehicle, and load 3 scooters at a time [Pos19]. The amount of money that Bird gives to the independent contractors for charging a particular vehicle depends on how long the scooter has been sitting out on the street after being flagged for needing a charge, and on how long before the Charger reflags the scooter in an app to claim the reward.

Lime – Lime's e-kickscooters are available for use from 9 am to 10 pm. In March 2019, the company began working in collaboration with the Herzliya Interdisciplinary Center Student Association, during which it offered dozens of vehicles for riding. Students were also offered to serve as scooter chargers to generate additional income in parallel with their studies [Pro19]. Lime uses also collaborative models for the recharging operations. The vehicles are charged by private contractors who sign up to become "Juicers"; the company sends approved Juicers to load the equipment, pays them to charge the scooters overnight, and then place them at designated places throughout the company's service area in the morning. Juicing can become competitive with Juicers in some markets using vans and other creative means to pick up scooters all over the city.

In coordination with the Tel Aviv municipality, Lime made a strategic decision to grant payment exemption for the unlocking of the vehicle. It charges only for riding time in Jerusalem Boulevard following the blocking of the Boulevard in Tel Aviv to cars and buses due to light rail work. This was formulated following the Tel Aviv municipality's appeal to the company with the intention to provide a solution to the traffic issues. In addition, Lime placed more scooters to ensure a greater availability to riders in the area. The discount allows for a ride of a few km at a cheaper price than a bus trip [Etz2019c].

Wind - The scooters are available for use until 8 pm. Unlike the competitors, charging is done by the company and not by the users of the app. The battery can be removed and recharged remotely without physically connecting the scooter to an electrical outlet, which should increase the supply of devices located at the pickup stations across cities [Cas20]. At the beginning of its operation in Tel Aviv, Wind reported that it would distribute helmets, glowing vests, and even run a safe riding course to cope with the new regulations of the Ministry of Transport [BenT18].

In December 2019, the company decided to change their payment model and determined that, at least in the next month and a half, the unlocking of their scooters would be free. However, the price per minute has risen and now Wind Scooter rental costs NIS 0.85 (€0.20) per minute. This means that short trips (up to 12 minutes) with Lime will be cheaper and longer trips more expensive. Beyond 12 minutes, Wind's service will be more expensive than the competitors. Another option offered by Wind is to purchase bank minutes in advance and receive a cash bonus. Thus, for example, anyone who charges NIS 75 (€18) will receive a balance of NIS 120 (€29) for use, i.e. a NIS 45 (€11) bonus [Yai19].

4.2.5 Degree of use and parameters for comparison

Tel Aviv Municipality data shows that between August 2019 and May 2020, approximately 6 million trips were made in Tel Aviv by the three scooter companies. A survey conducted by the municipality among 1400 Bird's users found that 15% of the riders replaced the use of a private vehicle and the use of car sharing in the city with the scooters and 18% replaced the use of taxis with scooters. According to the survey, 20% of the rent was made for commuting to and from work and 5% for study. In terms of user age distribution, 14% were found to be aged 18-24, 62% were aged 25-39, and 24% were aged 40+. The survey also revealed that 70% of users live in Tel Aviv.

An update recently received from the Tel Aviv Municipality and related to the first lockdown period due to COVID19 in April 2020, indicates a 20% increase in the use of electric scooters in the city after the end of the lockdown, compared to the previous period. The increase is explained by the decline in the use of public transportation because the passengers fear to get infected while using it.

Data collected by the Tel Aviv-Jaffa Municipality from the three companies indicates that, on average, an e-kickscooter is used 5 times a day. Most users ride 2.2 km (the median is 1.6 km) and the average travel time is 14 minutes. About 8.5% of travel is used to arrive by bus or train.

During an interview in October 2019, Israel Bird's CEO claimed that the number of trips made with the company's vehicles was over 2 million with more than 25,000 users. According to surveys they conducted among their customers, 20% of the trips currently made with one of their e-kickscooter substituted private cars and 25% of their clients use a Bird e-kickscooter in combination with the public transportation. More than 35% of the trips are made during rush hours from 8 a.m. to 10 a.m. and 5 p.m. to 7 p.m. [Etz2019a].

According to Yaniv Goder, Lime CEO, in the first 11 months of its operations in Israel, no less than 4 million scooter rentals were made in Tel Aviv alone. This figure places Tel Aviv as the highest use per population size compared to the 130 cities in which Lime operates. He said that about 30% of the company's 3,000 vehicles offered substituted private cars in the city, and that about 15% of trips done during the week are done to commute. 50% of Lime users are under 35 and 85% work or live in one of the three cities in the center: Tel Aviv, Ramat Gan, and Givatayim. On average, each company vehicle was rented five times a day and, in total, Lime's fleet accumulated over 7.6 million kilometers of riding [Pos20]. Most users ride for a distance of 1.2 to 4 km for 10 to 15 minutes [Etz19c].

4.2.6 Comparisons with other mobility services in Tel Aviv

Other digital mobility services operating in Tel Aviv include taxi, bicycle rental, and car sharing. The following section is a concise description of these services.

Taxi services

Gett Taxi - This taxi service operates through a smartphone app for taxis, as Uber that was not allowed to operate in Israel by the Ministry of Transport. This is a location-based service that allows taxi drivers and passengers to communicate with each other directly, including coordinating collection, making payments, and giving feedback.

The app was launched in 2010 as “Get Taxi” and quickly became popular. In 2015, its activity was expanded to include errands, and as a result, the company changed its brand to “Get” [Kri15]. The company currently employs around 1,200 people of which 200 are R&D workers. It currently positions itself as a company providing shuttle services to corporations and has more than 17,000 business customers today [Orb20b]. As of March 2018, approximately 8,000 taxi drivers are listed in the Israeli database. The taxi drivers that use the “Gett” service pay the company a minimum fee of NIS 1,100 (€282) per month [Sad18]. There are no exact numbers on the use of the Gett app in Tel Aviv; in 2015, the company reported 35,000 trips a day across the country, with an estimated half in Tel Aviv. In the same year, it also reported more than 2 million downloads of its app in Israel.

Yango - The Russian Yandex travel brand began to operate in Israel in late 2018 as a competitor to Gett Taxi. The company offers its shuttle services via a thousand taxis connected to an app uploaded to Google and Apple stores in the Hebrew version. Yaniv Alfie, the former CEO of the company in Israel, said in a personal interview to Calcalist that Yango, unlike the business model of Gett Taxi, does not work with drivers directly but through other taxi stations and ushers that they consider as their business partners. In this way, the company claims it is easier to provide service to drivers nationwide and to overcome the difficulties of availability during rush hours. One of the main problems in the taxi market in Israel, and especially in Tel Aviv, is taxi unavailability during rush hours. According to the CEO, the Greater Tel Aviv area has an average of total 275,000 trips per week. Only in Tel Aviv the current offer is able to catch 25% of the demand and, as a consequence, people wait a long time for taxis [Orb18].

Recently, the company decided to make a major change to its business model and offered all independent drivers (that are not necessarily related to any taxi stations) to work directly with Yango. The reason for this move is Yango's dissatisfaction with a number of stations that the company has worked with, mainly due to the high commissions requested from the drivers beyond the usual commission [Orb20a].

Yango gives two options to the drivers: a 5% service charge on each trip they receive, or a regular monthly payment of NIS 300 (€77), and a fee of 3% on each trip. By default, the option with the higher commission is applied but drivers can switch between them once a month [Etz19b].

Bubble° Dan - Bubble is an on-app public transport service that operates in a defined area but not on regular routes. The service is defined as premium public transport. Bubble Dan's existing fleet of vehicles includes about 100 minibuses, and the number of passengers on each minibus is limited to 5 passengers [Etz20].

The service was initiated by the Ministries of Finance and Transport. Its aim is to encourage drivers to give up their private vehicles during rush hours and to board a minibus operated around the city with a folding scooter instead. The service order is made on demand and pre-booked with the possibility to change the itinerary in relation to the demand areas. This is made through an app that adjusts the schedules and routes for passenger demand so that the route is best suited for everyone. The passenger is picked up at a bus stop close to his/her home and she/he knows exactly when to wait there. The trip is not made directly to the destination but it is intended to be faster than a bus [Cas19].

Data collected by an outside company in collaboration with the Tel Aviv University show that by the end of November 2019, a 30% increase in daily travel volume was recorded compared to the beginning of the month, and that the service stabilized at the end of the month to around 4,500 travels in the peak days. Additional data transmitted to the Ministry of Transport on habits, based on a questionnaire filled out by the travelers using the service's app, show that half of the respondents have a private vehicle, and 34% of the respondents said they used this service instead of the private vehicle. Around 112,000 trips were made since the service began, according to the operators. Also, about 60% of bubble users commute thanks to this service [Gut19].

Car sharing services

Car2GO - Car2GO was created in 2008 with the goal to provide a car sharing arrangement for residents. It is one of the world's pioneering car sharing companies [Mor18]. The residents who live near the company's parking lots (and there are about 20 parking lots operated by the company in the city) are the ones who use the service. The service is suitable for those who need a car for a few hours or when they want to visit friends and relatives on weekend. Car2GO claims it has about 10,000 active subscribers most of whom are residents of and around Tel Aviv. Several hundred cars serve the subscriptions.

Its business model relies on annual subscription fee payment, and an additional charge for each car rental that depends on the hour or day (this fee includes fuel and insurance). Each subscriber receives a personal ticket, arrives at the parking lot in advance, and uses a card to open it, while the keys are already inside. At the end of use, he/she returns the car to the same parking lot. The card is personal because the insurance only covers the subscribed driver, so it is not possible to transfer it to someone else; it is impossible for several persons to contract a joint subscription. It is possible to add a first-time family member at a one-time cost of NIS 45 (€12) to the annual subscription. The number of parking spaces is limited and is not available to all residents of the city within walking distance. Resident can contract a subscription from the age of 21 with a seniority of at least two years driving license and no conviction for serious offenses [Mor18].

AutoTel - It is a car sharing venture in Tel Aviv-Jaffa, launched in October 2017, operated by the Municipal Economic Company. The subscribers of the venture can rent a car on a minute's basis and take it from wherever the vehicle is around the city and end up renting it in any parking allowed in the city. The project includes an array of 260 cars scattered throughout the city. The project allocated 520 dedicated parking spaces for the vehicles [Had17].

Car2Go won the tender for the launch of the project. The venture has a mobile app and website through which you can immediately locate a spare vehicle, view and edit your personal information, as well as follow other progression in the venture. AutoTel's array is a complementary array to Car2Go. While in the Car2Go service, the car must be returned to the parking lot from which it was taken. With AutoTel, the car is returned at a different parking place (i.e. no obligation to return at the same point) [Ova19]. According to the company's website, as of February 2020, it has about 10,000 subscribers making over a million trips (https://www.autotel.co.il/).

Bicycle rental services

Tel-O-fun - Tel-O-fun is a bicycle-sharing service provided by the Tel Aviv-Jaffa municipality through the private company FSM Land Services. The main purpose of the service is to reduce traffic within the city. The project also aims to reduce air pollution, create a friendly atmosphere within the city, and encourage physical activity [Mor18].

The service was launched on April 28, 2011. Today, the service offers over 2,000 bicycle pairs at over 200 docking stations for the people above 15. In 2015, the service was extended to Givatayim, in 2016 to Ramat Gan, and in 2017 to Bat Yam (the first ring cities of the Tel Aviv metropolitan core). In 2017, the system deployment reached hundreds of docking stations in over 200 stations with over 2,000 bicycle rentals, and about 8,500 annual subscriptions and tens of thousands of users for short periods (two and three days). The bikes are relatively new, 3-speed, uniform in size, tailored to both women and men [Mor18].

Today, the Tel Aviv-Jaffa Municipality is exploring the possibility of converting some of Tel-O-fun's bicycle fleet to electric bicycles at the docking stations, due to a gradual decline in use caused by the development of the electric bicycles and e-kickscooters market.

Services provided	Pricing principles	Comments
Bus	NIS 5.90 (€1.5) per person. Daily fee NIS 13.5 (€3.5), weekly free NIS 64 (€16.4), monthly free NIS 213 (€54.6)	Ministry of Transportation tariff. Service is not provided on Saturdays and holidays.
Service taxi	Tariff 1 on a weekday is NIS 6.8 (€1.7) for the first 6 Km and for every additional Km another 40 pennies (€0.1) are added. Tariff 2 (evening and night hours, Saturdays and holidays) NIS 9.24 (€2.4) for the first 6 Km plus 56 pennies (€0.14) for every additional kilometer.	A large taxi (usually a minibus) traveling on a predetermined route and along it collects and lowers passengers
bubble° Dan	Price of the trip ranges from NIS 12 (€3) to NIS 15 (€3.8) per trip, more expensive than the bus but cheaper than a taxi	Public transport service on request in the app
Special Taxis	Tariff 1 – Basic charges from 5:30 AM to 9 PM on weekdays = NIS 11.5 (€2.9). After about half a kilometer or 80 seconds, the counter starts running every 12 seconds or 87 meters until it reaches 15 kilometers, then the price goes up by 33 pennies (€0.08) per Km. Tariff 2 is charged from 21:01 to 05:29 am + Saturdays and holidays. Basically the base price is 25% higher than that of tariff 1, and the counter "runs" faster. You will pay another 33 pence (€0.084) every 10 seconds or 69.87 meters to a distance of 15 km.	In a taxi 4 passengers can travel and divide the between themselves. The driver can charge the fourth passenger an additional NIS 4.80 (€1.2)
Gett Taxi	The tariff is the same as the tariff for taxi with a counter but Gett charges an fixed order fees of NIS 4.8 (€1.2) during rush hour (7:00 AM to 10:00 AM, and 3:00 PM to 5:00 PM).	

Yango	The Tariff is the same as the tariff for taxi with a counter. However, when you book a taxi with the app, after entering the full travel information, the final fare will appear. The company guarantees that the price displayed will not change until the end of the trip, and that it will be lower or equal to the final price displayed on the driver's meter display.	Yango has launched a new technology in Israel that allows passengers to pre-screen the travel price. The price of the trip is calculated using technology that can predict the future price. The system is based on the travel route, forecasting travel time according to variables such as day, period of year, and hour of day, traffic data and more. The technologies take into account state tariffs, so that the elaborate price is equal to the counter price or the lower price - and is based on Israeli law.
Car2Go	The company offers three options: Sametimes - Designed for those who require the service less than once a month - One-year subscription fee - NIS 140 (€36); Price per hour – NIS 20 (€5.1); Price per day, 180 NIS (€46). In addition, you pay NIS 2 (€0.52) for every kilometer of travel in the first 50 km and NIS 1 (€0.25) for every additional kilometer. Simple - Designed for those who need service 3-4 times a month. Subscription fee per month - 100 NIS (€25.6); Price per hour - NIS 15 (€3.8); Price per day - 135 NIS (€35); The price per kilometer - as above. AnyTime - Designed for those who need service once a week at least. Subscription fee per month - NIS 200 (€51.2); Price per hour – NIS 14 (€3.68); Price per day – NIS 125 (€34.7).	The service offers a variety of cars with prices suitable for small cars. A luxury family car has an extra NIS 5 (€1.3) per hour and NIS 45 (€11.5) per day. The shuttle car (minivan) adds an extra NIS 30 (€7.7) per hour and NIS 320 (€82) per day plus NIS 2 (0.52) for every additional kilometer.
AutoTel	The standard fare per minute is NIS 1.2 (€0.31) on the "high gear" option and NIS 1.7 (€0.44) on the "low gear" option, as well as a monthly payment of a subscription fee, which is NIS 40 (€10) a month or NIS 10 (€2.5) a month (respectively).	The venture works in conjunction with Digital, the resident card of the city of Tel Aviv-Jaffa, which holds over 200,000 of the city's residents. City residents who hold the

		card are eligible for receiving benefits and discounts that change from time to time. In the estimation of the operating entities, the price is about 30% to 40% cheaper than a parallel taxi ride in the measurement of urban travel for up to 45 minutes.
Tel-O-fun	Cost of three-day access - NIS 48 (€12.3); Daily Access - Weekday - NIS 17 (€4.4); Daily Access - Saturdays and Holidays - NIS 23 (€5.9); Weekly access - NIS 70 (€17.9); Annual access - NIS 280 (€71.8); Annual access to Tel Aviv-Jaffa resident card holders - NIS 240 (€61.5). In addition to the access card, users are also required to pay usage fees based on bicycle usage time: up to 30 minutes - free; Up to 60 minutes - NIS 6 (€1.5); Up to 90 minutes (1.5 hours) - NIS 12 (€3.0); Up to 150 minutes (2.5 hours) - NIS 32 (€8.2); Up to 210 minutes (3.5 hours) - NIS 72 (€18.5); Up to 270 minutes (4.5 hours) - NIS 152 (€39); Every hour until the end of the first 24 hours - NIS 100 (€25.6).	You can buy a yearly, weekly, three-day and daily subscription. A daily or weekly access card can be purchased at Tel Tel-O-fun's website, or by credit card at any of the terminals at stations throughout the city.
E-Scooter Bird	NIS 5 (€1.2) for the release of the scooter lock and NIS 0.5 (€0.12) per minute. In addition, it is also possible to lock in a scooter reservation nearby up to half an hour in advance. Cost of service is NIS 0.20 (€0.05) per minute "lock".	From October 2019, the company began charging NIS 0.60 (€0.15) per minute on days and hours when there is no public transport services.
E-Scooter Lime	The same as Bird, Lime charges NIS 5 (€1.2) for the release of the scooter lock and NIS 0.5 (€0.12) per minute. The company also offers a coupon of NIS 11 (€2.6) to users who are able to invite a member to travel.	In 2020, Lime launched a dynamic pricing model based on variables such as the scooter location and rush hour in Tel Aviv. Accordingly, the price in some cases rises to NIS 0.6 (€0.15) per minute but in other cases drops to NIS 0.4 (€0.10) per minute.
E-Scooter Wind	The same as above.	

Figure 4: Pricing strategies for mobility services in Tel Aviv.

4.3. e-Micromobility Business in Barcelona

Barcelona is the European city with more privately-own mopeds (and motorbikes) per capita in Europe. It is not surprising, then, that the e-mopeds sharing services are very popular, as well as the public e-bicycle sharing service (Bicing) of the city.

In May 2020, the Barcelona City Council adjudicated 6,958 licenses to 12 shared e-mopeds operators. 4 of these 12 operators have already been operating in the city during the last 2 to 5 years. In early 2020, there were 5 companies offering this type of service with already 6050 e-mopeds, which represented 87% of the total number of licenses awarded. As a consequence, the existing operators (that were operating before the adjudication of the licenses) had to reduce the fleet according to the number of licenses awarded (up to 580). Some of them had more than 1200 e-mopeds in the streets and had to halve it.

The companies that were given some licenses had a period of up to 60 days to deploy the fleets in the public space, always respecting the conditions set by the regulation. Therefore, in August 2020, the free-floating e-moped sharing market in Barcelona had a total of 6,958 vehicles operated by 11 different companies (one of the operators retired and these licenses were distributed among the other companies). The 11 current e-moped sharing operators are: SEAT MÓ (SEAT's mobility services company), eCooltra, Acciona, Movo, Yego, Avant, Cityscoot, Gecco, Tucycle, Oiz and Iberscot.

The total number of licenses awarded was decided considering the availability of e-moped parking spots in the city as well as the possible demand.

In the framework of the e-moped sharing service licenses adjudication process, the bike (and e-bike) sharing services was also regulated. Barcelona has since 2007 a public station-based bicycle (and e-bicycle) sharing service, that currently operates a total of 6,000 bicycles and has 424 stations. Therefore, on top of this public service (Bicing), there are 3,031 more bicycles – free-floating model – since August 2020, operated by seven companies, three of them also awarded with the e-moped licenses: Yego, Scoot and eCooltra. This regulation will last for three years.

Regarding the trendiest e-kickscooter sharing services, they are still not regulated in the Catalan city, therefore the free-floating services are forbidden. While waiting for this regulation process, which should start in the second semester of 2020, two companies had small fleets of e-kickscooters before the crisis of Covid-19. However, to be able to operate, they were required that their fleet was parked in private areas (off-ground parking, university facilities, parking of supermarkets, etc.). These two operators were Reby (100 vehicles – still operating) and Wind (50 vehicles – no longer available in Barcelona).

Probably, the licensing process of the e-kickscooter sharing services might differ from the one of e-mopeds and (e-)bicycles. First, because the city wants tidy streets and not many e-kickscooters thrown in pedestrian areas. Second, the city might want to avoid distributing licenses to a large number of operators.

The revenue models for currently operating e-moped and e-kickscooter sharing services are as follows:

- e-mopeds: €0.19/min to €0.26/min. Some of them offer discounts based on the purchase of minute packages or the use of the vehicles during off-peak hours.

- e-kickscooters (Reby): €0,20/min. Until April, they had the same price as Wind: €1 to unlock + €0.15/min, but Reby offered students and monthly public transport subscribers the unlocking at 0€.

On the other hand, SEAT MÓ launched in July 2020 a subscription model both for e-kickscooters and e-mopeds: “an all-inclusive subscription model that gives users access to a vehicle for weeks or months, including vehicle insurance, maintenance, a helmet and a weekly battery change. And all without any time commitment. The cost is €75 per week; €200 per month and in the case of renting one quarterly, €150 per month. The subscription model is intended for one user and an additional person, such as a family member”. Additionally, “the company has also implemented a weekly and monthly subscription format for its two e-kickscooter models. The e-kickscooter 25 costs €15 per week and €40 per month, while the new e-kickscooter 65 can be rented for €25 per week or €75 per month” [SEAT20].

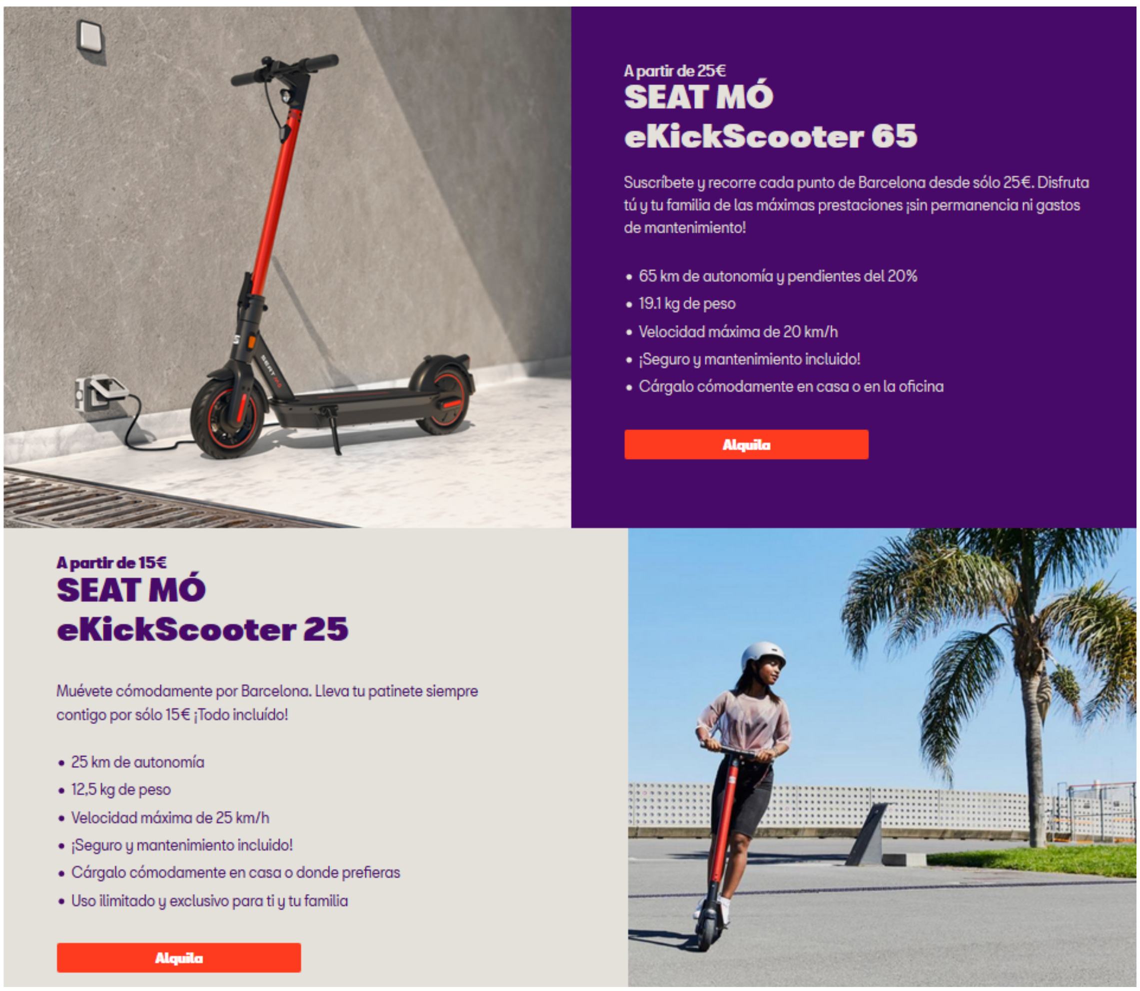


Figure 5: SEAT MÓ e-kickscooter rental page, with description of the vehicle, prices and services [SEAT20].

4.4.1 Pricing Strategies for Mobility Services

Services provided	Pricing principles	Comments
Public transport	"T-Casual" - 10 trips - €11.35 "T-Usual" – unlimited trips during 30 consecutive days - €40 "T-jove" – unlimited trips during 90 consecutive days for people that are less than 25-year old – €80 "T-day" – unlimited trips during one day – €10.5 Single ticket – €2.4	All the travel cards give access to the whole Barcelona public transport network (metro, tramway, bus, light train…) A trip can be multimodal. Passing from the bus to the metro is considered the same trip for instance. The "T-day" is important for tourists that want to travel a lot throughout the city. Data source: [TMB20]
Taxi	Tariff 1 – From 8 am to 8 pm – €0.38/min while the driver is waiting + €2.25 (fixed) + €1.18/km Tariff 2 – From 8 pm to 8 am – €0.38/min while the driver is waiting + €2.25 (fixed) + €1.41/km	The fee corresponding to the driver waiting time only applies when the taxi is pre-booked. Data source: [AMB20]
Cabify (ridesharing service)	The basic pricing is from €3.5 starting fee with an additional fee of €1.11/km and €0.27/min.	The pricing depends on the supply and demand. Data source: [Cab20]
Bicing (public station-based bicycle sharing service)	Tariff 1 – Fixed cost of €50/year Additional fee for each trip: ▪ Bicycle ○ First 30 minutes are free ○ Between 30 minutes and 2 hours of usage: €0.7 per 30 minutes of use ○ Beyond 2 hours: €5 per hour ▪ E-bicycle ○ First 30 minutes: €0.35	Data source: [Bic20]

	○ Between 30 minutes and 2 hours of usage: €0.9 per 30 minutes ○ Beyond 2 hours of usage: €5 per hour Tariff 2 – Fixed cost of €35 per year Additional fee for each trip: ▪ Bicycle ○ First 30 minutes: €0.35 ○ Between 30 minutes and 2 hours of usage: €0.7 per 30 minutes ○ Beyond 2 hours: €5 per hour ▪ E-bicycle ○ First 30 minutes: €0.55 ○ Between 30 minutes and 2 hours of usage: €0.9 per 30 minutes ○ Beyond 2 hours of usage: €5 per hour	
E-kickscooter sharing services	Reby: €0.2/min	
Free-floating e-bicycle sharing services	€0.15/min (bicycle) to €0.24/min (e-bicycle)	Some of them offer discounts based on the purchase of minute packages.
E-moped sharing services	€0.19/min to €0.26/min.	Some of them offer discounts based on the purchase of minute packages or the use of the vehicles during off-peak hours.

Figure 6: Pricing strategies for mobility services in Barcelona.

4.4.2 E-kickscooter licenses in Madrid and current status

The first city of Spain, Madrid, and also some other big cities in the country, have already tendered the licenses for the e-kickscooter sharing services. This process took place in Madrid at the beginning of 2019, in order to bring order to the situation of these businesses. In total, 25 companies participated and asked for more than 100,000 licenses. Finally, the city conceded nearly 10,000 licenses to 22 operators. And they authorized a maximum and minimum of licenses per neighborhood, so that all of neighborhoods could have access to this type of service.

One year after the tender, in January 2020, the number of e-kickscooters present in the city was 4,821, half of the total licensed (Figure 7).

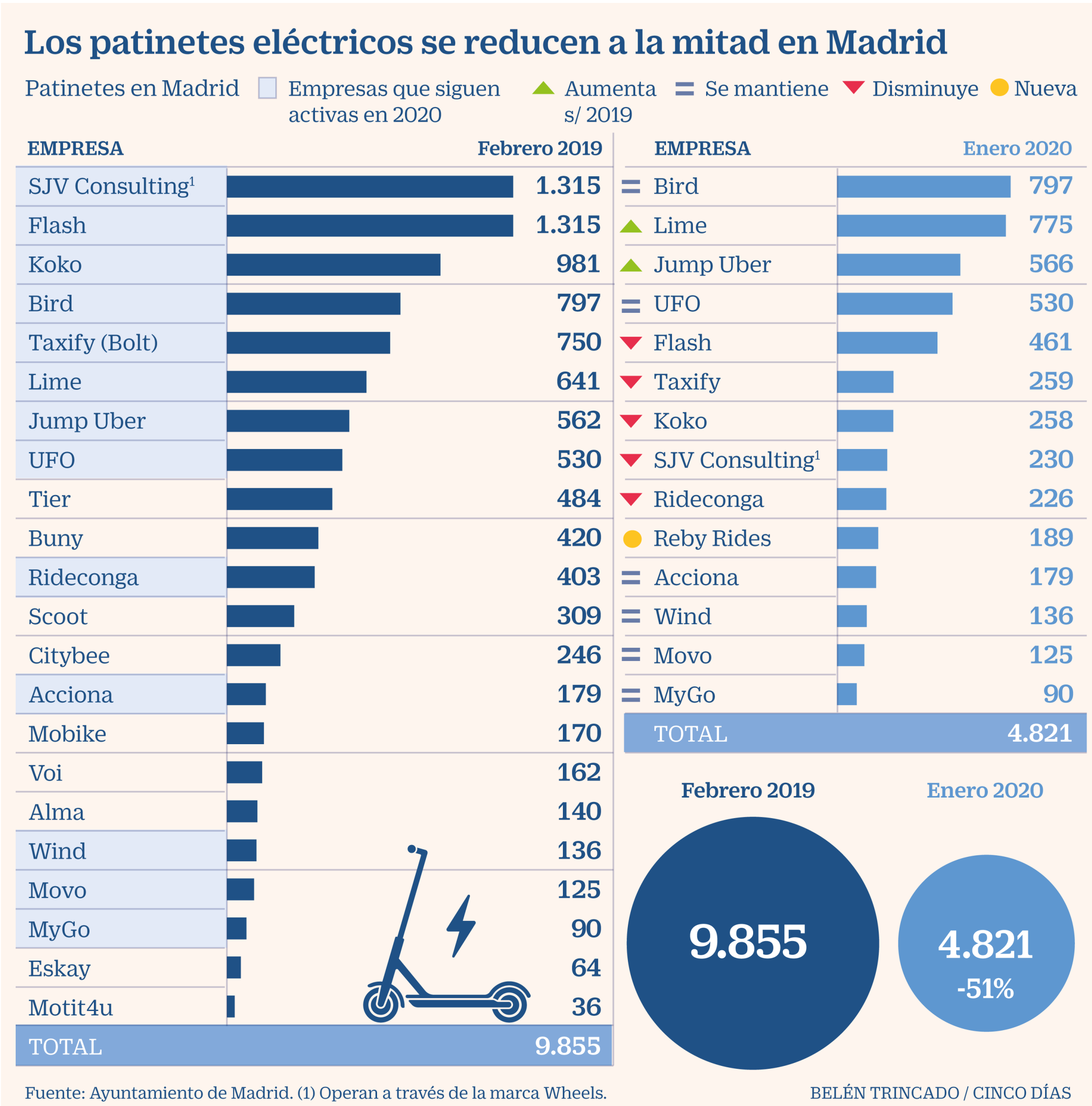


Figure 7: Total number of e-kickscooters in February 2019 and January 2020 in Madrid [Sob20].

The next table shows the different pricing strategies of operators. Some of them choose to charge €1 to unlock the vehicle and offer a lower price per minute, while others prefer to not charge the unlocking and charge 5 to 8 cents more per minute. The unlocking is on one side a barrier (not interesting for the users that just want to ride a small distance), but on the other side a security for the operators that the users who unlock their vehicles want to use it for a few minutes (so that the ride is profitable for both parties).

Empresa	Precio	Tarifa de desbloqueo	Nº de patinetes
Acciona	0,23€/min	No	179
Ari	0,15€/min	1 €	420
CityBee	0,15€/min	1 €	246
Flash	0,15€/min	1 €	1.315
Jump Uber	0,12€/min	1 €	566
Koko	0,15€/min	1 €	981
Lime	0,15€/min	1 €	641
Mobike	1€/20 min	No	170
Movo	Desde 1€	No	125
Mygo	0,15€/min	1 €	90
Rideconga	0,11€ - 0,15€/min	No	403
Scoot	10€/1h 15€/2h 30€/3h	No	309
Taxify	0,15€/min	1 €	750
Tier	0,15€/min	1 €	484
Ufo	0,15€/min	1 €	530
Voi	0,15€/min	1 €	162
Wind	0,15€/min	1 €	136

Figure 8: Pricing of the e-kickscooter sharing services in Madrid [Lop19].

4.4. e-Micromobility Business in Munich

As in many large European cities, micromobility has been on the rise in Munich for many years. The share of bicycle rides in the modal split increased steadily.

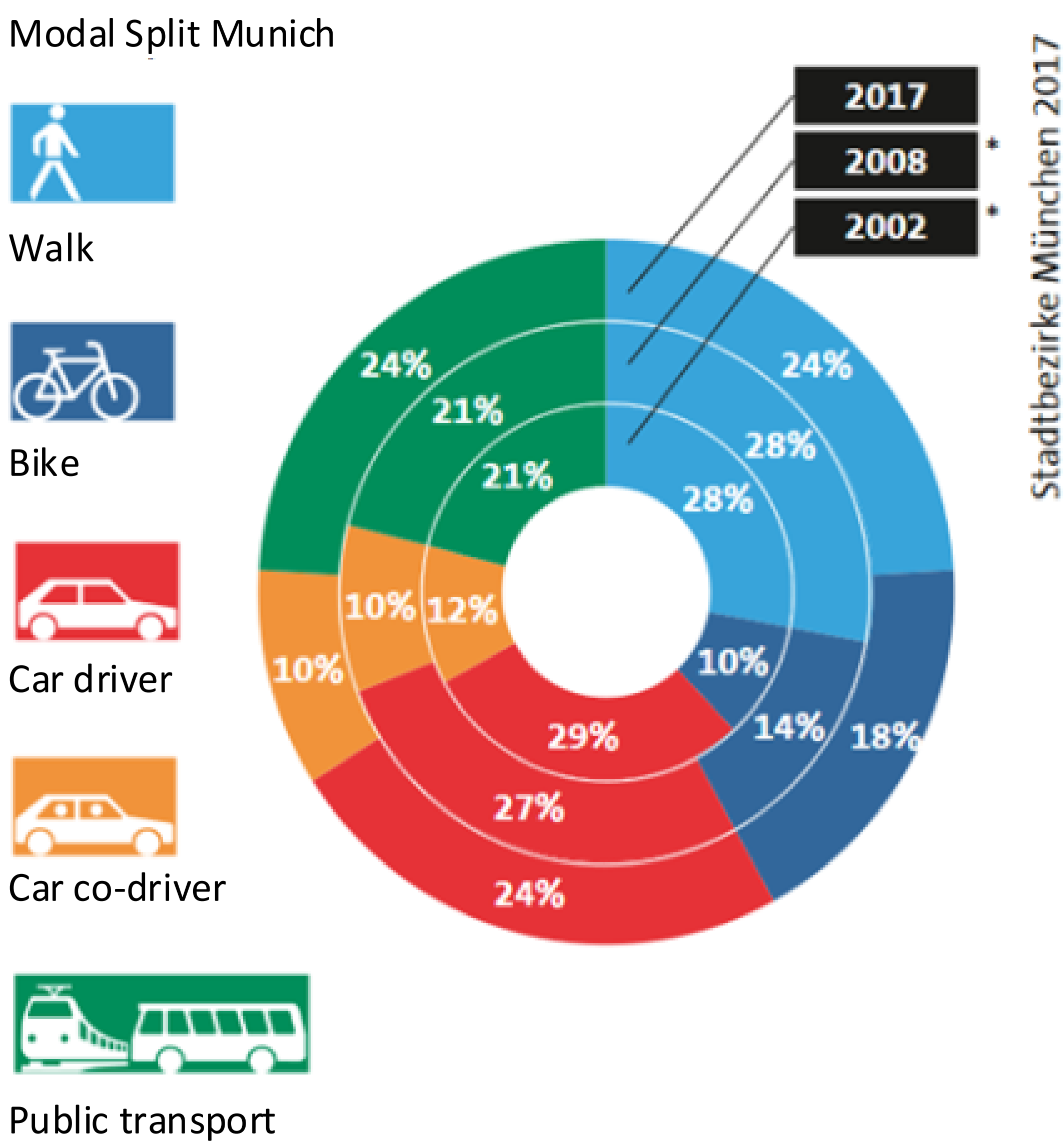


Figure 9: Modal Split in Munich 2002-2017, Source: [Inf18], translated

Between March and May of 2020 (corona related lockdown), about 20% additional cyclists were counted related to the same period of 2019; see [Br20a]. All this shows that micromobility is becoming increasingly important in a city like Munich, which is characterized by a high proportion of motorized individual traffic.

Unfortunately, Munich has made bad experiences with bike sharing in 2018. A bike sharing company based in Singapore flooded the city with 7000 bicycles of low quality. After the withdrawal of the company, waste disposal was largely left to the city. As a result, the city was cautious with regard to all shapes of shared micromobility, bike sharing as well as sharing of e-scooters, and tried to regulate the offer and the provider diversity.

In Germany, the electric scooters are legal in public road traffic since June 15, 2019. The German legislation enacted some limitations for the use of electric micromobility vehicles. For example, driving on the sidewalk is prohibited, the maximum speed for e-scooters is limited to 20 km/h, and the electrical support for e-bikes may only operate up to a maximum speed of 25 km/h.

While the demand for rental bikes is increasing, a concentration can be observed with e-scooters.

4.4.1 The most significant providers

After the introduction phase and the e-scooter hype, winter and the ongoing pandemic have led to a reduction of e-scooter usage. While the demand for rental bikes is increasing, there is a concentration concerning e-scooter providers and vehicles. In July 2019 about 10-12 different providers of shared e-scooters planned to start the business in Munich in July 2019. Only five providers are still active in September 2020; see [Mue20].

TIER - In July 2019, the Munich public transport operator (MVG) started their e-scooter rental system together with Tier Mobility GmbH, a company with headquarters in Berlin. TIER was the first provider of shared e-scooters in Munich. The company, founded in 2018, is active in 77 cities in nine countries; see [Tier20]. About 470 people were employed in January 2020 worldwide; see [Wiki20]. While most of the e-scooter rental systems stopped their business during the pandemic, TIER continued working at a lower level in Germany; see [Schw20]. In their view, e-scooters were a safe way of getting around for everyone who had to work. Therefore, they offered the service to medical personal partly free of charge. Nevertheless, they applied for short-time work for about 60% of their employees in Germany and reduced the fleet, significantly.

In June 2020, TIER also established a rental system for small electric motorcycles in Munich.

Figure 10: Shared motorcyles from TIER, Source: [Cha20]

Bird - The American e-scooter supplier Bird, based in Santa Monica (California), started it' e-scooter rental system in Munich in August 2019. With the "Oktoberfest" in mind, Bird expanded its fleet in Munich from 100 to 800 scooters only in October 2019; see [Tz19]. In January 2020, Bird has taken over the German competitor **Circ**, which had much larger market shares in Europe; see [Stüb20]. With the assumption, Bird strengthened its market position, especially in relation to the direct US rival Lime. The acquisition came at a time when Bird had suspended operations in Munich. At the beginning of winter, Bird took its scooters off the streets; see [Boe19]. They planned to use them again in spring. However, due to the Corona pandemic, the restart was delayed until early summer.

Lime - The company Lime Bike was founded in the US in 2017 sharing bikes, e-bikes and e-scooters. In Munich, the distributor is represented since spring 2018, starting the offer of e-scooters as soon as possible. At the end of 2019, Lime claimed to have moved out of the red in the rental of scooters in Germany. Lime initially ceased operations in Munich during the pandemic, but resumed them in May 2020.

Since July 2020, there exists a cooperation between Lime and Uber. Lime e-scooters are available within the Uber-App; see [Uber20]. Besides, Lime took over the e-bikes and e-scooters from **Jump Bikes und E-Scooter**, the bike and scooter sharing part of Uber, and brought them back to the streets of Munich. The vehicles can be booked via Uber as well as in the Lime App.

Dott - The supplier Dott is a company founded in Amsterdam (Netherlands). It started services in Munich in November 2019, some month after most of the other providers; see [Wei19]. According to its own statements, the Dutch provider Dott is focusing on a sustainable rental concept. The e-scooters are installed at selected locations only, depending on demand; see [Mue20]. Besides, Dott wants to set himself apart through sustainable distribution of the electric scooters, central charging with green electricity, consistent repair and recycling and (in near future) with a new model with exchangeable batteries; see [Rei20].

However, Dott is still a rather small provider, which is represented in Germany in only a few cities.

Voi - The Swedish company Voi was founded in Stockholm in 2018. It started services in Munich right from the beginning. Voi is a big player within this segment in Europe, providing additional services such as a virtual road safety school and a digital parking management system for e-scooters; see [Az20b]. Besides Voi adapted the services after the time out caused by corona. The distribution of the e-scooters has been adapted to enable higher availability within residential and suburban areas. Additionally, Voi introduces a frequent driver discount; see [Emo20]. Besides, the services of Voi are available within the App of FreeNow (BMW, Daimler) in Munich; see [T3n20].

Bond - Besides the e-scooter providers, also at least one company for e-bikes is working in Munich. The Swiss company Bond stationed 250 e-bikes in the city at the beginning of June 2020. Bond primarily sets up its e-bikes, which can reach speeds of up to 45 kilometers per hour, at central intersections such as suburban and subway train stations; see [Sz20]. To use these vehicles, at least a moped driver's license and a helmet are required. The company provides the latter in the bicycle basket.

4.4.2 The products and services provided

While in summer 2019 a lot of information was available concerning technology and test of e-scooters of different providers, the information is quite limited, now. Besides, the fleets do not seem to be homogeneous. The reasons for this are, on the one hand, the further development of technology and, on the other, the concentration of suppliers with partial takeover of vehicles.

Figure 11: Development of e-scooters from Voi, Source: [Voi20]

If you ask users for differences, there are statements like:

- The vehicles of provider x accelerate faster than others do.
- I feel safer with the vehicles from provider y.
- The vehicles of provider z are more agile.

However, the differences do not seem to be very significant for the users. Although the maximum ranges specified by the providers vary, this does not appear to be a distinguishing feature for users either. These ranges (30-50 km) significantly exceed the distance that a user normally covers with an e-scooter. A major topic is replacement of batteries, which is on the future agenda of most suppliers.

In addition, there are differences in the general conditions, such as charging the vehicles, maintenance and working conditions of the employees. These different approaches seem to be more important to some users than the technological differences.

Figure 12: Charging of Dott e-scooters in Munich with eco-power, Source; [Mer20]

Another topic of interest to users are the services offered. The operational area for e-scooters in Munich is located in the city center, limited by the “Mittlerer Ring” for most providers. However, there are e-scooters available outside of this area, for example e-scooters from TIER at the “Olympia Einkaufzentrum” (OEZ).

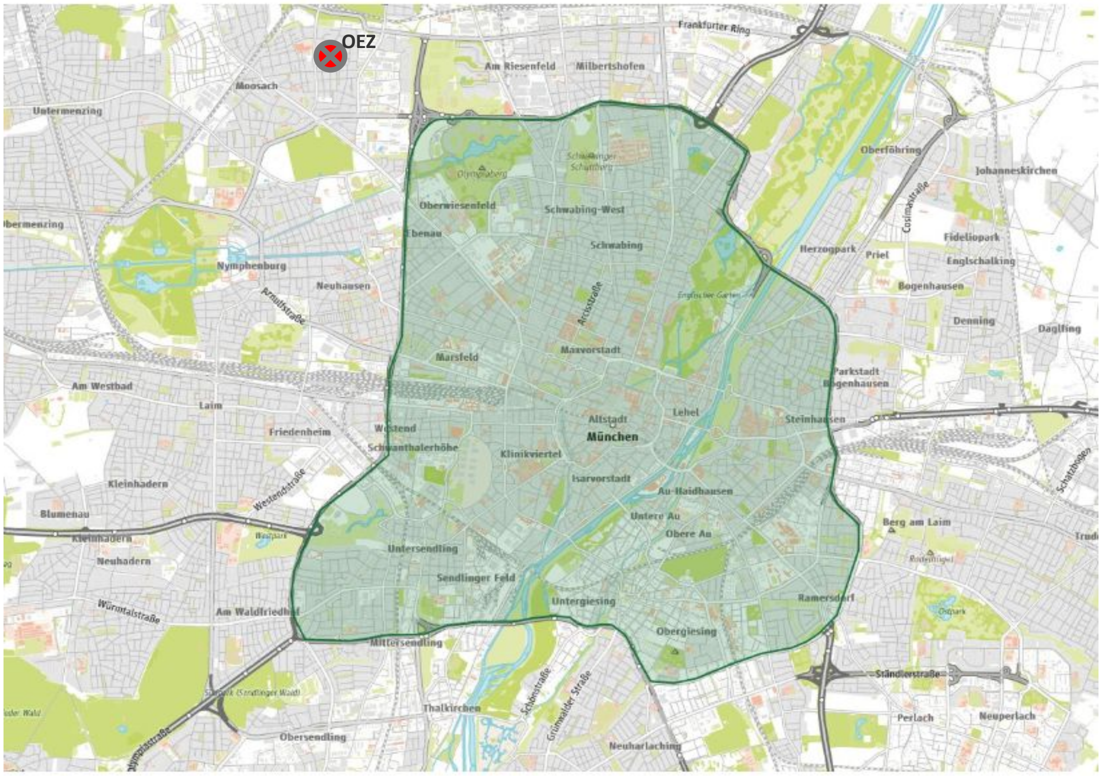


Figure 13: Munich Mittlerer Ring, © @OpenStreetMap, Source: https://www.muenchen.de/rathaus/.imaging/mte/lhm/generic-lightbox-image/dam/Home/Stadtverwaltung/Referat-fuer-Gesundheit-und-Umwelt/Bilder/Luft_und_Strahlung/Umweltzone/umweltzone_uebersicht.jpeg/jcr:cont

Munich has set a limit on the number of e-scooters. Currently, 100 e-scooters per provider may be provided within the inner City ("Altstadtring") and a maximum of 1000 within the "Mittlerer Ring".

4.4.3 Distribution and marketing to customers

All providers have their own apps that make it possible to find and borrow vehicles. In addition, some of the companies operating in Munich are linked with other mobility service providers. In these cases, users can also book the vehicles via the app of the associated company. Both companies perform the marketing, reaching more potential users.

This also leads to adapted self-portrayals. In Munich, TIER is connected to MVG and therefore presents itself as the provider for the last mile. Lime works together with Uber; Voi is connected to FreeNow, the mobility platform of BMW and Daimler. Accordingly, they present themselves as a fast and environmentally friendly alternative to cab or car sharing for short distances.

4.4.4 The companies' revenue models

Especially after the period of limited or discontinued business in spring 2020, there are major financial problems for e-scooter providers. They must make a new attempt to enter the loss-free zone for the first time or again. The fleets were reduced. However, attempts are also being made to gain new market share with improved services, for example extension of the catchment area. In particular, measures to prevent infection, such as disinfection or frequent maintenance, are currently being advertised.

The base tariffs for short trips differ only marginally, but there are special packages available as well as additional offers.

Provider	TIER	Voi	Lime	Dott	Bird
Unlock fee	€1Error! Bookmark not defined.	€0,99	€1	€1	€1
Price per minute (July 2020)	€0,19[1]	€0,15	€0,25	€0,19	€0,15
Packages and prices	no unlock fee for 1 month €5,99	day pass with 45 minutes free of charge for each trip €9,99	day pass with 30 minutes free of charge for each trip €9,99	2 trips, no unlock fee €4,99	
	60 driving minutes, no unlock fee €14,99	moth pass with 45 minutes free of charge for each trip €39		5 trips, no unlock fee €9,99	
	120 driving minutes, no unlock fee €22,99			10 trips, no unlock fee €14,99	
	600 driving minutes, no unlock fee €39,99				
Special offers		parking management with cost reduction for parking			cost reduction for parking at special parking spaces

[1] Same unlock fee and minute price for small electric motorbikes; see [charivari (06/2020)]

		according to the advise			
Payment method	credit card, Paypal	credit card, dedit card, Paypal	credit card, dedit card, Paypal	credit card, Paypal	credit card, dedit card, Paypal

Figure 14: Tariffs of e-scooter providers in Munich, Source: [Dah20], [Ros20], [Az20b]

4.4.5 Degree of use and parameters for comparison

Since there was a massive reduction of services and usage in spring 2020, it seems to be more interesting to have a look to the figures of late 2019 or early 2020 instead of finding out the current situation. The pre-pandemic level of usage of e-scooters gives an indication of the potential. In September 2019, there were in total about 5400 e-scooters provided in Munich by TIER, Voi and Lime; see [Sta19], of which Lime had a share of about 40%. The statistics do not show the corresponding information for the other two providers.

A survey conducted in Munich at the end of 2019 showed that at that time more than 42% of young adults (18-25 years) had already ridden an e-scooter at least once; see [Ton19]. However, the same survey also showed that trips with the e-scooters mostly replace trips with public transport (64% of the responses[2]) or walking (49% of the responses). Rarely do the e-scooters replace car rides (21% of the responses).

Evaluations from November 2019 also show that at this time in Munich an e-scooter was used on average about three times a day; see [Wil19]. Sometimes the providers gave slightly higher numbers.

4.4.6 Comparisons with other mobility services in Munich

Public transport

The two modes PT and e-scooter usage differ too much to make a real comparison reasonable. Only a rudimentary price comparison seems possible.

A single ride on an e-scooter with a duration of more than 15 minutes is in any case more expensive than a corresponding public transport ride, since a single trip within one traffic zone costs €3.30 in Munich. A day ticket for downtown Munich (traffic zone M) costs €7.80, a monthly ticket costs €55.20. Compared to the offer from Voi, the day ticket for e-scooters is more expensive, the monthly ticket however clearly less expensive.

Taxi services

Taxi services are always more expensive than rides with e-scooters. There is a basic fee of €3.70 per trip and a staggered fee of €2 per kilometer for the first 5 kilometers. After that, the fee drops to €1.80 per kilometer. Because of the maximum speed of e-scooters, driving one kilometer takes at least three minutes, while five minutes are more realistic. That means driving five kilometers with an e-scooter takes about 25 minutes and produces costs of about €6. Driving the same Distance by taxi is (depending on traffic) probably much faster but is more than twice as expensive.

[2] multiple answers possible

Car sharing services

The electric scooters could be attractive for investors because the revenue per kilometer is relatively high. Renting Scooters, in comparison with car sharing services, can probably earn more money. The purchase cost of an e-scooter is less than 10% of the purchase cost of a small car while the rental prices per minutes do not differ so much. Small cars can be rented with prices from €0.09 to €0.33 per minute; see [Wil19]. Since cars normally drive much faster than e-Scooters, driving an e-scooter can be quite expensive for the user.

5. Methodology for Quantitative Business Model Analysis

The qualitative business model analysis, as described in Section 3 and reported on in Section 4, identifies requirements for business models on the shared e-micromobility service market, i.e., captures the current business environment of the actors. Where these investigations reveal that value proposition, delivery and capture of the businesses, to gain further insight into the key performance indicators of the existing businesses or future business in existing or new markets, one needs to be able to estimate the demand for these services in the context of the larger transport system. In preparation to build models that can estimate this demand (second part of the project, unfortunately not approved under BP2021), under the quantitative business model analysis of activity A2004, quantitative macroscopic models and information sources for the estimation of service demand and usage and business attractiveness indicators were reviewed and analyzed. The following paragraphs describe the process of this review and analysis.

First, in light with the quantitative business model analysis objectives presented in Section 2.2 and the aims of the activity as a whole, based on the expert knowledge of the participants, aspects and dimensions for the literature review and analysis where selected and defined as it is shown below:

Aspect	Dimension	Notes
Model basics	Model structure	E.g., regression, classification, gravity, 4-step, agent-based, etc.
	Model level of detail	E.g., microscopic, mesoscopic, macroscopic
Micromobility service and context	Travel modes modelled	E.g. subway, bus, car, private bicycle
	Nature and level of Public Transport (PT) integration	E.g., incentive modal chaining

	Micromobility service type	E.g., vehicles, sharing schemes
	Micromobility service usage patterns, constraint, assumption	Integrated in the model
Data and variables	Independent variables	E.g. travel time, start/end coordinates, bus route
	Dependent variables	E.g. hourly/daily demand, travel time, modal shift
	Spatial level of detail / resolution	E.g. 15 minutes, 200m X 200m
Model application	Geographical study area	E.g. Nanjing, Delft, Washington, D.C.
Modelling results	Estimated demand	Absolute and/or relative modal share / shift, level PT integration in the modeled mobility patterns, etc.
	Variability of demand in space or time or other attributes	Variability of demand depending on weather, day of the week, transit accessibility, etc.

Second, in a desk study, the scientific literature on demand models for share e-micromobility services has been reviewed via a combination of keyword / phrase searches and manual citation analysis. As the underlying models and their modelling results might be of interest even if the model demand is not for a shared service or does not use an electric vehicle, the reviewed literature was wider in scope. The keywords / phrases used on the search were as follows: “demand models for shared mobility service”, “shared micromobility”, “modelling integration of shared e-scooters”, “cooperation of shared micromobility and public transport”, “drivers of demand for shared e-scooters”, “factors affecting modal shift for shared micromobility”, etc. In total 57 candidate articles have been identified and based on their abstracts ranked. The top 36 articles were deemed to be of interest and have been reviewed along dimensions listed in the table above, i.e., relevant information has been extracted from the reviewed papers for each dimension. In the process 2 more articles were removed from the top ones but have been listed in the table anyway. The full results of this part of the process are submitted as supplementary material to this deliverable (see the LitRev-sheet of the file DEL04-SUPP1_DemandModel.xls).

Next, to get a better overview of the trends within the dimensions, for each dimension, the extracted relevant information from the reviewed papers where thematically clustered and generalized in order to identify a smaller set of and more generic variable values for each dimension. The so identified dimensional variable values, their explanation and association with the reviewed papers are submitted as supplementary material to this deliverable, (see the DimAnal-sheet of the file DEL04-SUPP1_DemandModel.xls).

Finally, based on the association between the dimensional variable values and the papers, the for each dimension the trends have been summarized; these summaries are presented in Section 6.2 and collectively form the complete review of the literature. For the sake of simplicity, the dimensions related to “micromobility service and context” in terms of service type, integration, constraints and assumptions are jointly presented with the results of the “estimated demand” with a focus on integration in Section 6.2.1.

In order to gain understanding as to how shared e-micromobility services can be made more environmentally sustainable through integration with public transport, for example via different incentives, during the literature review and analysis special attentions have been payed to how models can take into accounts the integration and incentive aspects, what data such modelling requires and how such integrated modelling affects the results.

6. Results of Quantitative Business Model Analysis

The results of the quantitative business model analysis reached the objectives that were set out for the subtask (see Section 2.2). In particular, an extensive literature review of quantitative (macroscopic) demand models for shared e-micromobility services has been performed (see Section 6.1) according the methodology that was in line with what was proposed in BP2020 and is explained in Section 5. As part of the literature review, an inventory of over information and data sources and methods have been created (see supplementary material DEL04-SUPP1_DemandModel.xls). A deep analysis of the review models' structure, input data, variables and results (see Section 6.2) reveals that one can construct models that estimate realistic shared e-micromobility service demand in the context of the larger transport system (including public transit), and some models can even adequately model service integration with public transport services via incentives or restrictions. However, as it is summarized in Section 7.2, while such models can be applied to different geographies to estimate service demand, they are data and computationally intensive. Overall conclusions of the deep analysis of the models with a focus on the feasibility of creating a general demand model that could be used by operators to evaluate the business potential in unexplored geographies with realistic information available about the competition (price model, service area, fleet size, hour of operations etc.) for different deployment scenarios are drown in Section 7.2

6.1. List of reviewed papers on demand modelling shared micromobility services

[1] Campbell, K., & Brakewood, C. (2017, May 05). Sharing riders: How bikesharing impacts bus ridership in New York City. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0965856416304967

[2] Lin, L., He, Z., & Peeta, S. (2018, November 05). Predicting station-level hourly demand in a large-scale bike-sharing network: A graph convolutional neural network approach. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0968090X18300974

[3] Campbell, A., Cherry, C., Ryerson, M., & Yang, X. (2016, March 24). Factors influencing the choice of shared bicycles and shared electric bikes in Beijing. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0968090X16000747

[4] Kager, R., Bertolini, L., & Brömmelstroet, M. (2016, February 10). Characterisation of and reflections on the synergy of bicycles and public transport. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0965856416000240

[5] Zhou, X., Wang, M., & Li, D. (2019, August 02). Bike-sharing or taxi? Modeling the choices of travel mode in Chicago using machine learning. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/abs/pii/S0966692318304678

[6] Fishman, E., Washington, S., Haworth, N., & Mazzei, A. (2014, August 22). Barriers to bikesharing: An analysis from Melbourne and Brisbane. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0966692314001677

[7] Mattson, J., & Godavarthy, R. (2017, July 03). Bike share in Fargo, North Dakota: Keys to success and factors affecting ridership. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S2210670717303268

[8] Shaheen, S., & Martin, E. (2016, February 10). Unraveling the Modal Impacts of Bikesharing. Retrieved September 26, 2020, from https://escholarship.org/uc/item/3cd802js

[9] Pan, Y., Zheng, R., Zhang, J., & Yao, X. (2019, February 06). Predicting bike sharing demand using recurrent neural networks. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S1877050919302364

[10] Fan, A., Chen, X., & Wan, T. (2019, May 14). How Have Travelers Changed Mode Choices for First/Last Mile Trips after the Introduction of Bicycle-Sharing Systems: An Empirical Study in Beijing, China. Retrieved September 26, 2020, from https://www.hindawi.com/journals/jat/2019/5426080/

[11] Ma, X., Yuan, Y., Oort, N., & Hoogendoorn, S. (2020, March 04). Bike-sharing systems' impact on modal shift: A case study in Delft, the Netherlands. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0959652620308933

[12] McKenzie, G. (2019, May 24). Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/abs/pii/S0966692319302741

[13] Zhu, R., Zhang, X., Kondor, D., Santi, P., & Ratti, C. (2020, March 27). Understanding spatio-temporal heterogeneity of bike-sharing and scooter-sharing mobility. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S0198971519305812

[14] Westland, J., Mou, J., & Yin, D. (2018, September 25). Demand cycles and market segmentation in bicycle sharing. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S030645731830503X

[15] Scott, D., & Ciuro, C. (2019, April 12). What factors influence bike share ridership? An investigation of Hamilton, Ontario's bike share hubs. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S2214367X18300188

[16] Noland, R. B., Smart, M., & Guo, Z. (2016, December). Bikeshare trip generation in New York City. Retrieved September 27, 2020, from https://www.sciencedirect.com/science/article/abs/pii/S0965856416307716

[17] Eren, E., & Uz, V. (2019, October 15). A review on bike-sharing: The factors affecting bike-sharing demand. Retrieved September 26, 2020, from https://www.sciencedirect.com/science/article/pii/S2210670719312387

[18] Wang, X., Lindsey, G., Schoner, J., & Harrison, A. (2016, March 24). Modeling bike share station activity: Effects of nearby businesses and jobs on trips to and from stations. Retrieved September 26, 2020, from https://experts.umn.edu/en/publications/modeling-bike-share-station-activity-effects-of-nearby-businesses

[19] Voorhees, A. M., Bloustein, E. J., Gebhart, K., & Noland, R. B. (2013). (PDF) The impact of weather conditions on bikeshare trips ... Retrieved September 26, 2020, from https://www.researchgate.net/publication/271919684_The_impact_of_weather_conditions_on_bikeshare_trips_in_Washington_DC

[20] Noland, R. B., Smart, M. J., & Guo, Z. (2018, October 11). Bikesharing Trip Patterns in New York City: Associations ... Retrieved September 27, 2020, from https://www.researchgate.net/publication/328244064_Bikesharing_Trip_Patterns_in_New_York_City_Associations_with_Land_Use_Subways_and_Bicycle_Lanes

[21] Guidon, S., Reck, D., & Axhausen, K. (2020, March 26). Expanding a(n) (electric) bicycle-sharing system to a new city: Prediction of demand with spatial regression and random forests. Retrieved September 27, 2020, from https://www.sciencedirect.com/science/article/pii/S0966692319307136

[22] Mathew, J., Liu, M., Li, H., & Seeder, S. (2019, June). Analysis of E-Scooter Trips and Their Temporal Usage ... Retrieved September 27, 2020, from https://www.researchgate.net/publication/333634549_Analysis_of_E-Scooter_Trips_and_Their_Temporal_Usage_Patterns

[23] Mesaric, R. (2019, June). *The drivers of demand for free-floating car-sharing* [Scholarly project]. In *ETH Zurich*. Retrieved from https://ethz.ch/content/dam/ethz/special-interest/baug/ivt/ivt-dam/publications/students/601-700/sa650.pdf

[24] Aguilera-García, Á, Gomez, J., & Sobrino, N. (2019, August 27). Exploring the adoption of moped scooter-sharing systems in Spanish urban areas. Retrieved September 27, 2020, from https://www.sciencedirect.com/science/article/pii/S0264275118318614

[25] Jin, H., Jin, F., Wang, J., Sun, W., & Dong, L. (2019, March 03). Competition and Cooperation between Shared Bicycles and Public Transit: A Case Study of Beijing. Retrieved September 27, 2020, from https://www.mdpi.com/2071-1050/11/5/1323/htm

[26] Ma, S., Zhou, Yu, & Zhang. (2019, August). College Students' Shared Bicycle Use Behavior Based on the NL Model and Factor Analysis. Retrieved September 27, 2020, from https://www.researchgate.net/publication/335316031_College_Students'_Shared_Bicycle_Use_Behavior_Based_on_the_NL_Model_and_Factor_Analysis

[27] Ye, M., Chen, Y., Yang, G., Wang, B., & Hu, Q. (2020, March 8). (PDF) Mixed Logit Models for Travelers' Mode Shifting ... Retrieved September 27, 2020, from https://www.researchgate.net/publication/339789574_Mixed_Logit_Models_for_Travelers'_Mode_Shifting_Considering_Bike-Sharing

[28] Jiao, J., & Bai, S. (2020, February 24). Understanding the Shared E-scooter Travels in Austin, TX. Retrieved September 27, 2020, from https://www.mdpi.com/2220-9964/9/2/135

[29] Yanjie, J., Yu, C., Yang, L., & Xinwei, M. (2019). Analysis of temporal and spatial usage patterns of dockless sharing system around rail transit station area. *Journal of Southeast University, 35*(2), 228-235. doi:10. 3969/ j. issn. 1003 - 7985. 2019. 02. 013

[30] Lu, M., An, K., Hsu, S., & Zhu, R. (2019, May 08). Considering user behavior in free-floating bike sharing system design: A data-informed spatial agent-based model. Retrieved September 27, 2020, from https://www.sciencedirect.com/science/article/pii/S2210670719301623

[31] McKenzie, G. (2019, November 09). Urban mobility in the sharing economy: A spatiotemporal comparison of shared mobility services. Retrieved September 27, 2020, from https://www.sciencedirect.com/science/article/pii/S0198971519303060

[32] Smith, C. S., & Schwieterman, J. P. (2018, December). E-Scooter Scenarios: Evaluating the Potential Mobility ... Retrieved September 27, 2020, from https://www.researchgate.net/publication/330093998_E-Scooter_Scenarios_Evaluating_the_Potential_Mobility_Benefits_of_Shared_Dockless_Scooters_in_Chicago

[33] Li, Y., Dai, Z., Zhu, L., & Liu, X. (2019, September 12). Analysis of Spatial and Temporal Characteristics of Citizens' Mobility Based on E-Bike GPS Trajectory Data in Tengzhou City, China. Retrieved September 27, 2020, from https://www.mdpi.com/2071-1050/11/18/5003/htm

[34] University, G., McKenzie, G., University, M. (2019, November 01). Shared micro-mobility patterns as measures of city similarity: Position Paper. Retrieved September 27, 2020, from https://dl.acm.org/doi/abs/10.1145/3356392.3365221

[35] Yang, F., Ding, F., Qu, X., & Ran, B. (2019, June 11). Estimating Urban Shared-Bike Trips with Location-Based Social Networking Data. Retrieved September 27, 2020, from https://www.mdpi.com/2071-1050/11/11/3220

[36] Caspi, O., Smart, M., & Noland, R. (2020, July 02). Spatial associations of dockless shared e-scooter usage. Retrieved September 27, 2020, from https://www.sciencedirect.com/science/article/pii/S1361920920305836

6.2. Dimensional analysis of the reviewed papers

6.2.1 Model structure

The vast majority of the models, that are used partially or completely for the evaluation of the integration of shared mobility services into the existing transit chain, are part of the regression family: 15 out of 34 studied papers. The other models are used only in 1-3 articles each.

Depending on the main goal of a paper, it is either linear, logit or binomial regression. It is the most popular model family, as after the optimization and validation of the model, it is possible to calculate such important values as value of time, consumer surplus and revenues. It is also possible to estimate a policy, which could be implemented in the further analysis of integration. Even 1 out of 2 random forests ([21]) is based on the linear and spatial regression models, because they are also easy to estimate. Another important factor that makes researchers use some of the regression models is the ability of some model types to capture dependences between utilities (nested in [26], mixed in [27]) and represent individual specific parameters as random, i.e. varying for individuals (mixed in [27]). Notably, Bayesian estimation [16] (estimating distributions of parameters, not exact values) can also be used to study this aspect.

Another direct method, that could be also used for quantification of a policy, is a differences in difference estimator, which is able to capture unbiased differences between two groups without any temporal effects interfering [1].

Some other models are estimating factors driving people to shift to another transport mode from their original one (e.g. factor analysis in [6] and [28]), which might be also useful for policy makers to create a sustainable future not only in terms of sustainable energy, but in accessibility and quality of life as well.

Nevertheless, some methods are only useful for studying of the current situation and for drawing conclusions regarding it. Therefore, those models cannot model future movement without being able to calculate the abovementioned values (e.g. value of time), which are of high interest for the purposes of this project.

6.2.2 Model's level of detail

In total, 13 papers belong to microscopic models, 9 are mesoscopic, and 11 are macroscopic. From these 7, 6 and 6 papers, respectively, are concerned with the new service's integration into the existing transit chain.

The level of detail of the models depend on the type of model and the researcher's choice on whether or not to aggregate the values. For example, in [36] researchers aggregate the data in order to protect personal information of the micromobility users. In [15] buffer zone is studied, while in [18] ridership data is aggregated into groups by docking stations and a new overview over the micromobility service use is presented.

Papers that aggregate data are more or less evenly distributed between micro-, mezzo- and macroscopic models. Even models of the same family (e.g. regression) are being dispersed in every level of detail. Sometimes it is argued that such data aggregation leads to the Multiple Areal Unit Problem (MAUP) that can results in explanatory power or even unrealistic trends.

6.2.3 Modeled travel modes

While all the papers model some form of shared micromobility service, they are split into parts according to a variety of service types. In total, 25 papers study bikesharing, 8 investigate e-bikesharing, 10 explore the scope of e-scooters and 2 papers take into account carsharing as a side object of research. 15 papers study the impacts of public transportation, 6 papers include private (e-)bikes, 5 papers have motorized vehicles in the models, 5 have taxis and 5 include walking mode.

7 papers concentrate on effects of subway stations in the model, which makes it the second most popular type of transport in the articles after the shared micromobility services. This might be a consequence of the research being run in the cities with subway and the latter actually being one of the most popular public transport modes due to its speed and lack of congestion. It is mostly included as subway stations being in proximity of the shared micromobility service.

Papers that include a few modes typically use discrete choice models, which allow to study interactions between a few modes simultaneously. The most representative article is a Delft case study [11] that is trying to take into consideration as many modes as possible, so that the actual effect of the performed transit chain integration is unraveled on as many levels as possible. Another one is a Beijing case study [3] that attempts to compare classical bikeshare and e-bikeshare and to analyze from which modes the switch towards the shared micromobility will be made.

Finally, it should be mentioned that some of the papers solely consecrate on interaction of two particular modes, to see how they could compete/cooperate ([1] - bikeshare vs. bus, [5] - bikeshare vs. taxi).

6.2.4 Input data

As it is seen from the dimension, 24 papers are focusing on the ridership data for both studying shared micromobility services as a standalone mode of transport and as an integrated one (13 integration-concerned papers). However, as the majority of the latter studies the integration as correlation between to modes. Coordinates of the public transportation are used the most frequently for this purpose, not the public transport network itself, i.e.: 14 articles are focused on the proximity of stops/stations.

Some of these papers are also using a specifically constructed user survey to study individual preferences or to get more detailed statistical data. As in [3], [10], [11], [24] and [26] for example, a survey is a tool for retrieving data from a targeted and pre-chosen group of people. This way, the data would suit the best the purposes of the study if the survey is designed properly. It is traditionally a more expensive way, but with a proper approach it might be faster and easier to retrieve a sample with the help of this method. Some other models of the same (regression) family ([7], [15], [19], [27], [36]) are using statistical databases for the data collection, which might take longer time during the processing in order to make the data suitable for the model. Using databases might limit the scope of the research to an overall analysis without specifying the population's preferences.

Even though the data is mainly collected from different sources (shared micromobility services, public transportation services, population statistics, etc.), some of the articles have a specific scope of research and, therefore, the data is collected from one source or some additional atypical sources is used. In [8] survey is the main way of understanding the system processes due to the appearance of shared micromobility. Therefore, it is also the only data source. In [30] an agent-based model is constructed for studying the interactions of different parts of the environment, agents and rules. For its purposes, the study suggests to use the digital elevation model for a more realistic modelling of the utility of the newly provided service.

Overall, both micromobility ridership and stations'/stops'/docking stations' location are the most popular input data for studying demand/patterns of the mobility services with other types of data being added according to the scope of each case study.

6.2.5 Model's independent (predictor) variables

Overall, 22 articles use shared micromobility trip information and 15 use environmental variables. Infrastructure is included into that variable type, because the relationship between the shared micromobility services and current network is mainly studied via spatial associations. 5 papers are exploring how weather is impacting the shared micromobility use and the modal shift between it and some other modes. 10 articles also retrieve socio-demographic data about population. Lastly, 3 articles study the drivers of either use or non-use of the micromobility services.

As for the trip information, 14 papers are using travel time as one of the independent variables. Such a wide use might be due to 1) the importance of travel time for the shared micromobility services, as it is also one of its limitations and 2) the fact that it is relatively easy to retrieve this information. Public transport routes are one of the least popular independent variables: in [1] it is probably used, because the dependent variable is actually the bus ridership and the paper is studying how the shared micromobility services are affecting it; in [32] the impact is unclear, as the other limitation of the shared e-scooter would also be the price variation around the time spent on board, but there are some possible suggestions that are later mentioned in Section 6.2.9.

Weather impacts are studied in [3], [5], [7], [15], [19], [27] from which 3 are marked as papers studying integration into the already existing transit chain. As the scope of this research is the shared micromobility services, this might be one of the most important factors driving people away from using unsheltered modes in an unpleasant environment or during the weather that would make the experience uncomfortable (e.g. heavy rain is one of the most statistically significant variables in [3]).

It is important to note, that socio-demographics are used by the papers studying integration; the only exception to this is [26], where the mode switch is unable to study integration and choice towards the shared bicycle is made due to other modes being unattractive (traffic congestion, lack of transport). Age (8/34), education (6/34), gender (7/34), income (5/34) and occupation (6/34) are the most commonly used socio-demographic variables, which might be due to their overall significance in the model and availability via public databases. In [3], [24] and [26] environmental concern is added as one of the factors affecting the use of shared micromobility services. It is not so commonly used among the reviewed papers, but might be an important driver, because environmental concern might be helpful in the mode shift for building up a sustainable society.

Discounts are mentioned only in the case study of Delft [11] which is trying to integrate shared bicycles into the transit system by merging payment systems and offering discounts for the joint use of the included modes.

Motivation is a group of different variables(e.g. safety, lanes' quality), [11] gives an insight into some of the factors driving demand of the shared micromobility services, among which are: price (compared to other modes and owning a bicycle), quality of bicycles, required effort, theft problem, parking problem, concerns about environment and health, easy of the system use, preferences of the dockless service, PT subsidies. Price, theft, quality of service and subsidies seem to be significant depending on the type of service (company) being used, because they have different special offers and levels of integration. In [24] individual concerns are also being captured due to the model being generalized, i.e. allowing for the correlation of the variables: willingness to download news apps, share personal data, and share bank account info. As for the results, familiarity with the shared e-scooters seems to be one of the main drivers of demand, which would also include familiarity with technology and sharing the personal/bank account data.

Independent variables seem to be more or less evenly distributed across the papers, with some preferences in each type: travel time, locations of stations, origin-destination and distance information about the trips; infrastructure and land use in the environmental variable type; education, age, gender and occupation for the socio-demographic and weather. With the latter one it might be a result of these variables being the most common for transportation model estimation, i.e., "basic" independent variables. For studying integration of the shared micromobility into the current transport system, it seems to be important for the model to be able to capture some individual specific parameters: both population ones and individual preferences. The last one might provide a significant piece of information regarding the population preferences, how to familiarize the population with the new mode of transport, which in different aspects might be too new for some big groups of people but still attractive because of some other factors (as it is shown in [24] and [26]) and how to process the integration in the most profitable way for the society and environment.

6.2.6 Model's dependent (target) variables

The preference in dependent variables is varying among the models. However, the majority of papers (15/24 for trip frequency and 5/24 for travel time) focuses on identifying demand in terms of trip frequency and travel time. The most popular target variables are number of trips per hour and per day which is probably due to further studying of correlation between transit, private transport and shared services.

Travel time is quite often estimated together with the trip frequency, which might be due to the fact that the same data is being used for estimation of both and that such analysis increases the research scope.

[11] and [24] study modal shift from different modes towards the shared micromobility services with binary models (1/0: yes/no shift). Travel willingness (a kind of proxy for demand) [27] is studied as a standalone target variable in one of three paper's models. In [30] an agent-based model is constructed and one of the main observed objects for the scope of the article is accessibility.

In total, the majority of dependent variables that are studied in 1 paper only (travel mode, shift, k-clusters), come together with another dependent variable, as they might be supplementary for the latter one.

6.2.7 Model's spatial level of detail

15 out of the reviewed papers do not have any resolution (neither spatial, nor temporal) due to the models representing rather preferences for the whole area.

Otherwise, the choice apparently depends on the available data and on the preferences/limitations (e.g. legal) of the researchers: as in [30], [31] and [33] 1-minute time resolution is chosen due to the data limitations (a record every minute), in [5] 15 minutes are chosen in order to avoid using faulty records, that are not actual rides.

As to spatial resolution, data is mainly split into zones and one of the most interesting solutions is to perform the separation into Thiessen polygons as in [16] and [20], which might catch the effect of the station more precisely. However, this might be also causing some issues, because areal partition might be affected by some other unobserved characteristics.

Sometimes choosing a grid is a necessary measure for data security, as in [28], where the major goal is to protect private data of the users by not disclosing exact coordinates and time, for instance.

As to [14], space-time irregular graph is believed to be the most exact solution for the result representation of the three-dimensional wavelet decomposition.

6.2.8 Geographical study area

17 of the papers are study cities in the United States, 4 in Canada, 8 in the People's Republic of China, 1 in Singapore, 6 in Australia, 2 in the Netherlands, 1 in Switzerland and 1 in Spain. Some of them are studying differences between countries, e.g. [8] studies US and Canadian cities.

It is difficult identify clusters in this dimension, as some of the papers have been found "in a chain", i.e., while one is a result of the search, the others are appearing as suggestions for further reading. Therefore, geographical area clusters might appear as the result of this. However, an interesting fact is, that in [8], [24] and [25] the authors are arguing about one-sided nature, i.e. being only a complementary/substitutive mode of transport in the system, of the shared micromobility service for the network, and those studies are conducted in different areas: Minneapolis-Saint Paul, Washington, DC (the US), Montreal, Toronto (Canada); Spain; Beijing (PRC), respectively. This might be an important finding, that should be studied further in other cities in order to understand the duality of the shared micromobility services' nature.

Overall, the papers' geographical extent represents either "green" cities that are focusing on the development of sustainable society [4], [11], [21] or the very modern ones, which can allow to have a shared micromobility service, and they are trying to solve current transportation problems, e.g., overcrowding on bus [6].

6.2.9 Results with focus on service integration and its effects

In total, there are 24 papers that study shared micromobility service integration to some extent. Out of these, in 1 [15] the variable for public transportation (presence of subway stations inside the studied buffer zone) is found insignificant. In 9 articles it is revealed that the newly added mode is more of a competition to the current transit system, as this was of most concern for the researchers. One out of nine papers [1], seeing the negative effect, assumes that the impact of incentive (i.e., reduced fare for public transport) is extremely significant for the model by separating the people who are getting it. This group mainly contains of either older people or the ones, who have disabilities. 18 articles conclude that shared micromobility services would be complementary to the current public transit system by being a first-/last-mile solution in 14 articles and by being able to fill in the existing gaps in the transit network in 4 papers. Some of the articles (3 in total: [8], [24] and [25]) are revealing the dual nature (complementing at some places/modes and being competitive) of the shared micromobility services and the traditional public transit network.

In some cases, the differences between places have to be studied in order to understand processes caused by shared micromobility activities. As in [8] four cities of the North America are studied and some of them have a completely different mode change. For example, while in Washington, DC shared bicycles substituted shorter trips and, therefore, there appeared a switch from train, in Minneapolis-Saint Paul, on the contrary, the use of shared bicycles is causing an increase in the walk and train trip numbers by switch from either car or bus: 38% of people preferred to walk more (with a loss of 23%), 15% - to use rail (with a loss of 3%), 52% to drive less (with a gain of 0.3%) and 17% to use a bus less (with a gain of 15%). In [11] a higher number of commuter rail is also observed, however, other public transportation modes happen to be abandoned by the users. This result is explained by the joint payment system and relative proximity of destinations after reaching the main station.

Some of the articles are exploring the possibility of shared micromobility services being a nice substitution for motorized vehicles within the area of first-/last-mile modal choices. In [20] and [21] proximity to commuter rail and subway stations, respectively, generates more bicycle trips, although in the latter one it is the opposite during October and February due to the weather. In [10] the estimated model also supports this theory by the change in modal share after implementing the shared micromobility service; furthermore, this paper's results indicate that convenient location of the shared micromobility service may become a driver for switch towards more sustainable modes of transport. According to it, there is about a 10-20% negative change for car use as a first-/last-mile choice within people using car for those purposes once in one or two days with a proportionate growth within people using private bicycle 1-3 times/week and a drop of 15% within those who use it almost every day. Presence of subway station is positively correlated regardless other factors in [16]; it has some slight variations dependent on land use and socio-demographic variables being included.

In [25] it is also found that shared bicycles substitute the public transportation but generate more re-entries for trips less than 2km, thus being used in the transit chain. A similar situation is observed in [28] (with 62% use decrease when being more than 1km away from the transit area), [31] and [27]. However, in the first paper more trips are conducted within the 2-6km distance, therefore, shared bicycles contribute to sustainable development by increasing accessibility of places.

It is also interesting, that in [15] shared bicycles as a first-mile of trips are not a popular choice, because, according to the paper, the variable for proximity between public transport and shared bicycles is statistically insignificant. Nevertheless, it is quite the opposite with the last-mile choice. As it is suggested by the authors, this might be happening due to the last part of the trip being more important in the perception of the travelers. This follows from shared bicycles being a popular choice when the transit distance is between 800m and 1000m. Apparently, this is a situation happening in different places and with various shared micromobility services, because in [35] e-scooters are also preferred as rather a standalone or last-mile mean of transportation.

Some of the studies go further by claiming that micromobility services might be able to fill in the gaps in the current system. As in [24], for example, where according to the results of study some preliminary knowledge of similar modes (scooters and motorcycles, carsharing) would lead to use of e-scooter sharing (with those groups being 500% and 20%, respectively, more likely to ever use scooter-sharing). Otherwise scooter-sharing has some complementary effects on pedestrian and bike mobility by the private motorized vehicle substitution. As to the date of study, there were no clear effects on the public transportation in urban areas of Spain. In [32], depending on the part of the city, e-scooters are believed to be 55-66% time-competitive in the areas with parking constraints for the trips in range of 0.8-3.2km.

If the previous studies are mainly unraveling the positive or dual nature of integration of shared micromobility services and current modal chain, there are a few that are discovering the new mode of transport to be a competition to the others, i.e. to substitute from the other modes, which would mainly be walk, public transport and cycling. An interesting research is conducted in [3]: both e-bikesharing and bikesharing are included in the model. According to the paper, due to probably the difference in accessibility modes has different types of behavior: while bikesharing is drawing people from unsheltered modes (walk, bike, bus), e-bikesharing has a significant positive utility of replacing bus links, however, it could contribute to increasing accessibility for people living far away from transit areas and, therefore, increase their quality of life through allowing them to get to work in better places. In [6] public transportation accessibility is affecting the shared bicycle use in a negative manner. For that case study of Melbourne and Brisbane, shared bicycles are being a competitive mode of transport not a complementary one. Another limitation that is difficult to overcome is the trip length for shared micromobility services: in [19] the number of trips is negatively affected by the number of subway stations, while their length remains within the same range.

Importance of well-developed infrastructure cannot be left without a notice as well: in two studies ([16] & [20]) conducted in the New York City the variable of bicycle lane is statistically significant indicating that lanes' proximity generates more shared bicycle trips. The same effect is observed in [36], where both bicycle lanes and bus stops are positively associated with both departure and arrival (model estimates for lanes: 0.294 and 0.260, respectively; model estimates for bus stops: 0.507 and 0.417, respectively) of electric scooters. In Nanjing [31] density of the network is also positively correlated with the bikeshare use.

Unfortunately, acceptance of the shared micromobility services as an incentivized element of the multimodal chain is not finished yet. Therefore, not many papers have been found, that would take into account incentives stimulating integration of the new service with the public transportation chain.

However, in the Delft case study [11] it is suggested to use the joint pricing scheme and discounts for people using two transport modes, which results in a shift towards commuter rail and increases the number of bikeshare trips, as it is mentioned above.

In total, the vast majority of papers comes to a conclusion that shared mobility services are a great solution for the first-/last-mile in the transit chain. Some of the papers are able to capture the dual nature of the shared micromobility services (both complementary and competitive sides), while some of them focus on comparing shared micromobility services with shared e-micromobility services. The latter ones have been of the main interest for this research, but not many papers concerning that have been found online, which might be due to shared e-mobility services being a relatively new mode of transportation. As it is said in a few articles, regardless any modelling results, the long-perspective outcomes might be different from the immediate ones.

7. Conclusions and Lessons learnt

The subsections below draw conclusions about four aspects of the results of the qualitative and quantitative business model analysis. Section 7.1.1 describes three characteristically different business environment conditions and city regimes that were observed in the four cities that were studied. Section 7.1.2 describes some consequences of the business environment conditions on the business models and strategies of the actors. Section 7.1.3, based on the price and costs structures and low asset utilization of the shared e-micromobility services operators, describes two emerging disruptive technologies and services that have a potential for reshaping the business landscape of shared e-micromobility services. Finally, based on the quantitative business model analysis, Section 7.2 reflects on the most promising models and their input data needs that can be used to give quantitative assessment of revenues or business potential for shared e-micromobility services in the context of the larger transport system (including public transit) and explores the feasibility of creating a general demand model that could be used by operators to evaluate the business potential in unexplored geographies with realistic information available about the competition (price model, service area, fleet size, hour of operations etc.).

7.1. Qualitative Business Model Analysis

The mapping of the current e-micromobility services of Stockholm, Tel Aviv, Madrid, and Barcelona provides an understanding of how the dynamics of this emerging market. Compared to other sectors, the market of e-kickscooters is still in its fluid phase, with new actors entering the market over a short period of time (as well as some the actors withdrawing from the market) and cities and regulatory bodies apply very different approaches to the e-kickscooters and the regulations are still changing. Neither the market, nor the regulations have stabilized. It seems to be a venture capital driven market where various scooter providers try to position themselves, in order to become market leaders and gain advantages for, e.g. public procurements, in the future. Many of the scooter providers still experiment with different kind of pricing models, number of scooters, scooter designs, and to collaborate with other type of actors in order to expand their value propositions and services offered.

In the following, three main conclusions from the qualitative business model analysis are discussed further (1) differences in the cities' policy regimes have significant impact on the business environments for the kick-scooter providers; (2) the environmental consequences on business models and strategies, and (3) emerging (potentially) emerging disruptive technologies and services.

7.1.1 Three types of policy regimes creating different business environment

There are strong commonalities between the kick-scooter providers. On an overarching level, they are competing with similar value propositions, rely basically on similar value creation processes, and apply very similar revenue models. Thus, the providers are all applying the same generic business model based on a free-floating fleet of vehicles, a fleet management software system, and an easily accessible mobile application software (an "app"). The software systems are the key. The very same fleet management and app software could be used for various types of vehicle- and ride-sharing services, such as cars, bikes and mopeds. Thus, the emerging pattern of external partnerships, as well as own additional services, indicates a development towards a broader portfolio of service offerings, comprising various types of vehicles and combinations of travels.

From the analysis of the cities it is however possible to identify three different archetypes of business environments:

1) "The Wild West - come to the land of opportunity and do as you like": Stockholm and Munich apply liberal policies with respect e-scooter providers, and there is harsh competition between the providers: as long as a new provider complies to the basic rules, it is free to deploy free-floating, e-kickscooter services. The market is dynamic and it has changed significantly during the Covid 19- period. In Stockholm, after a dip during the Spring 2020, the supply of kick-scooters during the Fall 2020 seems to be larger than ever. In Munich, the market seems to be saturated and now starts to be concentrate to fewer, but larger, providers. This might, however, be a Covid 19-effect; the long-run pattern of the is still ambiguous.

2) "The opportunistic-exploitive - permission to operate in exchange of business intelligence". In Tel Aviv, the number of scooter providers is regulated and limited three actors who run their operations on commission from the city. Providers have to obtain an operating permit for six months and the number of scooters is limited to 2,5000 per operator. In addition, the providers are required to transfer information on vehicle-use and mobility patterns to the city.

3) "The protective-conservative - restrict operations until its clear how the city can benefit". In Barcelona, free floating e-kickscooter rental is, so far, forbidden. Today, only two providers are allowed to operate, but under the strict requirement that the scooters are parked in private areas. Consequently, there is instead an increasing business of e-scooter for sale to private customers. If the City of Barcelona decides to allow e-scooter rental in the future, the large diffusion of privately owned scooters might function as a market threshold for providers trying to enter the Barcelona market.

Thus, these three different business environments create different possibilities and constraints for the actors involved at each of the markets.

7.1.2 Business environments' consequences of on business models and strategies

The common business model of shared e-micromobility is based on scalability and growth in order to establish a profitable service. The identifies patterns of different business environment conditions (e.g., regulations on the number of vehicles / operators, no-go areas, service usage data sharing requirements) present challenges for the operators in developing sustainable business models. Thus, qualitative business model analysis of operators in the four cities and under the three business environment conditions indicates that there are different trends that affect the business models and strategies of the actors.

Development of service delivery under competition: The "wild west" business environment conditions of Stockholm and Munich, compared to the other two the opportunistic-exploitive and protective-conservative conditions of Tel Aviv and Barcelona, respectively, create fierce competition between the operators. To increase their market share, asset utilizations, and unit economics and thereby attract, increase and satisfy venture capital, the scooter providers:

- modularize their service as is it shown in Figure 2 for Stockholm,
- outsource parts of their operations to more traditional actors (e.g., operators move from using gig-workers toward using logistic service providers),
- eco-brand their service (e.g., they claim large degrees of mode chaining with public transit and substitution of / shift from private car trips as well as utilize green electric vehicles for charging and rebalancing operations),
- employ service diversification and bundling (i.e., offer a list of different vehicles types such as cars, bikes, mopeds and kick-scooter to their customers),
- collaborate to a minimal extent with strategically selected operators by pooling their fleets,
- share resources (e.g., charging infrastructure, facilities, vehicle maintenance) with other industries with similar maintenance processes (like in logistics) in order to lower costs, and
- participate in MaaS-platforms (mostly operated by the city's public transport operator) such that the integration with other modes of mobility and the service becomes visible and attractive for more potential customers.

Limits of positive unit economies, market saturation: Under the opportunistic-exploitive and protective-conservative business environment conditions of Tel Aviv and Madrid/Barcelona, it is observed that approximately three operators establish themselves or remain active in a metropolitan area. This is in sharp contrast to the 10+ operators in Stockholm. Is it possible to demonstrate a viable business case for much more than three operators under these conditions (i.e. where operators either are heavily regulated or have to share service statistics which gives insights to their unit economies)?

Externalities of regulation: Due to the flexibility and convenience of e-kickscooters in urban environments regulating shared e-micromobility services may not always be effective. For example, in Barcelona, in lack of the shared micromobility services there is an explosion of private ownership and new leasing / renting business for e-micromobiles. Ensuring the safety aspects and environmental sustainable use of these vehicles by regulations is a challenge.

7.1.3 Emerging disruptive technologies and services

One big question is of course the unit economies of the shared e-micromobility service providers. The price models of the services together with the use patterns in Section 4 reveal that an average ride is approximately 15 minutes long which costs €3 - €4 depending on the city and that the vehicles are rented approximately 5 times per day. At the same time, each vehicle needs to be collected for charging, maintenance and/or repositioning on average daily once. The cost of this operation is dependent on the charge level and the "end-of-the-day" location of the vehicle. Even without the other costs that relate to the basic components of service operations in Figure 2, this leads to low profit margins. McKinsey, provides similar estimates for revenues and expenses [McK19].

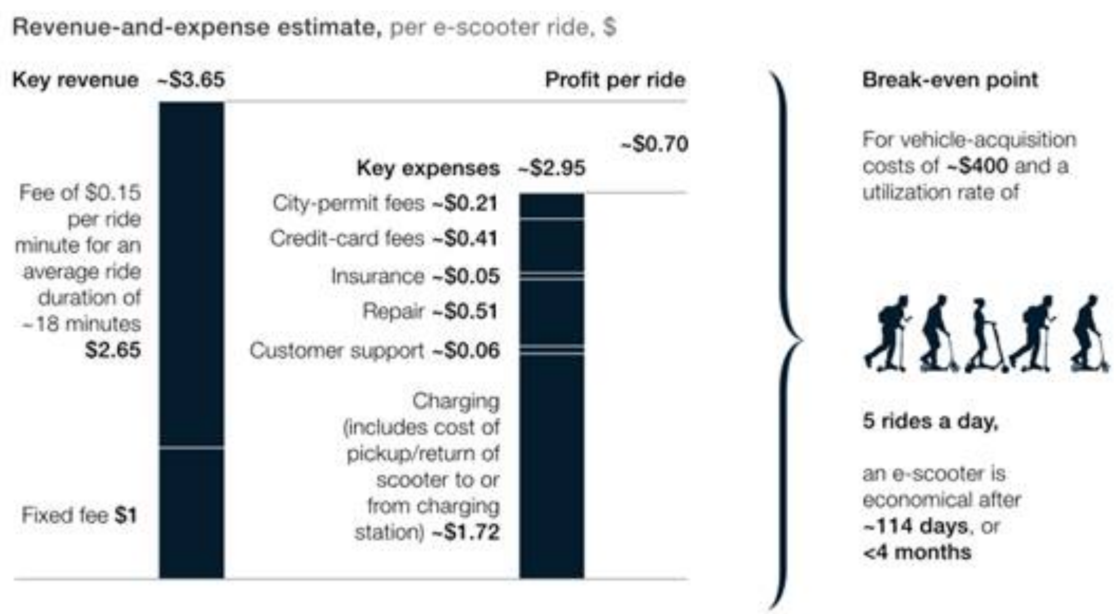


Figure 15: Revenue-and-expense estimates of shared e-micromobility services (source [McKi19]).

At the same time the use statistics also mean that vehicles are only used approximately 1.25 hours per day, i.e., are idling at least 90% of the time.

This demonstrates that the large business is in cutting the cost of charging and repositioning and / or increasing the utilization of the vehicles. Two emerging and disruptive technologies and services in this direction are: 1) supply-demand balancing via dynamic pricing and 2) remote controlled and autonomous driving.

An example of a business that is founded based on the first idea is Zoba {Zob20a[. Zoba is a startup that "provides demand forecasting and optimization tools to shared mobility companies, from micromobility to car shares and beyond" [Zob20a]. As it is stated by Zoba in a series of bods on its website: "an operator deployment is ideal exactly if the deployed vehicle quickly captures lots of rides as users move it from high-demand area to high-demand area" [Zob20b]. To this extent, Zoba creates sophisticated demand models beyond the analysis of ridership, vehicle idle time and app open logs and uses simulations to discover dynamically changing low demand locations that attract supply and create an idling-supply [Zob20b]. To correct for the natural imbalance between supply and demand of vehicles Zoba "provides a priori vehicle (position) based incentive independent of destination (for [the user's] simplicity) to nudge users and the fleet towards a balance" [Zob20c]. According to the simulations on real data "a failure to maintain the fleet's spatial distribution can cost an operator over a quarter of potential rides" [Zob20a]. Moreover, as Zoba claims, "using a poorly designed dynamic pricing or rebalancing model may be worse than doing nothing — each will add costs without meaningful performance contributions" [Zob20b] or can perhaps even lead to losses.

From the cities' perspective profit optimizing supply-demand balancing via dynamic pricing has both negative and positive consequences. On the one hand, "driving supply from high demand areas to high demand areas" may not be sustainable because it is contrary to the idea of "mobility for all". People that live in an area of low demand will have a limited access to the service and will pay a lot more transportation, contributing to the use of private vehicles or lower accessibility. On the other hand, having too many repositioning operations could become a problem because the repositioning trucks/vans create congestion (they stop many times and they are not necessarily well parked), they emit greenhouse gases and they generate noise. So it is essential that repositioning operations are indeed meaningful and increase the performance of the service and the quality and accessibility that the services provide.

In relation to the service offering of Zoba, the qualitative business analysis of the operators in Section 4 reveals that, with the exception of few operators (e.g., Lime), most operators at best vary pricing of the service with the time of the day. Provided the current low utilization of vehicles and relative high expense of repositioning of vehicles, it is expected that operators that possess and act on high-quality intelligence regarding balancing supply and demand will gain a competitive edge over their rivals, which will ultimately lead to a new business landscape of shared e-micromobility services.

An example of a business that is founded based on the second idea, i.e., remote controlled (teleoperated) and autonomous driving, is Tortoise [Tor20]. Tortoise is a tech startup in the autonomous diving business sphere that has identified the opportunity in low speed automation for micromobility, which is according to the co-founder of Tortoise, an ex-Uber executive who has overseen the modality partnership strategy at Uber, is an "incredible solution for a huge volume of trips that people take, [in particular,] 60% of private car trips are under 2 miles and 50% of Uber and Lyft trips are under 2 miles." Cheap, light electric batteries allow vehicle form factors, e.g., e-kickscooters / e-bikes etc., that can cater for these short trips. As identified by Tortoise, the three challenges with dockless shared e-micromobility are: sidewalk clutter and obstruction, rider predictability and consequent service reliability, and financial sustainability due to low vehicle utilization and high recharging and reposition costs. Tortoise aims to solve all three challenges through remote controlled and autonomous driving. Tortoise provides reference designs for retrofitting e-kickscooters with forward/backward facing cameras, an electric steering bar motor, training wheels, and a microcontroller with GPS and mobile communication for a cost of €100 per e-kickscooter. Tortoise also provides unlimited repositioning per scooter per month with mixed teleoperation and autonomous driving as a service to fleet operators. Through these services Tortoise estimates that fleet operators can double and triple their vehicles utilizations and revenues [Aut19]. While Tortoise is in early stages with a few pilot operations in the US, it is clear that the possible solutions offered by the technologies and services offered by companies like Tortoise also have a great potential for reshaping the business landscape of shared e-micromobility services.

As a reflection on remote controlled (teleoperated) and autonomous driving technologies and services for shared e-micromobility, the main question is: Does the increase in the “increased demand capitation” justify this increase in the price of the e-kickscooter? In particular, one of the main problem that sharing operators have currently is vandalism, i.e., people basically steal or destroy the e-kickscooters. The 100€ retro-fitting costs represent a 30% increase in the price of the e-kickscooter (if one assumes a basic vehicle cost of around €300) so, when it is robbed or destroyed, the cost for replacement is also 30% higher.

7.2. Quantitative Business Model Analysis

There’s a wide variety of models that can be chosen for estimating demand of the shared micromobility services. The most interesting of those would be models of the regression family and the ones using Bayesian estimation. Estimates of those two groups could be later used for estimating different policies and benefits that might be brought by those policies. One of the best examples is calculation of consumer surplus, that is typically used for quantitative assessment of changes in policies. Aside from that, there is value of time, that could be used for estimating differences in the system. Another model, that could assist in quantitative estimation of the effects of a new system, would be differences in difference estimator that can compare two groups without any side effects (e.g. time changes within the groups). Due to the ability to estimate those values, these models are still in active use and are being developed further.

However, any of the methods that is able to estimate how changes in the system might affect the movement require a sufficient and often quite a big amount of data, that is difficult to process. Therefore, the scope of the model might get narrowed in order to answer some particular questions. This is also a limitation for implementing models in other geographical areas: first of all, there always has to be run analysis on how similar and different estimated and desired areas are. Some of the models are strictly limited by the geographical extent of their training zone, because some variables that are significant in that place might be insignificant for the unexplored area and vice versa. On the other hand, creating a general model also hides its weaknesses, that are connected to the ability to capture important specific variables, as major drivers of demand might vary across areas. Thus, it is important to have a test sample, that could be used for extraction of main data and at very least comparing it to already existing sample. The size of the training sample should be sufficient enough for the model validation.

All in all, in every situation, there should be either some training sample collected or some analysis of environment that would let assume to what extent any model could estimate the demand and quantify the revenues and business potential od shared micromobility services in a particular area.

In summary, a deep analysis of the reviewed models’ structure, input data, variables and reveals that one can construct models that estimate realistic shared e-micromobility service demand in the context of the larger transport system (including public transit), and some models can even adequately model service integration with public transport services via incentives or restrictions. However, while such models can be applied to different geographies to estimate service demand, they are data and computationally intensive.

Also, there is no obvious choice for a universal model and data sources that would allow to quantify the business opportunity in terms of estimated service demand and hence business profitability (under some cost assumptions) for different service deployment scenarios, which was aimed to be built as part of BP2021. Nonetheless, the value of such a universal model and a simple web based decisions support tool for shared e-micromobility service planning is enormous. Such tool would allow operators to evaluate market opportunities for deployment scenarios with positive unit economics at the tactical / strategic level, which could have similar disruptive effects on the shared e-micromobility market as the emerging services that provide improve vehicle utilization and unit economics via supply-demand balancing and dynamic pricing at the operational level (Section 7.1.3).

8. References

8.1. References Stockholm

2nd Street, 2020. Lime partners with Cosmo Connected to help riders around the world stay safe. Lime. Retrieved from: https://www.li.me/second-street/lime-partners-with-cosmo-connected-to-help-riders-around-the-world-stay-safe). Retrieved 2020-07-10

Adeshokan, O. 2019. Uber rival, Taxify is changing its name as it becomes a multi-format transport service. Quartz Africa. Retrieved from: https://qz.com/africa/1568416/uber-rival-taxify-changes-name-to-bolt-adds-scooters/. Retrieved 2020-07-07

Aimo Solution. [n.d.]. Om Oss. Retrieved from: https://aimosolution.com/om-oss/. Retrieved 2020-07-08

Allianz, 2020. Allianz and Lime jointly address safety needs in micromobility industry. Retrieved from: https://www.allianz.com/en/press/news/business/insurance/200527_Allianz-Lime-jointly-address-safety-needs-in-micromobility-industry.html. Retrieved 2020-07-07

Berg, W. 2019. Gångavstånd för resor med elsparkcykel - En studie baserat på elsparkcykelaktören Voi Technology i Stockholm. Skolan För Arkitektur Och Samhällsbyggnad, KTH.

Bird. [n.d.]a. Platform. Retrieved from: https://www.bird.co/platform/. Retrieved 2020-07-08

Bird. [n.d.]b. Bird two. Retrieved from: https://two.bird.co/. Retrieved 2020-07-08

Bird. [n.d.]c. There's a new way to make money. Retrieved from: https://flyers.bird.co/. Retrieved 2020-07-08

Bird. [n.d]d. About. Retrieved from: https://www.bird.co/about/. Retrieved 2020-07-08

Blixt, T. 2018. Hyrcyklarna EU-bikes kritiseras för att lura användare på pengar. Breakit. Retrieved from: https://www.breakit.se/artikel/15628/green-economys-hyrcyklar-eu-bikes-kritiseras-for-att-lura-anvandare-pa-pengar Retrieved 2020-07-08

Blixt, T. 2019a. Glydes elscootrar spårlöst försvunna från Stockholms gator. Breakit. Retrieved from: https://www.breakit.se/artikel/20568/utmanarens-elsparkcyklar-sparlost-forsvunna-fran-stockholms-gator. Retrieved 2020-07-07

Blixt, T. 2019b. Bolaget bakom Mrkoll har lanserat elscooter-tjänst i Stockholm. Breakit. Retrieved from: https://www.breakit.se/artikel/21532/bolaget-bakom-mrkoll-har-lanserat-elscooter-tjanst-i-stockholm. Retrieved 2020-07-07

Bolt. [n.d.]a. Ta en Bolt Scooter!. Retrieved from: https://bolt.eu/sv/scooters/. Retrieved 2020-07-10

Bolt. [n.d.]b. Bolts scooterplattform. Retrieved from: https://bolt.eu/sv/scooters-platform/. Retrieved 2020-07-10

Denbratt & Lindnér, 2020. foodora och Wheels i samarbete kring elcyklar. MyNewsDesk.com. Retrieved from: http://www.mynewsdesk.com/se/foodora-punkt-se/pressreleases/foodora-och-wheels-i-samarbete-kring-elcyklar-2993639.Retrieved 2020-07-10

Dickney, M. R. 2019. Wheels raises $50 million for pedal-lees e-bike share. Tech Crunch. Retrieved from: https://techcrunch.com/2019/10/15/wheels-raises-50-million-for-pedal-less-e-bike-share/. Retrieved 2020-07-07

EY. 2020. How micromobility is moving cities into a sustainable future. Retrieved from: https://www.ey.com/en_gl/automotive-transportation/how-micromobility-is-moving-cities-into-a-sustainable-future. Retrieved 2020-07-06

Goldmann, 2018a. Voi - eldriven kick-bike för uthyrning. Gröna Bilister. Retrieved from: http://www.gronabilister.se/tester/andra-fardmedelstester/voi-eldriven-kick-bike-for-uthyrning. Retrieved 2020-07-06

Goldmann, M. 2018b. Lime - eldriven kick-bike för uthyrning. Gröna Bilister. Retrieved from: http://www.gronabilister.se/tester/andra-fardmedelstester/lime-eldriven-kick-bike-for-uthyrning. Retrieved 2020-07-09

Goldmann, M. 2019a. Bird eldriven kick-bike för uthyrning. Gröna Bilister. Retrieved from: http://www.gronabilister.se/tester/ny-mobilitet/2019/bird-eldriven-kick-bike. Retrieved 2020-07-10

Goldmann, M. 2019b. Tier eldriven kick-bike för uthyrning. Gröna Bilister. Retrieved from:

http://www.gronabilister.se/tester/andra-fardmedelstester/tier-eldriven-kick-bike-for-uthyrning. Retrieved 2020-07-06

Goldmann, M. 2019c. Moow eldriven kick-bike för uthyrning. Gröna Bilister. Retrieved from: http://www.gronabilister.se/tester/andra-fardmedelstester/moow-eldriven-kick-bike-for-uthyrning. Retrieved 2020-07-07

Goldmann, M. 2019d. Aimo eldriven kick-bike. Gröna Bilister. Retrieved from: http://www.gronabilister.se/tester/ny-mobilitet/2019/aimo-elsparkcykel-for-uthyrning. Retrieved 2020-07-07

Hawkins, A.J. 2019. Wheels redesigns its shareable e-bikes to include a helmet. The Verge. Retrieved from: https://www.theverge.com/2019/12/10/21003734/wheels-electric-bike-bikeshare-helmet-redesign-included. Retrieved 2020-07-07

Hunter, N.K. 2020. Voi and Fortum in partnership to improve micro mobility sustainability. Retrieved from: http://meltwater.pressify.io/publication/5ef9e0fd01045a0004b5f7f0/5cc2e92ebc666f1000014954. Retrieved 2020-07-09

Höök, P. 2019.Bolt gör företagets körningar i Europa koldioxidneutrala. Dagens Miljöteknik.se. Retrieved from: https://www.dagensmiljoteknik.se/20190918/158/bolt-gor-foretagets-korningar-i-europa-koldioxidneutrala. Retrieved 2020-07-07

Kristoffersson, H. & Wallin, I. 2019. Delningstjänster för elsparkcyklar Ett hållbart transportalternativ eller en ohållbar ekvation. Skolan För Arkitektur Och Samhällsbyggnad, KTH.

Lejonhufvud, J. 2019. Bildelningsbolaget Aimo lanserar egen elscooter. Dagens Industri. Retrieved from: https://digital.di.se/artikel/bildelningsbolaget-aimo-lanserar-egen-elscooter

Lejonhufvud, J. 2020. Scooterjätten Bird köper tyska Circ. Dagens Industri. Retrieved from: https://digital.di.se/artikel/scooterjatten-bird-koper-tyska-circ. Retrieved 2020-07-09

Lindahl, B. 2020. Så gick det när Uber mötte Norden. Arbetsliv i Norden. http://www.arbeidslivinorden.org/nyheter/nyheter-2020/article.2020-06-01.2592969100

Lime. [n.d.]a. Åk när du vill. Retrieved from: https://www.li.me/sv/. Retrieved 2020-07-09

Lime. [n.d.]b. Careers. Retrieved from: https://www.li.me/careers. Retrieved 2020-07-09

Lime. [n.d.]c. Lime-s. Retrieved from: https://www.li.me/electric-scooter. Retrieved 2020-07-09

Lundell, S. 2019. Sparkcykel ska hjälpa svenska bildelartjänsten att växa. Breakit. Retrieved from: https://www.breakit.se/artikel/21189/sparkcykel-ska-hjalpa-svenska-bildelartjansten-att-vaxa. Retrieved 2020-07-07

M. [n.d.]. Om Oss. Retrieved From: https://m.co/se/sv-SE/om-oss/ Retrieved 2020-07-28

Micu, P. 2019. Hundratals klagomål mot elsparkcyklarna. Dina Pengar. Retrieved from: https://www.expressen.se/dinapengar/hundratals-klagomal-mot-elsparkcyklarna/. Retrieved 2020-07-31

Petzinger, J. 2018. Ride-hailing app Taxify is joining the e-scooter fray in Paris. Quartz.

Retrieved From: https://qz.com/1380986/ride-hailing-app-taxify-is-joining-the-e-scooter-fray-in-paris/. Retrieved 2020-07-07

Rabe, M. 2016. Allt fler hyr ut sin bil privat – storlastare populärast. Teknikens Värld. Retrieved From: https://teknikensvarld.se/allt-fler-hyr-ut-sin-bil-privat-storlastare-popularast-279032/ Retrieved 2020-07-28

Satariano, A. 2019. This Estonian Start-Up Has Become a Thorn in Uber's Side. The New York Times. Retrieved From: https://www.nytimes.com/2019/04/23/technology/bolt-taxify-uber-lyft.html. Retrieved 2020-07-07

Segway-Ninebot. [n.d.]. About us. Retrieved From: https://se-en.segway.com/about-the-brand. Retrieved 2020-07-27

Shead, S. 2019. Electric scooters are a terrible business, says Bolt boss. Sifted. Retrieved From: https://sifted.eu/articles/markus-villig-bolt-interview/. Retrieved 2020-07-07

SL. [n.d.]. Om oss. Retrieved From: https://sl.se/sv/info/om-sl/om-sl/ Retrieved 2020-07-28

SLL. 2019. Elsparkcyklar i delningsekonomin, Studie med fokus på regional utveckling.

Snappcar. [n.d.]. Hyra bil privat, helförsäkrat via If. Retrieved From: https://www.snappcar.se/. Retrieved 2020-07-28

Strand, S. 2019. TEST: Jag har åkt alla elsparkcyklar i Sverige – här är de bästa, sämsta och billigaste. Breakit. Retrieved from: https://www.breakit.se/artikel/21867/test-jag-har-akt-alla-elsparkcyklar-i-sverige-har-ar-de-basta-samsta-och-snabbaste. Retrieved 2020-07-07

Sunfleet. [n.d.]. Vill du testa det nya sättet att använda bil? Retrieved From: https://www.sunfleet.com/sunfleet-valkomnar-m/ Retrieved 2020-07-28

Taxi Stockholm. [n.d.]. https://www.taxistockholm.se/sv/

The Green Charging Company. [n.d.].The Green Process. Retrieved From: https://greenchargingco.com/index.html. Retrieved 2020-08-03

Tier Mobility. 2019. How we use technology to drive sustainable and inclusive mobility. Medium. Retrieved from: https://medium.com/@tiermobility/how-we-use-technology-to-drive-sustainable-and-inclusive-mobility-41a16d9050b3. Retrieved 2020-07-06

Tier Mobility. [n.d.]a. Tier reached 1 million rides, faster than any escooter company before. Retrieved from: https://www.tier.app/tier-reached-1-million-rides-faster-than-any-escooter-company-before/. Retrieved 2020-07-06

Tier Mobility. [n.d.]b. LinkedIn Profile - Videos. Retrieved from: https://www.linkedin.com/company/tiermobility/videos/. Retrieved 2020-07-06

Tier Mobility. [n.d.]c. LinkedIn Profile – About. Retrieved from: https://www.linkedin.com/company/tiermobility/about/. Retrieved 2020-07-06

Tier Mobility. [n.d.]d. My Tier. Retrieved from: https://mytier.app/. Retrieved 2020-07-06

Tier Mobility. [n.d.]e. The 7 myths about e-scooters. Retrieved from: https://www.tier.app/the-7-myths-about-e-scooters/. Retrieved 2020-07-06

UbiGo. [n.d.]. Tjänster. Retrieved from: https://www.ubigo.me/tjanster/bilpool Retrieved 2020-07-28

View Stockholm. [n.d.]. Cykla i Stockholm med City Bikes. Retrieved from: https://viewstockholm.com/sv/cykla-stockholm-city-bikes/. Retrieved 2020-07-28

Voi. [n.d.]a. Åka voi. Retrieved from: https://www.voiscooters.com/sv/aka-voi/. Retrieved 2020-07-06

Voi. [n.d.]b. Våra Fordon. Retrieved from: https://www.voiscooters.com/sv/voi-fordon/. Retrieved 2020-07-06

Voi. [n.d.]c. Har du vad som krävs för att bli en Business Hunter?. Retrieved from: https://www.voiscooters.com/sv/hunters/. Retrieved 2020-07-06

Vosh. [n.d.]. Vosh Kickfleet System. Retrieved from: https://vosh.app/produktblad_2019.pdf. Retrieved 2020-07-08

Weelo, [n.d.]). How it works. Retrieved from: https://www.weelo.tours/how-it-works. Retrieved 2020-07-06

Wheels. [n.d.]a. Clean and Safe Transportation. Retrieved from: https://www.takewheels.com/. Retrieved 2020-07-08

Wheels. [n.d.]b. Wheels Private E-Bike Rental. Retrieved from: https://shop.takewheels.com/pages/wheels-bike-rental. Retrieved 2020-07-08

Wilhelmsson, W. 2019. Idag lanseras cykeltjänsten Wheels i Stockholm. Feber. Retrieved from: https://feber.se/fordon/idag-lanseras-cykeltjansten-wheels-i-stockholm/404359/. Retrieved 2020-07-10

Wisterberg, E. 2019a. Moow lanserar i Stockholm – sparkcykelkriget trappas upp. Breakit. Retrieved from: https://www.breakit.se/artikel/20059/moow-lanserar-i-stockholm-sparkcykelkriget-trappas-upp. Retrieved 2020-07-07

Wisterberg, E. 2019b. Wheels vill få dig att dumpa elsparkcykeln – lanserar i Stockholm. Breakit. Retrieved from: https://www.breakit.se/artikel/22579/wheels-vill-fa-dig-att-dumpa-elsparkcykeln-lanserar-i-stockholm. Retrieved 2020-07-10

Wunder mobility. [n.d.]. Fleet. Retrieved from: (https://www.wundermobility.com/fleet, https://www.youtube.com/watch?v=-QIOomiSDlssecond 01.43). Retrieved 2020-07-10

8.2. References Tel Aviv

[BenT18] Ben Tovim, I. (2018). The scooter companies are finally taking over our streets. Retrieved from *Greektime* https://www.geektime.co.il/wind-scooters-coming-to-israel/ (14/3/2020).

[BenT19] Ben Tovim, I. (2019). Official: Lime starts operating in Israel; Claims: We have a significant advantage over competitors. Retrieved from GeekTime. https://www.geektime.co.il/lime-scooters-in-israel/ (14/3/2020).

[Cas20] Castel, D. N. (2020). Tel Aviv Scooters - All about electric scooter apps. Retrieved from Website Financial Guides Capital. https://www.hon.co.il/ (14/3/2020).

[Cas19] Castel, D. N. (2019). Bubble Service - Cooperative Public Transport has arrived in Tel Aviv. Retrieved from HON. https://www.hon.co.il/ (20/3/2020).

[Etz19a] Etzion, U. (2019). CEO of Bird: "20% of our trips are in private cars". Retrieved from Y-net https://www.ynet.co.il/articles/0,7340,L-5597829,00.html (17/3/2020).

[Etz19b] Etzion, U. (2019). Yango will start charging a taxi cab. Retrieved from Calcalist https://www.calcalist.co.il/local/articles/0,7340,L-3768889,00.html (20/3/2020).

[Etz19c] Etzion, U. (2019). For the first time: a price war between scooter operations. Retrieved from Calaclist https://www.calcalist.co.il/local/articles/0,7340,L-3763332,00.html (17/3/2020).

[Etz20] Etzion, U. (2020). The bubble's public transport service is returning to operate only in Tel Aviv, Ramat Gan and Givatayim. Retrieved from Calcalist https://www.calcalist.co.il/local/articles/0,7340,L-3816772,00.html (23/3/2020).

[Got19] Gutman, L. (2019). Bubble reported to the Ministry of Transport: 4,500 co-passengers a day. Retrieved from Calcalist https://www.calcalist.co.il/local/articles/0,7340,L-3776289,00.html (23/3/2020).

[Had17] Hadar, T. (2017). Auto Tel, Tel Aviv's car sharing, is off. Retrieved from Calcalist https://www.calcalist.co.il/local/articles/0,7340,L-3716332,00.html (20/3/2020).

[Had19] Hadar, T. (2019). BIRD Customers: Want a scooter? Give your ID. Retrieved from Calcalist https://www.calcalist.co.il/local/articles/0,7340,L-3766940,00.html (17/3/2020)

[Hai19] Haimovich, H. (2019). Separate from Xiaomi: Bird launches the upgraded scooter she developed in Israel alone. Retrieved from GeekTime. https://www.geektime.co.il/bird-one-tel-aviv/ (17/3/2020).

[Kri15] Kristal, M. (2015). Gett Taxi is expanding to order pizza and a doctor. Retrieved from Y-net https://www.ynet.co.il/articles/0,7340,L-4651437,00.html (20/3/2020).

[Kol17] Kolodny, L. (2017). LimeBike raises $12 million to roll out bike sharing without kiosks in the US. Retrieved from TechCrunch https://techcrunch.com/2017/03/15/limebike-raises-12-million-to-roll-out-bike-sharing-without-kiosks-in-the-us/ (23/3/2020).

[Mor18] Morganstern, R. (2018). Tel Aviv Transportation - Car2Go, Gett Taxi, Public Transportation - Which is Better? Advantages and Disadvantages. Retrieved from HON http://www.hon.co.il/ (20/3/2020).

[Orb18] Orbach, M. (2018). Yango Israel CEO: "Drivers are looking for an alternative to Gett. Retrieved from Calcalist https://www.calcalist.co.il/internet/articles/0,7340,L-3751669,00.html (23/3/2020)

[Orb20a] Orbach, M. (2020). Yango storms Gett's drivers. Retrieved from Calcalist https://www.calcalist.co.il/internet/articles/0,7340,L-3800501,00.html (23/3/2020).

[Orb20b] Orbach, M. (2020). Issue moving away: Gett in $ 24 million private equity raising. Retrieved from Calcalist https://www.ynet.co.il/articles/0,7340,L-5681247,00.html (23/3/2020).

[Ova19] Ovadia, A. (2019). AutoTel - Everything you need to know! How many cars will be in the venture? How many parking spaces will be allocated to the venture? How much will it cost? What are the pros and cons? And why is there great opposition to the venture? Retrieved from HON http://www.hon.co.il/ (20/3/2020).

[Pos20] Posek, H. (2020). CEO of Lime: Tel Aviv is a world leader in scooter rental. Retrieved from Y-net https://www.ynet.co.il/wheels/article/SkKLV36x8 (14/3/2020)

[Pos19] Posek, H. (2019), Bird's Scooters - 24 hours a day and "order" option. Retrieved from Y-net https://www.ynet.co.il/articles/0,7340,L-5504444,00.html (14/3/2020).

[Pro19] Protocol System (2019). Lime Electric Scooters - How does It work and is it worth? Retrieved from Protocol https://protocol.co.il/lime-scooters/ (17/3/2020).

[Raz-H19] Raz-Haimovich, M. (2019). "A car that stands in the parking lot is a nuisance. I'm 33, and I've never had one." The man who brought the scooter to TA speaks. Retrieved from Globes https://www.globes.co.il/news/article.aspx?did=1001271292 (17/3/2020).

[Sad18] Sade T. (2018) Get Taxi drivers are threatening sanctions following the increase in the monthly payment. Retrieved from Y-net https://www.ynet.co.il/articles/0,7340,L-5070743,00.html (20.3.2020).

[Sha20] Shafir, N. (2020). Wind's third-generation electric scooter: a significant improvement over its predecessors. Retrieved from Maariv https://www.maariv.co.il/business/tech/Article-743908 (17/3/2020).

[Tza18] Tzahi, S. (2018). Gett drivers are threatening sanctions following the monthly payment increase. Retrieved from Y-net https://www.ynet.co.il/articles/0,7340,L-5070743,00.html (20/3/2020).

[Yai19] Yaish, Y. (2019). News for electric scooter riders. Retrieved from Israelhayom https://www.israelhayom.co.il/article/718451(14/3/2020).

8.3. References Barcelona

[AjBCN20] Ajuntament de Barcelona. (2020). L'Ajuntament de Barcelona adjudica definitivament les llicències per a motos i bicis d'ús compartit. Press service. Retrieved from https://ajuntament.barcelona.cat/premsa/2020/05/19/lajuntament-de-barcelona-adjudica-definitivament-les-llicencies-per-a-motos-i-bicis-dus-compartit/ (2020-09-25)

[AMB20] Barcelona Metropolitan Area (2020). Tarifas taxi. Retrieved from https://taxi.amb.cat/es/usuari/tarifes (2020-09-25)

[Bic20] Bicing (2020). Tarifas. Retrieved from https://www.bicing.barcelona/es/tarifas (2020-09-25)

[Cab20] Cabify (2020). Tabla de tarifas. Retrieved from https://cabify.com/es/barcelona/lite/tarifas (2020-09-25)

[Lop19] López Redondo, N. (2019). Analizamos la oferta de patinetes eléctricos compartidos de Madrid, empresa a empresa (ACTUALIZADO). Movilidad Electrica. Retrieved from https://movilidadelectrica.com/analizamos-la-oferta-de-patinetes-electricos-compartidos-de-madrid-empresa-a-empresa/ (2020-10-08)

[Sob20] Sobrino, R. (2020). Madrid reduce a la mitad el número de patinetes eléctricos en un año. Cinco Días. Retrieved from https://cincodias.elpais.com/cincodias/2020/01/27/companias/1580152493_614573.html (2020-10-08)

[SEAT20a] SEAT (2020a). SEAT MÓ rolls out its motosharing service in Barcelona. SEAT news page. Retrieved from https://www.seat-mediacenter.com/newspage/allnews/company/2020/SEAT-MO-rolls-out-its-motosharing-service-in-Barcelona.html (2020-09-25)

[SEAT20b] SEAT MÓ. (2020b). Subscriptions. Retrieved from https://www.seatmo.com/suscripcion/ (2020-09-25)

[TMB20] Transports Metropolitans de Barcelona (2020). Datos del transporte de TMB. Retrieved from https://www.tmb.cat/es/sobre-tmb/conocenos/transporte-cifras (2020-09-25)

8.4. References Munich

[Az20a]: Nach dem ersten Halbjahr: Die ganze Statistik zu E-Scootern in München.
Retrieved from https://www.abendzeitung-muenchen.de/muenchen/nach-dem-ersten-halbjahr-die-ganze-statistik-zu-e-scootern-in-muenchen-art-485826 (2020-09-25).

[Az20b]: München: Voi führt virtuelle Parkplätze für E-Scooter ein.
Retrieved from https://www.abendzeitung-muenchen.de/muenchen/muenchen-voi-fuehrt-virtuelle-parkplaetze-fuer-e-scooter-ein-art-487422 (2020-09-24).

[Boe19]: Bird hält Winterschlaf: E-Scooter-Verleiher sammelt Roller ein.
Retrieved from https://www.boerse-online.de/nachrichten/aktien/bird-haelt-winterschlaf-e-scooter-verleiher-sammelt-roller-ein-1028d726771 (2020-09-24).

[Br20a]: BR24-Datenanalyse: Ein Fünftel mehr Radfahrer in München.
Retrieved from https://www.br.de/nachrichten/bayern/br24-datenanalyse-ein-fuenftel-mehr-radfahrer-in-muenchen,S2QQqc8 (2020-09-23).

[Cha20]: TIER Mobility startet mit E-Mopeds durch.
Retrieved from https://www.charivari.de/muenchen/aktuell/e-mopeds-tier-mobility-muenchen-bayern/9366816 (2020-09-24).

[Dah20]: Dahmen, S., Mit diesen E-Scooter-Anbietern bist du in München unterwegs.
Retrieved from https://www.inside-digital.de/ratgeber/e-scooter-in-muenchen (2020-09-25).

[Emo20]: München: E-Scooterverleih Voi kehrt mit neuem Abomodell zurück.
Retrieved from https://www.emove360.com/de/muenchen-e-scooterverleih-voi-kehrt-mit-neuem-abomodell-zurueck/ (2020-09-24).

[Inf18]: infas, DLR, IVT und infas 360 (2018): Mobilität in Deutschland (im Auftrag des BMVI.
Retrieved from https://www.muenchen-transparent.de/dokumente/5499206/datei (2020-09-23).

[Mer20]: Zu Besuch in der E-Scooter-Zentrale: Hier werden die Tretroller gewartet und geladen.
Retrieved from https://www.merkur.de/lokales/muenchen-lk/garching-ort28709/garching-hier-werden-e-scooter-von-dott-gewartet-und-geladen-13532325.html (2020-09-25)

[Mue20]: E-Scooter leihen: Was die Anbieter unterscheidet.
Retrieved from https://www.muenchen.de/freizeit/e-scooter-leihen.html (2020-09-23).

[Rei20]: Reichel, J., dott Scooter: Dasselbe in Grün.
Retrieved from https://vision-mobility.de/news/dott-scooter-dasselbe-in-gruen-24415.html (2020-09-24).

[Ros20]: Rost, P., Tier führt Paketpreise für E-Scooter ein.
Retrieved from: https://movinc.de/e-scooter/tier-fuehrt-paketpreise-fur-e-scooter-ein/ (2020-09-25).

[Schw20]: Schwär, H.,Der Chef des einzigen E-Scooter-Startups, das noch auf der Straße ist, erklärt den „Survival Modus“ seines Unternehmens.
Retrieved from https://www.businessinsider.de/wirtschaft/mobility/fast-alle-e-scooter-sind-von-den-strassen-verschwunden-warum-tier-trotzdem-weitermacht (2020-09-24).

[Sta19]: Anzahl der E-Scooter in ausgewählten deutschen Städten.
Retreived from: https://de.statista.com/statistik/daten/studie/1031136/umfrage/anzahl-der-e-scooter-in-deutschland-nach-ausgewaehlten-staedten/ (2020-09-25)

[Stüb20]: Stüber, J., Circ-Übernahme.
Retrieved from https://www.welt.de/wirtschaft/gruenderszene/article205603381/Circ-Uebernahme-Scooter-Start-ups-nutzen-ein-altes-Samwer-Modell.html (2020-09-24).

[Sz20]: Bikesharing boomt.
Retrieved from https://www.sueddeutsche.de/muenchen/muenchen-leihraeder-bikesharing-trend-1.4947587 (2020-09-24).

[Tier20]: Where to find us.
Retrieved from https://www.tier.app/where-to-find-us/ (2020-09-24).

[Ton19]: E-Scooter bei jungen Menschen in München beliebt.
Retrieved from https://www.t-online.de/region/muenchen/news/id_86793970/muenchen-e-scooter-bei-jungen-muenchnern-beliebt.html (2020-09-25).

[Tz19]: Roller-Flut kommt.
Retrieved from https://www.tz.de/muenchen/stadt/muenchen-neue-e-scooter-ueberschwemmen-muenchen-anbieter-verachtfacht-flotte-13104768.html (2020-09-24).

[T3n20]: Free Now: Mobilitäts-Plattform öffnet sich für Dritte.
Retrieved from https://t3n.de/news/free-integriert-e-scooter-voi-app-1285159/ (2020-09-24).

[Uber20]: Lime E-Scooter ab sofort über die Uber-App in Deutschland verfügbar.
Retrieved from https://www.uber.com/de/newsroom/lime-integration/ (2020-09-24).

[Voi20]: Unsere Fahrzeuge.
Retrieved from https://www.voiscooters.com/de/voi-fahrzeuge/ (2020-09-25)

[Wei19]: Weimer, M., Mit Dott startet das siebte E-Tretroller-Sharing in Deutschland.
Retrieved from https://www.gruenderszene.de/automotive-mobility/dott-e-tretroller-sharing-muenchen (2020-09-24).

[Wiki20]: E-Scooter-Verleihsystem.
Retrieved from https://de.wikipedia.org/wiki/E-Scooter-Verleihsystem (2020-09-24).

[Wil19]: Wilke, F., Der Winter wird hart für die Rollerverleiher.
Retrieved from: https://www.zeit.de/mobilitaet/2019-11/e-scooter-tretroller-anbieter-stadtverkehr-mobilitaet-markt (2020-09-25).

8.5. References Other

[Ami12] Amit, R., & Zott, C. (2012). Creating value through business model innovation. MIT Sloan Management Review, 53(3), 41–49.

[Aut19] Autonocast. (2019) Autonocast episode #174: Dimitry Shevelenko of Tortoise. Retrieved from https://tinyurl.com/y3v4ucwo (2020-09-30)

[Bir15] Birkinshaw, J., & Ansari, S. (2015). Understanding Management Models. In Business Model Innovation (pp. 85–103). Oxford University Press. Retrieved from https://doi.org/10.1093/acprof:oso/9780198701873.003.0005 (2020-09-30)

[DaS14] DaSilva, C. M., & Trkman, P. (2014). Business model: What it is and what it is not. Long Range Planning, 47, 379–389. Retrieved from https://doi.org/10.1016/j.lrp.2013.08.004 (2020-09-30)

[Jov18] Jovanovic, M. (2018). Navigating Manufacturing Firms to Service-led Business Models. Doctoral Thesis, Department of Industrial Economics and Management, KTH Royal Institute of Technology.Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-227275 (2020-09-30)

[MaK19]]McKinsey. (2019). Micromobility's 15,000-mile checkup. Retrieved from https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/micromobilitys-15000-mile-checkup# (2020-09-25)

[Ost10] Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

[Ton14] Tongur, S., & Engwall, M. (2014). The business model dilemma of technology shifts. Technovation, 34(9), 525–535. Retrieved from https://doi.org/10.1016/j.technovation.2014.02.006 (2020-09-30)

[Tor20] Tortoise. (2020). Retrieved from https://www.tortoise.dev/ (2020-09-30)

[Zob20a] Zoba. (2020). Retrieved from https://www.zoba.com/ (2020-09-30)

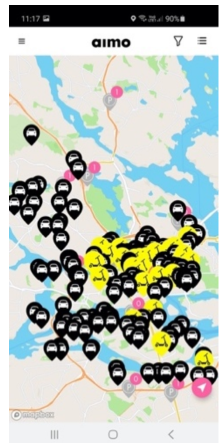
[Zob20b] Zoba. (2020). Supply-demand imbalance in shared mobility: cost and consequence. Retrieved from https://medium.com/zoba-blog/supply-demand-imbalance-in-shared-mobility-cost-and-consequence-72a50007831b Retrieved (2020-09-30)

[Zob20c] Zoba. (2020). Dynamic pricing for shared mobility: Zoba's approach. Retrieved from https://medium.com/zoba-blog/dynamic-pricing-for-shared-mobility-zobas-approach-3c59ec461712 Retrieved (2020-09-30)

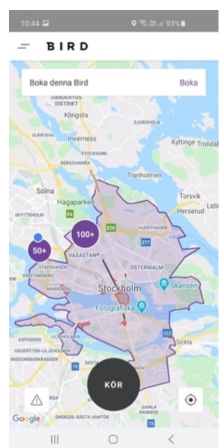
Annex I Vehicle Images Stockholm

Aimo, June 2020





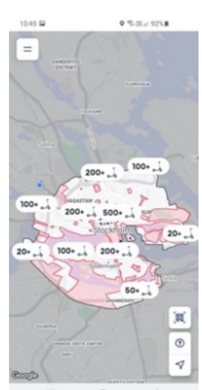
Bird One, June 2020

Bolt, June 2020

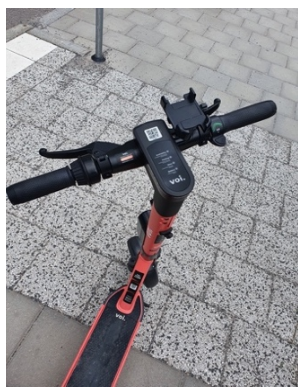
Lime, June 2020

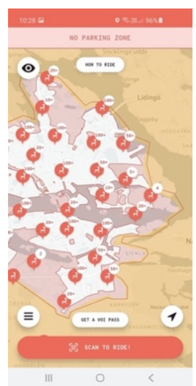
Tier, June 2020



Moow, June 2020

Voi, June 2020





Vosh, June 2020

Wheels, June 2020

Bird Two, June 2020

Annex II Images of Sheets of DEL04_SUPP1_DemandModel.xls

						Model basics		E-micromobility service and context				Data and variables				Application	Results	
Title	URL	Abstract	Author's keywords	Reviewer's keywords	Relevance (1 least - 5 most)	Model structure (regression, classification, gravity, 4-step, agent-based,	Model LOD (Micro, Mezzo, Macro	Travel modes	Nature and level of PT integration	E-micromobility service type (vehicle, sharing)	E-micromobility service usage pattern / constraint / assumption	Input data	Independent variables	Dependent variables	Spatial level of detail / resolution	Geographical study area	Estimated demand	Variability of demand (in space or time or other attributes)
Sharing riders: How bikesharing impacts bus ridership in New York City	https://www.sciencedirect.com/science/article/pii/S0965856416304967	The objective of this research is to quantify the impact that bikesharing systems have on bus ridership. We exploit a natural experiment of the phased implementation of a bikesharing system to different areas of New York City. This allows us to use a difference-indifferences identification strategy. We divide bus routes into control and treatment groups based on if they are located in areas that received bikesharing infrastructure or not. We find a significant decrease in bus ridership on treated routes compared to control routes that coincides with the implementation of the bikesharing system in New York City. The results from our preferred model indicate that every thousand bikesharing docks along a bus route is associated with a 2.42% fall in daily unlinked bus trips on routes in Manhattan and Brooklyn. A second model that also controls for the expansion of bike lanes during this time suggests that the decrease in bus ridership attributable to bikesharing infrastructure alone may be smaller (a 1.69% fall in daily unlinked bus trips). Although the magnitude of the reduction is a small proportion of total bus trips, these findings indicate that either a large proportion of overall bikeshare members are substituting bikesharing for bus trips or that bikesharing may have impacted the travel behavior of non-members, such as private bicyclists. Understanding how bikesharing and public transit systems are interrelated is vital for planning a mutually reinforcing sustainable transport network.	Bikesharing Bus ridership Difference-in-differences estimator Natural experiment	difference-in-difference, OLS, bus routes	4 … it is very interesting that the model studies docks being along the bus lanes as possible effect, not the proximity to bus stops. It is also important to note that here placebo model is studied to prove the importance of the results. This might be related only to one mode of transport, but the study itself helps to see different effects (areal, fare) separately in order to understand the bikesharing impact. Unfortunately impact of this system on the sustainability is only assumed and it is believed that this new integrated robust network could actually have a strong positive long-term impact on sustainability of transportation in NYC.	Difference-in-differences estimator: uses panel data to compare the outcome in one group that receives treatment to a control group during the study period in an attempt to quantify the casual impact of a policy. The differences before/after the policy are substracted: their difference is the estimated effect of the policy. It removes biases caused by the permanent differences between the control and treatment groups, as well as biases caused by time trends impacting the entire sample; ordinary least square estimation	Macro .. studying buffer zone (0.25 miles) for the bus routes	Bus, bikesharing system	bike as a transit alternative to bus or as a compliment to the bus system. People within reduced fare are less likely to use the bikesharing system. Actual reasons are unknown, but it is assumed that this is happening due to them falling under the group of people older than 65 or having reduced fare due to some disabilities. As it is assumed, although there's a decline in the short-term impact, it might not reflect the long-term one, as a transportation network based on a robust transit system and cycling network could impact future travel behaviour, particularly long-term factors like a decision to own a car.		The vast majority of trips (over 90%) are taken by annual members, who provide basic demographic information. Median age during the time of studies: 35 years old and 77.7% of those trips were taken by men. Average speed: 8.4 mph Average distance: 1.7 miles. Higher ridership on weekdays than weekends with peaks during the morning and afternoon commutes. Bikeshare trips are high from mid-May to mid-October.	Bus data: daily unlinked bus trips per oute, daily unlinked bus trips by route split by fare type used (full, reduced, or student fare), and scheduled revenue miles per route, longitude and latitude of each bus stop along all NYCT bus routes as of June 2015. Citi Bike data (publicly available): total ridership and membership data for the period May 27,2013 to December 31,2014; trip history data which includes the date and the station where each bike trip begins; Citi Bike Station feed data that includes # of docks at each bike station; A map of Boro Taxi service area and launch date; Miles of bike lanes and date built from the NYC Cycling Map	Date, bike open x bike area x docks number (number of docks near the bus route), route, controls; Date, bike open x full fare x docks number (number of docks near the bus route), date, full fare x route, controls	Natural log of ridership on day t on bus route j		New York City (Manhattan and Brooklyn)	Overall, the results indicate a significant decrese in bus ridership coincident with the implementation of the bikesharing system in New York City: significant decrease in daily bus ridership along routes that are near bikesharing in comparison to routes that aren't. This result holds regardless the control over the bike lane infrastructure. every thousand bikesharing docks along the bus route is associated with a 0.0245 reduction in the natural log of daily unlinked bus trips, or equivalently a 2.42% reduction in unlinked trips. Manhattan and Brooklyn: 3.3% reduction in unlinked bus trips with the mean number of docks.Manhattan: 3.2% and 6.4% reduction with the mean. For the FARE model (based on reduced-full dare groups): 3.13% reduction of full fare trips, 4.2% reduction of full fare trips on a route with a mean number of docks along it.	Manhattan and Brooklyn vary from overall results, as well as Manhattan is slightly different when studied alone in both area and fare models. When additional bikelanes are included the decrease for bus is slightly smaller, but the result remains significant and negative: a decrease in bus ridership of 1.69%/1000 bikesharing docks and 2.3% for a route with the mean number of docks, for Manhattan alone: 2.59% nd 5.2%, respectively.
Predicting station-level hourly demand in a large-scale bikesharing network: A graph convolutional neural network approach	https://www.sciencedirect.com/science/article/pii/S0968090X18300974	This study proposes a novel Graph Convolutional Neural Network with Data-driven Graph Filter (GCNN-DDGF) model that can learn hidden heterogeneous pairwise correlations between stations to predict station-level hourly demand in a large-scale bike-sharing network. Two architectures of the GCNN-DDGF model are explored; GCNNreg-DDGF is a regular GCNN-DDGF model which contains the convolution and feedforward blocks, and GCNNrec-DDGF additionally contains a recurrent block from the Long Short-term Memory neural network architecture to capture temporal dependencies in the bike-sharing demand series. Furthermore, four types of GCNN models are proposed whose adjacency matrices are based on various bike-sharing system data, including Spatial Distance matrix (SD), Demand matrix (DE), Average Trip Duration matrix (ATD), and Demand Correlation matrix (DC). These six types of GCNN models and seven other benchmark models are built and compared on a Citi Bike dataset from New York City which includes 272 stations and over 28 million transactions from 2013 to 2016. Results show that the GCNNrecDDGF performs the best in terms of the Root Mean Square Error, the Mean Absolute Error and the coefficient of determination (R2), followed by the GCNNreg-DDGF. They outperform the other models. Through a more detailed graph network analysis based on the learned DDGF, insights are obtained on the "black box" of the GCNN-DDGF model. It is found to capture some information similar to details embedded in the SD, DE and DC matrices. More importantly, it also uncovers hidden heterogeneous pairwise correlations between stations that are not revealed by any of those matrices.	Bike sharing Graph Convolution Neural Network Data-driven graph filter Long Short-term Memory network Deep learning Spatio-temporal demand prediction	long short-term memory, deep learning, pre-defined graph, graph theory, GCNN-DDGF	3 … using machine learning for predicting demand based on graph is an interesting thought, however, there're still issues with defining the graph itself and with ruling out socio-economic variables. Maybe this approach based on different areas can actually overcome the issue.	Graph Convolutional Neural Network with Data-driven Graph Filter (GCNN-DDGF) model: its performance relies on a pre-definied graph-structure. six GCNN models depending on how adjacency matrix is generated. Performance of each is estimated using RMSE as the main criterion.	Mezzo … study is based on single stations, where the trips are aggregated and later different areas of the city become units of research.	Bikesharing			The highest demand is over 4.5 million trips, when the distance between stations is 1-2 miles. The demand drops when the distance is closer (0-1 mile) as well as when the distance increases beyond 1-2 miles. The average duration is about 10 min for the trips within 1 mile, it increases with the distance and can take more than 45 min when the trips are longer than 5 miles. Actual trip distances are unknown, those are assumed on (lat,long) of the stations.	Citi BSS	Stations existing in all three years of study and that were used more than once/hour (lat, long), bike trips	Hourly demand		New York City	When the demand between stations is fewer than 1000, the average edge weight is the smallest for all communities, and the curves for most communities have a decreasing trend in general. See three figures to the right.	The average edge of weight is the highest when the demand correlation coefficient is in the range of [0.8,1] for all eight communities. For other demand correlation ranges, the average edge weights are much lower, and curves are almost flat. For Community 8, the average weight is 0 when the demand correlation is in [0.6, 0.8) because no observations are found.
Factors influencing the choice of shared bicycles and shared electric bikes in Beijing	https://www.sciencedirect.com/science/article/pii/S0968090X16000747	China leads the world in both public bikeshare and private electric bike (e-bike) growth. Current trajectories indicate the viability of deploying large-scale shared e-bike (e-bikeshare) systems in China. We employ a stated preference survey and multinomial logit to model the factors influencing the choice to switch from an existing transportation mode to bikeshare or e-bikeshare in Beijing. Demand is influenced by distinct sets of factors: the bikeshare choice is most sensitive to measures of effort and comfort while the e-bikeshare choice is more sensitive to user heterogeneities. Bikeshare demand is strongly negatively impacted by trip distance, temperature, precipitation, and poor air quality. User demographics however do not factor strongly on the bikeshare choice, indicating the mode will draw users from across the social spectrum. The e-bikeshare choice is much more tolerant of trip distance, high temperatures and poor air quality, though precipitation is also a highly negative factor. User demographics do play a significant role in e-bikeshare demand. Analysis of impact to the existing transportation system finds that both bikeshare and e-bikeshare will tend to draw users away from the "unsheltered modes", walk, bike, and e-bike. Although it is unclear if shared bikes are an attractive "first-and-last-mile solution", it is clear that e-bikeshare is attractive as a bus replacement	Bikeshare E-bike Stated preference Bicycle Transit Choice modeling	MNL switching model, environmental impact, socio-demographic analysis, weather impact, bikeshare, e-bikeshare	4 … this paper is concentrating on switching modes but is also studying the possibility of bikeshare being a competition or complement to already existing pt network. It is also interesting to see how air quality could affect the bikeshare use	Multinomial Logit Mode Switching Model: estimates the likelihood of respondents switching from their original choice (a stated preference from revealed trip data) to a new option. Three options: - original mode choice - bikeshare - e-bikeshare	Micro	Shared bicycles, shared e-bicycles, shared e-scooters, bus, subway, auto solo, carpool, taxi, private e-bike, bike, walk, motorcycle	Interaction with pt through Original Trip Link variables. For example: if the Original Trip Link by Bus variable is one, and the final mode choice is e-bikeshare, then the respondent chose to replace a bus trip link with e-bikeshare. Bikeshare is revealed to rather be a competition to pt than a compliment last-mile choice: the significant positive utility of replacing bus links with e-bikeshare. This variable is one of the strongest positive influences on the choice of e-bikeshare in the model. The utility of shared bikes as transit feeders (first and last mile solutions) is questionable: for e-bikeshare the coefficient is slightly positive, though at a lower significance level; for bikeshare it is negative at a very low significance level. Although bikeshare is an intuitive first and last mile solution, the study cannot state certainly that it will be used this way. It actually looks like it will either compete with bus for the whole trip or will draw its users from the unsheltered modes.	E-bicycles, e-scooters	There are different problems in e-bikesharing (environmental impact, erratic behaviour, conflicts with drivers) that could be addressed by a shared system, since the bikeshare operator could choose and maintain appropriately safe bikes and control the battery waste stream. Not clear socioeconomic(-demographic) pattern; original mode choice influences final mode choice and significant differences exist in the distributions of trip link distances for the three choices. 47% of e-bikeshare users drawn from sheltered modes. The majority of trips will be drawn from so-called green modes (66% from walking and biking modes). The median for bikeshare: 2.9 and 1.5km. E-bikeshare: 4.5 and 4km Commute trips: 3.2km and 4.5km for private bike and e-bike across Beijing.	Stated preference survey designed for the study	Income, age, higher education indicator, environmental concern indicator, gender female indicator, ASC, distance, age^2, air quality bad indicator*dist, air quality medium indicator*dist, air quality good indicator*dist, congestion indicator, congestion indicator*female indicator, license plate restriction indicator, heavy rain indicator, light rain indicator, no rain indicator, temperature cold indicator*dist, temperature hot indicator*dist, temperature comfortable indicator*dist, original mode sheltered indicator, original mode not sheltered indicator, original trip link by bus, original trip link was transit feeder, original trip link did not involve transit,original trip link by subway	Bikeshare and e-bikeshare use		Beijing's four core urban districts: Haidian, Chaoyang, Dongcheng and Xicheng.	Original mode choice influences final mode choice and significant differences exist in the distributions of trip link distances for the three choices. From coefficient estimates: the bikeshare choice is most sensitive to measures of effort and comfort while the e-bikeshare choice is more sensitive to user heterogeneities. Log likelihood: 1154.154 adjusted rho-square: 0.412 E-bike is preferred by women People who change from car to e-bike do it willingly (plate number var is insignificant walk, bike and e-bike users are more drawn to bikeshare. Attraction of bikeshare in terms of competition and complement is varied. The most outstanding result is the significant positive utility of replacing bus links with e-bikeshare. The U of shared bikes as transit feeders in questionable: the coefficient is low at a very low significance level, while for e-bikes the coefficient is slightly positive but of a lower significance level. The study results that e-bikeshare can be deployed with more targeted purposes than classic bikeshare in Beijing. The modelling results demonstrate that shared bike demand in Beijing, especially for conventional bikeshare, will be quite sensitive to weather and air quality conditions.	E-BIKESHARE: young to middle age males with low education and income would prefer e-bikeshare to their original mode. For e-bikeshare age is the greatest contributor to utility for young respondents, with a peak effect at 36 years. Decreasing air quality would result in overall depressing bikeshare demand. Both bike share modes are strongly affected by heavy rain. E-bikeshare will be more viable than bikeshare in areas with low-density superblock forms. The tendency for users to take longer trips suggests e-bikeshare will appeal to workers commuting outside of their neighbourhood. Design of an e-bikeshare network must consider the mode's considerably higher fixed costs, both for the bikes and for the docking stations, which are a likely to require trenching for power lines. This suggests a network structure based on a small number of large docking stations will be most economical. . The tolerance for longer travel distances improves the viability of such a design. Since access costs will suffer in the sparser network, station location must be carefully considered to ensure a sufficient volume of attractions in proximity of docking stations. Three scenarios are considered: - bus-relief : shifting users off of over-subscribed bus routes. - bikeshare-backup: co-locating alongside bikeshare. It will serve users when conditions are not conductiv to bikeshare - sub-center circulator: a series of stand-alone e-bikeshare systems would be deployed in Beijing's sub-centers to improve internal circulation. E-bikeshare could mitigate the negative effects of lowered density and land use diversity (e.g. increased automobile use and congestion and decreased access) BIKESHARE: Modelling results indicate that bikeshare demand will be primarily driven by environmental conditions and individual travel habits. Socio-demographics do not factor heavily, and thus bikeshare will draw users from across the social spectrum. Bikehsare will be more appealing for people from unsheltered original modes. Given the importance of short trips,
Characterisation of and reflections on the synergy of bicycles and public transport	https://www.sciencedirect.com/science/article/pii/S0965856416000240	The bicycle is often understood as a disjointed 'feeder' mode that provides access to public transport. We argue that combined use of the bicycle and public transport should be understood in a broader perspective, especially where bicycles link to higher speed and higher capacity public transport, such as the train. Cycling and public transport can have a symbiotic relationship forming a hybrid, distinct transport mode, which should be reflected in transport planning. The bicycle is seen as a way to soften the rigid nature of public transport and thus accommodate diverse individual travel needs and situations. Public transport can be seen as a means to dramatically extend cycling's speed and spatial reach. We combine a system perspective with conceptual analysis to explore how, why and when this reconsideration is important. We use the Netherlands as illustrative case because of the relative maturity of its bicycle–train connections. The case shows that the synergy between rather opposite yet highly complementary aspects, high speed of the train, high accessibility of the bicycle and flexibility in combining both sub-modes, are the fundamental characteristics to understand the functioning of this system in a wider spatial context. In our conclusion we propose a research agenda, to further explore the relevance of this system for land-use and transport planning and distil wider implications for the international debate.	Integrated transport Public transport Cycling Transport system analysis Sustainable accessibility Urban transport	travel time, two scenarios. Route comparison, bike-train integration, framework for the integration	2-3 … the paper does not study shared mobility services and thus is missing on re-usability of each vehicle. Except for that, average bike speed and road requirements differ from e-scooters and therefore, the result time is affected. However, this paper states a good framework for theoretical comparison of single transits and integrated ones, where different modes are used.	Travel time scenarios for different types of intgration of bicycles to the public transportation. Cooperation bicycle-train is studied with three main rules defined: 1) The trip includes 1 or more 'train' trips that together constitute the 'main travel' segment of the trip chain 2) The trip icludes one or more bicycle trip segments, whereby at least one such cycling segment needs to be directly connected 3) The trip consists of the supply components: origin, destination, implicit supply components for (local) walk trips at origin, destination transfer locations	Macro .. travel time is studied from known (usually used for such calculations) average for a trip	Bicycles, public transportation	Bicycles are defined as part of O-D chain,which means they are representing a transport mode that is a distinct system component within the general transport system: they might be used as a first or/and last mile solution. This is a method that would draw people to cycling from walking in a short-time perspective. However, it would also prevent people from using feeder transit as much, which would indicate a switch to non-motorised vehicles.			Theoretical study: average time to cycle + average transit time; average time to walk + average transit time; average transit time + average transit time	Origin, destination, implicit supply components for (local) walk trips at origin, destination and transfer locations	Travel time		Amsterdam region	The bicycle-train use is on average 26 min faster than walking, or 3 min faster than feeder transit (Ideal time scenario) When introducing penalties that simulate real-life preferencies, feeder transit is affected more than the bicycle-train combination. In Scenario II the original, average advantage of feeder transit over walking is almost halved, from 23 min to 13 min. On the other hand, the average time gain of cycling over walking decreases much less, from 26 min to 23 min. Cycling thus results in an average 3 and 10 min advantage over feeder transit services, respective to scenarion I and II, and per single journy (one-way).	
Bike-sharing or taxi? Modeling the choices of travel mode in Chicago using machine learning	https://www.sciencedirect.com/science/article/pii/S0966692318304678	In many big cities, the bike-sharing system (BSS) and taxi play critical roles in transportation services. They both offer on-demand transportation options and allow flexible riding scheduling and routing. Previous literature has compared BSS and taxi to other transport modes, such as public transit and private automobile, but little is known about the spatiotemporal factors that influence travel choices between these two alternatives. Understanding travel patterns of BSS and taxi is critical in traffic demand analysis and sustainable transportation planning. Also, an in-depth examination of the patterns of travel behaviors, especially when one would choose BSS over a taxi, will provide valuable insights on human mobility and active living research. In this study, we investigated the spatiotemporal patterns of BSS and taxi trips in Chicago from 2014 to 2016. To model travel choices between BSS and taxi, we applied machine learning techniques to simulate the means of transport based on environmental and temporal factors. Results show seasonal trip variations of the BSS and a declining trend of taxi trips. BSS speed is relatively stable while taxi speed varies primarily because of time and locations. Based on the random forest model, which has demonstrated the best fit with high processing speed, travel distance and the number of parks and recreational facilities seem to be critical spatial predicting factors of the travel choice. Given any time and location, the model can recommend the travel choices between BSS and taxis for users. This study shows the significance of machine learning techniques in urban mobility research. Results of the study may potentially support people's transportation decision-making and facilitate sustainable transportation planning.	Bike sharing systems Taxi Machine learning Geographic information systems	random forest model, model testing, spatiotemporal conditions, data analysis	3 … as the paper also focuses on the model choice (taxi-shared bicycle), even though it doesn't take into account other transportation modes and taxi&shared bicycles are viewed mainly as competitors. However, it can provide an inside look at when the shared bicycles can be preferred over taxis, which is a more sustainable solution	Linear, nonlinear (not ensembles)(k-NN, support vector machine, Gaussian naïve bayes, decision tree, neural network) and ensemble (e.g. random forest) algorithms. Model performance: ensemble models show the best performance, among which random forest and extra trees achieved the highest scores in all 4 metrics (accuracy, F1, precision, recall). Random forest is chosen for further analysis.	Micro	Taxi, bicycles	No integration: bicycles and taxi are represented as competitive transportation modes.		In general, the total trips of the taxi were much higher than those of BSS. BSS trip number was subject to weather conditions and therefore showed a seasonal pattern with peaks and troughs in winters. Both taxi and BSS revealed fluctuations between weekdays and weekends. The trip speed showev overall steady patterns, no apparent seasonal trend was observed.	The Chicago Data Portal: 1.the City of Chicago taxi data back to 2013: time trips started and ended, lengths of trips in time and distance, amount of taxi fare, starting and ending locations. 2. Data regarding the built environment: the total length of bike lanes (in km), number of parks and recreational facilities ptovided by the Chicago Park District	Travel distance, time of the day, weather, and land use factors. By default: there's a person who needs to travel about 8km on a weekday in June at noon with a good weather condition.	Probability of a person using BSS versus taxi under a given spatiotemporal situation	Start and end trips are rounded to 15 min	The City of Chicago	People tend to choose BSS when the travel distance is short. No matter what season it is, whnever the travel distance is greater than 8km, the BSS system becomes much less favourable. The likelihood of using BSS is consistenly 0.5 less during the rainy day regardless of precipitation. For the default situation: at 8 am, the person is a bit more likely to ride from North Chicago to the downtown area. However, in the south of Chicago, this person is more likely to use a taxi. At 6pm the likelihood to use BSS becomes higher, especially in the CBS areas. The demand for BSS becomes higher in the south of Chicago compared to the demand in the morning.	In winter and spring people are less likely to use BSS than in summer and fall. The likelihood of choosing BSS drop quickly around 6 to 8 kmof travel distance. This might be a reflection of the Divvy Bike policy: 30 min of each ride are included in the membership pass price, if the ride exceeds this time, additional fees will be applied. BSS is used more during weekdays than the weekend. People tend to use BSS in the daytime rather than during nighttime. After 6pm, people tend to select taxi rather than BSS to travel 8km. There's a clear trend of decreased BSS use as precipitation increases. When the wind speed is higher than 10 mph, people opt to use taxi rather than BSS. When the park and recreational facility count increases from 15 to 25, people are more likely to use BSS.
Barriers to bikesharing: an analysis from Melbourne and Brisbane	https://www.sciencedirect.com/science/article/pii/S0966692314001677	This study quantifies the motivators and barriers to bikeshare program usage in Australia. An online survey was administered to a sample of annual members of Australia's two bikeshare programs based in Brisbane and Melbourne, to assess motivations for joining the schemes. Non-members of the programs were also sampled in order to identify current barriers to joining bikeshare. Spatial analysis from Brisbane revealed residential and work locations of non-members were more geographically dispersed than for bikeshare members. An analysis of bikeshare usage in Melbourne showed a strong relationship between docking stations in areas with relatively less accessible public transit opportunities. The most influential barriers to bikeshare use related to motorized travel being too convenient and docking stations not being sufficiently close to home, work and other frequented destinations. The findings suggest that bikeshare programs may attract increased membership by ensuring travel times are competitive with motorized travel, for example through efficient bicycle routing and priority progression and, by expanding docking station locations, and by increasing the level of convenience associated with scheme use. Convenience considerations may include strategic location of docking stations, ease of signing up and integration with public transport.	Bicycle CityCycle Bikeshare Melbourne Transport Brisbane	factor analysis, revealed preferences survey, somparion between members and non-members	2 … this study focuses more on factors driving people to join the BSS community, not on its integration in the PT, nor socio-demographic variables.	Revealed preference survey Geospatial analysis Factor analysis	Micro	Bicycles	Public transport accessibility is included into geospatial analysis of the BS use with the established Public Transport Accessibility Levels methodology. Through the pt accessibility influencing BSS in the negative manner it can be revealed that bicycles are more of a competitive mode of transport rather than complimentory.		Bikeshare members are typically younger, more likely to know the distance between their home and work to their closest docking station, have pre tax incomes above $A104,000 per annum, and have friends or family who are bikeshare members. For commuting journeys, almost half the members in both Brisbane amd Melbourne reported no usage in the month prior to undertaking the survey, whereas around 13% for both MBS and CityCycle reported using BSP "everyday". 13% of BSS trips are ended at the same location as originated from. Many of the strongest trip patterns occur between stations located in areas of relatively weak public transit accessibility.	Online survey distributed among MBS and CityCycle annual members. 39 questions: socio-economics and demographics, bikeshare membership status, transport behaviour and vehicle ownership status. The spatial analysis of home and work postcodes of survey respondents. Factor analysis to quantify the barriers and facilitators to bikeshare.	-	-		Melbourne and Brisbane	DRIVING FACTORS Non-members: 1. Driving is more convinient, docking stations are not close enough to my house & work 2. I don't want to carry a helmet with me 3. Nothing; I am not interested in using CityCycle, no matter what. Members: 1. Convinience 2. Docking station close to work Factor analysis: docking station inconvinience was a greater influence against membership than scheme difficulty of use and helmet inconvinience, but less than car convenience and perceived danger.	Lower demand in the places with higher public transportation accessibility. Heavy concentration of members in residential locations within the inner city. Places of employment are heavily skewed towards the CBD.

Expanding a(n) (electric) bicycle-sharing system to a new city: Prediction of demand with spatial regression and random forests	https://www.sciencedirect.com/science/article/pii/S0966692319307136	Bicycle-sharing systems have experienced strong growth in the last two decades as part of a global trend that started in the 1990s and accelerated after 2005. Early bicycle-sharing systems were provided primarily as a public service by cities. Today, major international bicycle-sharing companies are emerging and seeking to expand their operations to new cities. Two major strategic questions arise: (1) which cities should be considered for expansion and (2) what should be the geographical extent of the service area? An important factor in such decision-making is the expected demand for bicycle-sharing because it relates directly to potential revenue. In this paper, booking data from an electric bicycle-sharing system was used to estimate and assess models for bicycle-sharing demand and to predict expansion to a new city. Employment, population, bars, restaurants and distance to a central location were amongst the most important predictors in terms of variance explained in the same city. Omitting centrality measures improved predictions for the new city.	E-bike sharing Bicycle sharing Demand prediction Vehicle sharing Spatial regression Random forests	Random forests; Moran's I; Classification; Regression
Analysis of E-Scooter Trips and Their Temporal Usage Patterns	https://www.researchgate.net/publication/333634549_Analysis_of_E-Scooter_Trips_and_Their_Temporal_Usage_Patterns	With the rising need for affordable shared mobility in urban cities and university campuses, a variety of companies are offering shared dockless e-scooters as a new transportation mode in these areas to provide connectivity for the "last mile." The recent popularity experienced by shared mobility services is perhaps driven by advances in technology (mainly smartphones, positioning systems, and mobile payments), economic changes, and social and environmental concerns related to vehicle ownership and urban living. It is hypothesized that travelers making trips between 0.5 and 2 miles (mi.) (0.8–3.2 kilometers [km]) will likely accrue the largest benefits from e-scooters. However, as this technology is introduced into the urban mobility ecosystem, it is critical for public agencies to understand the travel patterns and temporal usage to guide long-term planning and resource allocations.		origin - destination
The drivers of demand for free-floating car-sharing	Mesaric, R. (2019) The drivers of demand for free-floating car-sharing, Project report, Institute for Transport Planning and Systems, ETH	Free-floating car-sharing is a comparatively new service, which immediately enjoyed great popularity and expanded around the globe in recent years. Even though the service has already been on the market for a few years, little is known about the drivers of its demand. The objective of this project report is to shed light on this issue by analyzing transaction data of two free-floating car-sharing providers. The numbers show that free-floating car-sharing trips are of rather short duration and that there is a seasonal and temporal variation in the demand. The data is further analyzed by means of linear and spatial regression models. The results confirm the results of the descriptive analysis and illustrate the effect of public transport and various other points of interest as well as socio-economic variables on the demand. The comparison with the travel times of alternative means of transport reveals that traveling with free-floating car-sharing leads to a temporal advantage compared to public transport, but not always relative to cycling.	free-floating car-sharing, one-way car-sharing, GPS tracking, booking data, demand analysis, spatial regression	
Exploring the adoption of moped scooter-sharing systems in Spanish urban areas	https://www.sciencedirect.com/science/article/pii/S0264275118318614	Within the context of the sharing economy, innovative mobility solutions are emerging in urban areas to enable people short-term access to means of transport on an as-needed basis. Within this new trend, moped scootersharing is experiencing a great boom in many cities worldwide, particularly in Europe. The generalization of electric moped scooter-sharing services can bring benefits such as lowering noise and air pollution or reducing road congestion, with important implication for improving the livability and quality of life in urban areas. To date, many contributions have been conducted to characterize innovative mobility options such as car-sharing or bike-sharing, but almost no efforts have been devoted to explore the use of moped scooter-sharing services. Based on the information collected through an online survey disseminated in different Spanish cities, we developed a generalized ordered logit model to identify the key drivers determining the adoption and frequency of use of moped scooter-sharing services in urban areas. The research concludes the main role played by some sociodemographic and travel-related variables, such as age or level of education, while personal opinions and attitudes were not generally found statistically significant. The research found somehow similar profiles for occasional and frequent users of moped scooter-sharing, then public authorities should make further efforts to overcome the barriers related to the first contact with this mobility option.	moped scooter-sharing, shared mobility, urban mobility, user perception, generalized ordered logit model, spain	gologit, modal shift, drivers of demand, binary choice model, nature of relationship between modes
Competition and Cooperation between Shared Bicycles and Public Transit: A Case Study of Beijing	https://www.researchgate.net/publication/331491177_Competition_and_Cooperation_between_Shared_Bicycles_and_Public_Transit_A_Case_Study_of_Beijing	As an eco-friendly transportation mode, shared bicycles provide a new option for public transit users in urban areas. China's bicycle-sharing market began flourishing in July 2016 and reached a plateau in 2017. How shared bicycles influenced public transit systems during this period is an interesting topic. A case study of Beijing is conducted. This study aims to identify the competitive and cooperative influences of shared bicycles on public transit by exploring the changes in public transit trip distances before and after the upsurge in bicycle-sharing. A histogram shifting method is introduced to examine the influences of shared bicycles on public transit services from a travel distance perspective. A spatial correlation of bicycling usage and public transit changes is calculated using units of gridded cell spaces. The results show: (1) overall transit usage continued growing after the shared bicycles market reached a plateau; (2) short public transits within 2 km decreased while transfers within 2 km increased; and (3) the decrease of short transits and increase of transfers within 3 km were spatially highly correlated to the usage of shared bicycles. Hence, the role of bicycle-sharing systems is competitive for existing public transit systems during short trips and cooperative for connecting transits.	shared bicycle; public transit; trip distance; histogram shifting method; urban sustainability	spatial correlation; histogram-shifting method;
College Students' Shared Bicycle Use Behaviour Based on the NL Model and Factor Analysis	https://www.researchgate.net/publication/335316031_College_Students%27_Shared_Bicycle_Use_Behavior_Based_on_the_NL_Model_and_Factor_Analysis	The rise and rapid development of bicycle sharing brings great convenience to residents' travel and transfer, and also has a profound impact on the travel structure of cities. As college students make up a major share of shared bicycle users, it is necessary to analyze the factors that influence their travel mode and riding frequency choice and to explore how these factors affect their riding behavior. To analyze the bicycle riding characteristics of college students, this paper processes many factors with unknown correlations by using a factor analysis method based on revealed preference (RP) questionnaire data. Then, taking the significant common factors as explanatory variables, a two-layer nested logit (NL) model combining riding frequency and travel mode is established to study college students' riding behavior. The results suggest that the comprehensive hit rate of the upper and lower levels of the model (riding frequency and travel mode) are, respectively, 76.8% and 83.7%, and the two-layer NL model is applicable. It is also shown that environmental factors ("cheap," "mixed traffic," "signal lights at intersection," and so on) have a significant impact on the choice of travel mode and riding frequency. Also, improving the level of bicycle service can increase the shift from walking to riding. Such findings are meaningful for policy-makers, planners, and others in formulating operational management strategies and policies.	college students, bicycle sharing, nested logit model, factor analysis method, sensitivity analysis	nested logit model, sensitivity analysis, factor analysis
Mixed Logit Models for Travelers' Mode Shifting Considering Bike-Sharing	https://www.mdpi.com/2071-1050/12/5/2081	This study quantifies the impact of individual attributes, the built environment, and travel characteristics on the use of bike-sharing and the willingness of shifting to bike-sharing-related travel modes (bike-sharing combined with other public transportation modes such as bus and subway) under di_erent scenarios. The data are from an RP (Revealed Preference) survey and SP (Stated Preference) survey in Nanjing, China. Three mixed logit models are established: an individual attribute–travel characteristics model, a various-factor bike-sharing usage frequency model, and a mixed scenario–transfer willingness model. It is found that age and income are negatively associated with bike-sharing usage; the transfer distance (about 1 km), owning no car, students, and enterprises are positively associated with bike-sharing usage; both weather and travel distance have a significant negative impact on mode shifting. The sesearch conclusions can provide a reference for the formulation of urban transportation policies, the daily operation scheduling, and service optimization of bike-sharing.	bike-sharing, travel mode transfer, travel willingness, influencing factors, mixed logit model	revealed preference survey,
Understanding the Shared E-Scooter Travels in Austin, TX	https://www.mdpi.com/2220-9964/9/2/135	This paper investigated the travel patterns of 1.7 million shared E-scooter trips from April 2018 to February 2019 in Austin, TX. There were more than 6000 active E-scooters in operation each month, generating over 150,000 trips and covered approximately 117,000 miles. During this period, the average travel distance and operation time of E-scooter trips were 0.77 miles and 7.55 min, respectively. We further identified two E-scooter usage hotspots in the city (Downtown Austin and the University of Texas campus). The spatial analysis showed that more trips originated from Downtown Austin than were completed, while the opposite was true for the UT campus. We also investigated the relationship between the number of E-scooter trips and the surrounding environments. The results show that areas with higher population density and more residents with higher education were correlated with more E-scooter trips. A shorter distance to the city center, the presence of transit stations, better street connectivity, and more compact land use were also associated with increased E-scooter usage in Austin, TX. Surprisingly, the proportion of young residents within a neighborhood was negatively correlated with E-scooter usage.	e-scooter, urban environment, travel pattern, shared micro-mobility	Origin-destination, negative binomial regression model, e-scooter, spatial analysis, shared scooter
[illegible] behavior in free-floating bike sharing system design: A data-informed spatial agent-based model	[illegible] sciencedirect.com/science/article/pii/S2210670719301623	[illegible] the dramatic expansion of free-floating bike sharing (FFBS) services generates problems such as illegal parking and low utilization. An effective FFBS system needs to be highly regulated. This study combines Big Data and spatial agent-based modeling to understand the interactions between stakeholders to assist the bike-sharing system design. The key design decisions considered are the locations and capacities of bicycle parking lots in the system, as well as the connected bike lanes between parking lots. The model has been applied to the case of Hong Kong for demonstration. The results show that the parking lots with higher capacities are mostly close to the metro stations, and the cycleways are disconnected even for those that have high cycling occupancy. The results indicate that for most target people to be willing to change the parking location, the minimum fare discount rate for doing so should be set to 30%. The average trip time can be reduced by 3.8%, and per user cost can be reduced by 2.4% with an expected investment of 0.12 million USD to build new cycle tracks and connect existing cycleways.	[illegible] sharing system, data-informed, agent-based modeling	[illegible] floating bike-sharing, Big Data, agent based model, GAMA platform, spatial clustering
Urban mobility in the sharing economy A spatiotemporal comparison of Shared Mobility Services.pdf	https://www.sciencedirect.com/science/article/pii/S0198971519303060	The influx of micro-mobility services, such as dockless scooter-share and e-bikes, in many cities are contributing to a substantial change in urban transportation with adoption rates reminiscent of other shared-mobility services, such as ride-hailing, years prior. Touted as a solution to the last mile problem, a multitude of micromobility companies have situated themselves in urban centers promising low cost alternative transportation options for short, urban travel. The rapid arrival of these companies, however, has left little time for city officials, transportation planners, and citizens to assess the demand for these services and compare them to existing transportation options. In this work, we investigate two key aspects of these micro-mobility services. First, we identify the spatial and temporal differences between these mobility companies and highlight the nuanced differences in usage patterns. Second, we compare these new services to an existing mode of transportation, namely automobile-based ride-hailing, with regards to differences in travel time within a city. The results of these analyses indicate that while many micro-mobility companies are spatiotemporally similar, there are notable differences in where and when these services are used. Similarly, we find that automobile travel is not always the fastest means of transportation within an urban setting. During periods of heavy traffic congestion, e.g., rush hour, micro-mobility services offer a faster means of travel within the city. The findings presented in this work offer evidence on which to inform urban planning and transportation policy with respect to shared mobility services, free floating vehicles, and alternative urban transportation.	shared-mobility, micro-mobility, scooter share, bike share, dockless, ride-hailing	spatio-temporal comparison, micro-mobility, comparison, shared scooter services, ride-hailing
E-Scooter Scenarios: Evaluating the Potential Mobility Benefits of Shared Dockless Scooters in Chicago	https://www.researchgate.net/publication/330093998_E-Scooter_Scenarios_Evaluating_the_Potential_Mobility_Benefits_of_Shared_Dockless_Scooters_in_Chicago	This study examines the potential for public e-scooter sharing systems to fill mobility needs within and between Chicago neighborhoods. It explores how availability of this micro-mode of transportation could influence travel time, cost, and the convenience of trips relative to other active and shared-use modes including walking, bicycling, bikeshare, and public transit. To draw conclusions, it uses the Chaddick Institute's multimodal travel model to evaluate approximately 30,000 randomly selected hypothetical trips between locations on the North, South, and West sides of the city. Different assumptions about the quantity and distribution of shared dockless e-scooters are considered to assess the sensitivity of the results. The analysis shows that: On trips between 0.5 and 2 miles, e-scooters would be a particularly strong alternative to private automobiles. In parking-constrained environments, the introduction of e-scooters could increase the number of trips in which non-auto options are competitive with driving from 47% to 75%. The cost of using an e-scooter, inclusive of tax, would likely be around \$1.10 per trip plus \$1.33 per mile, making them cost-effective on short-distance trips. By filling a gap in mobility, e-scooters have the potential to increase the number of car-free households in Chicago. Due to their higher relative cost on trips over three miles, e-scooters would likely not result in significant diversion from public transit on longer-distance trips, particularly services operating to and from jobs in the transit-rich Loop business district. Often, the use of scooters on these longer journeys would likely be short connections to nearby transit stops. The benefits of e-scooters can differ widely between geographic areas that are only a few blocks apart due to the differential access of these areas to transit lines and bus routes. E-scooters would make about 16% more jobs reachable within 30 minutes compared to the number of employment opportunities currently accessible by public transit and walking alone. The gains tend to be markedly different across the North, South, and West study areas. By fostering insights into how e-scooters could influence travel time, cost, and convenience, these results can help set the stage for an informed discussion on the many tradeoffs associated with this micro-mode of transportation.		network analysis, multimodal synergy, accessibility, time saved
Analysis of Spatial and Temporal Characteristics of Citizens' Mobility Based on E-Bike GPS Trajectory Data in Tengzhou City, China	https://ideas.repec.org/a/gam/jsusta/v11y2019i18p5003-d266806.html	Environmentally friendly shared transit systems have become ubiquitous at present. As a result, analyzing the ranges and tracts of human activities and gatherings based on bike share data is scientifically useful. This paper investigates the spatial and temporal travel characteristics of citizens based on real-time-extracted electric bikes (e-bikes) Global Positioning System (GPS) data from May to July in 2018 in the central area of Tengzhou City, Shandong Province, China. The research is conducive for the exploration of citizens' changes in mobility behaviors, for the analysis of relationships between mobility changes and environmental or other possible factors, and for advancing policy proposals. The main conclusions of the study are as follows. First, in general, citizens' travelling is featured by rides that are less than 10 min, shorter than 5 km, and with a speed between 5 km/h and 20 km/h. Second, in terms of temporal characteristics, monthly e-bike usage and citizens' mobility are positively correlated with temperature in May and negatively correlated with temperature in July; an overall negative correlation is also manifested between the e-bike usage (mobility) and air quality index; daily usage reaches a trough on Tuesday and a peak on Friday, indicating the extent of mobility on respective days; e-bike usage and human outdoor behaviors are significantly lowered in rainy weather than in sunny weather; hourly rides reach a peak at 18:00 (more human activities) and a trough at 2:00 (less activities), and average hourly riding speed maximizes at 5:00 and minimizes around 8:00 and 17:00. Third, for spatial characteristics, destinations (D points) during morning rush hour and regions where e-bikes are densely employed are concentrated mainly in mid-north and middle parts of the central area (major human gatherings), and the rides have a di_using pattern; e-bike origin–destination (O–D) trajectories radiate mostly towards the mid-north and the east during evening rush hour. In addition, 9.4% of the total trips to work areas during morning rush hour represent spillover commuting, indicating that separations between jobs and residential are not severe in the central area of Tengzhou City and commuting is relatively convenient.	shared electric bike, spatial and temporal travel characteristics, changes in citizens' mobility, kernel density, spillover commuting	hotspot analysis, three-mode Gaussian function, behavioural usage habbits, kernel density comparison
Shared micro-mobility patterns as measures of city similarity	https://dl.acm.org/doi/10.1145/3356392.3365221	Micro-mobility services, such as dockless e-scooters and e-bikes, are inundating urban centers around the world. The mass adoption of these services, and ubiquity of the companies operating them, offer a unique opportunity through which to compare cities. In this position paper, a series of spatiotemporal measures are proposed based on activity data collected from shared micro-mobility services. The purpose of this paper is to identify a number of ways that these new mobility services can serve to augment existing city similarity approaches.	shared mobility, micro mobility, e-scooter, e-bike	dbscan, network density, trajectory metrics, temporal analysis, sociodemographic population data, points of interest
Estimating Urban Shared-Bike Trips with Location-Based Social Networking Data	https://www.researchgate.net/publication/333706300_Estimating_Urban_Shared-Bike_Trips_with_Location-Based_Social_Networking_Data	Dockless shared-bikes have become a new transportation mode in major urban cities in China. Excessive number of shared-bikes can occupy a significant amount of roadway surface and cause trouble for pedestrians and auto vehicle drivers. Understanding the trip pattern of shared-bikes is essential in estimating the reasonable size of shared-bike fleet. This paper proposed a methodology to estimate the shared-bike trip using location-based social network data and conducted a case study in Nanjing, China. The ordinary least square, geographically weighted regression (GWR) and semiparametric geographically weighted regression (SGWR) methods are used to establish the relationship among shared-bike trip, distance to the subway station and check ins in different categories of the point of interest (POI). This method could be applied to determine the reasonable number of shared-bikes to be launched in new places and economically benefit in shared-bike management.	dockless shared-bike, location-based social networking, semiparametric geographically weighted regression	kriging interpolation, grid aggregation, GWR, LBSN, SGWR
Spatial associations of dockless shared e-scooter usage	https://www.sciencedirect.com/science/article/pii/S1361920920305836	In this study, we explore the usage of e-scooter sharing services in Austin, Texas over about a sixmonth period. The study is based on trip records of all the shared e-scooter operators in Austin and includes trip start and end locations. We use both analysis of trip patterns and spatial regression techniques to examine how the built environment, land use, and demographics affect escooter trip generation. Our findings show that people use e-scooters almost exclusively in central Austin. Commuting does not seem to be the main trip purpose, and usage of e-scooters is associated with areas with high employment rates, and in areas with bicycle infrastructure. People use e-scooter sharing regardless of the affluence of the neighborhood, although less affluent areas with high usage rates have large student populations, suggesting that students use this mode of travel. Implications for planners suggest that better bicycle infrastructure will facilitate e-scooter usage, college towns are a ready market for e-scooter sharing services, and e-scooters may be a substitute for some short non-work trips, reducing car usage, and benefiting the environment.	geographically weighted regression. spatial analysis, micromobility, shared e-scooters	spatial log, gwr, spatial durbin, bicycle infrastructure

DIMENSIONS

MODEL TYPE

Value Name	Value Description	Paper Association
Difference in differences estimator	During the study period **difference in differences estimator** compares a treated group (with the policy being implemented) to a control group by using panel data in order to quantify the casual impact of a policy. The differences between before and after the policy is applied is the estimated effect of it. This method is capable of estimating the differences without being affected by the permanent inconsistences between the control and treatment groups and time trends that could have an effect on the sample. Base: ordinary least square estimation.	1
Neural Networks: **- Graph Convolutional NN with data-driven graph filter (GCNN-DDGF)** **- Optimised Convolutional NN** **- Long Short Term Memory Recurrent NN (LSTM)**	**GCNN-DDGF model's** performance relies on a pre-definied graph-structure. **LSTM** is a different type of gated RNN which is capable of learning long-term dependencies. Because RNNs are especially computationally expensive to train, normally a deep RNN model contains no more than 3 layers of LSTM. Deep RNN is very useful in learning complex functions.	2,9,14
Regression: **1. Logit Model: MNL, Binary, Gologit, Nested, Mixed** **2. Linear: OLS, Log-Linear, Spatial Lag, Spatial Durbin, GWR, semiparametric GWR, Random Intercept Multilevel Model** **3. Binomial**	**Linear regression** is a statistical method used to examine the direct(linear) relationship between a variable of interest (dependent variable) and one or more explanatory variables (predictors) **A spatial lag (SL) model** assumes that dependencies exist directly among the levels of the dependent variable (e.g. income in the city centre is affected by income in the neighbouring areas). **Logistic regression** analysis has also been used particularly to investigate the relationship between binary or ordinal response probability and explanatory variables. **GWR** constructs a separate equation for every feature in the dataset incorporating the dependent and explanatory variables of features falling within the bandwidth of each target feature. By doing this, it is dealing with spatial dependences. **A random intercepts model** is a model in which intercepts are allowed to vary, and therefore, the scores on the dependent variable for each individual observation are predicted by the intercept that varies across groups. This model assumes that slopes are fixed (the same across different contexts). In	3,7,10,11,15,18,19,20,21,24,26,28,27,35,36
Travel Time Scenario	Theoretical approach based on commonly used parameters for calculating travel time (e.g. walking to the bus stop is 5 minutes)	4
Random Forests	**Random forests** is an ensemble learning method for classification, regression and other tasks that operate by constructing a multitude of decision trees at training time. Thus, it estimates the whole tree of models and returns the class that is the mode of classes (classification) or mean prediction (regression) of individual trees.	5,21
Analysis: **- geospatial** **- spatio-temporal**	Analysis of the input data by studying general trends. It is not a direct modelling or prediction, but it is useful for comparing different datasets on the early stages or with limited funds.	6,12,31
Factor Analysis (as one of the main study methods)	**Factor analysis** is a statistical method that describes variability across the observed variables in terms of factors (unobserved variables).	6, 28
Survey	Conducting a **survey** helps to understand needs of population and factors that might drive the population's demand.	8
Origin-Destination Analysis	**O-D analysis** helps to understand preferrences and trends. Often used for promoting purposes: re-location of services, targeted propaganda. This method is easily visualised and can be useful for everyday monitoring.	13(through a weighted graph),20,22
Three Dimensional Discrete Wavelet Decomposition (DWT)		14
Bayesian Estimation & Markov Chain Monte Carlo Estimation	**Bayesian estimation** assumes that parameters are random variables with unknown distribution in stead of unknown constants. By constructing a **Markov chain** that has the desired distribution as its equilibrium distribution, one can obtain a sample of the desired distribution by recording states from the chain. The more steps that are included, the more closely the distribution of the sample matches the actual desired distribution.	16
Normalised Ratios	**Normalised ratios** are used for estimation of different values. They are commonly divided by some value in order to avoid incorrect understanding of the quantity (e.g. there are 50 shared cars in a city of 1500 inhabitants and 1700 in a city with 12000)	29
K-means Clustering	**the K-means algorithm** identifies *k* number of centroids, and then allocates every data point to the nearest cluster, while keeping the centroids as small as possible.	
Histogram-shifting Method	**The histogram method** is an estimate of the probability distribution of the distances.	25
Agent Based Model (ABM)	**ABM** is class that uses different models for simulation of movement (interaction of and between autonomous agents) within a certain environment and with some rules.	30
Network-Based Analysis Multimodal Model (Accessibility Model)		32
Kernel Density	A non-parametric way to estimate the probability density function of a random variable. Kernel density estimation is a fundamental data smoothing problem where inferences about the population are made, based on a finite data sample.	33
Three-mode Gaussian Function		

Overall: The vast majority of the models, that are used partially or completely for evaluation of the integration of shared mobility services into the existing transit chain, are part of the regression family: 15 out of 34 studied papers. The others are used only in 1-3 articles.

Depending on the main goal of a paper, it is either linear, logit or binomial regression. It is the most popular model family, as after the optimisation and validation of the model it is possible to calculate such important values as: value of time, revenues. It is also possible to estimate a policy, which could be implemented in the

MODEL LOD

Value Name	Value Description	Paper Association
Micro	Individual elements of the system are studied, e.g.: - individual vehicle dynamics - individual travel behaviour	3,5,6,10,11,19,22,24,26,27,33
Mezzo	Small groups of elements, where they are considered homogeneous: - vehicle platoon dynamics - household-level travel behaviour	2,7,9,13,15,18,29,32,35,36
Macro	Aggregated characteristics of transport elements: - aggregated traffic flow dynamics - zonal-level travel demand analysis	1, 4,8,12,14,16,20,21,25,28,30

Overall: In total 13 out of 34 papers belong to microscopic models, 9 out of 34 are mesoscopic, 11 out of 34 are macroscopic, from those: 7, 6 and 6, respectively, are from 24 concerning the integration.
Use of the LOD depends on the type of model and the researcher's choice (on whether to aggregate the values or not): like in [36] where researchers aggregate the data in order to protect personal information of the micromobility users. In [15] buffer zone is studied, while in [18] ridership data is aggregated into groups by docking stations, which would present a new overview over the micromobility service use.

In this case, both in total and specifically relevant papers are more or less evenly distributed between micro, mezzo and macro. Even models of the same family (e.g. regression) are being dispersed in every level of detail. Sometimes it is argued that such data aggregation might cause a map areal unit problem (MAUP) and some unrealistic trends would appear in the results, but sometimes it is easier to use aggregated data because of the computational complexity of the model.

TRAVEL MODE

Value Name	Value Description	Paper Association
Shared Service	Bikesharing	[illegible]
	electric Bikesharing	[illegible]
	electric scooter share	[illegible]
	carsharing	11, 24
Public Transport (PT)	Bus	[illegible]
	Subway	[illegible]
	Train	[illegible]
	Tram	11
	[illegible]	[illegible]
Private (e-)Bike		[illegible]
Private Motorised Vehicle	Car	[illegible]
	Motorcycle	3, 24
Taxi		[illegible]
Walk		[illegible]

Overall: While all the [illegible] micromobility service, [illegible] types. In total, 25 out [illegible] bikesharing, 10 of 34 [illegible] account carsharing a[illegible] impacts of public trans[illegible] motorised vehicles in [illegible]

7 papers concentrate[illegible] the second most popu[illegible] micromobility services [illegible] the cities with subwa[illegible] transport modes due [illegible] subway stations bein[illegible]

Papers that include a [illegible] which allow to study [illegible] most re-appearing art[illegible] consideration as many [illegible] performed integration [illegible] the Beijing case study [illegible]

INPUT DATA

Value Name	Value Description	Paper Association
	Fare Type	1, 5
	Revenue, also includes quality of the service	1, 21
PT, taxi	PT Stops/Stations (geodata)	[illegible]
	Ridership, depending on the system [illegible]	[illegible]
	Ridership, might be from: [illegible]	[illegible]
Shared mobility system	Membership (yes or no)	1
	[illegible]	[illegible]
Theory	Survey	[illegible]
	Theoretical Study	4
Built Environment	Land Use, might include possible destinations	[illegible]
	Weather, also includes air quality	[illegible]
	Geodata	[illegible]
Statistical Databases	Socio-demographic	[illegible]

Overall: [illegible]

DEPENDENT VARIABLES

Value Type	Value Name	Paper Association
Trip Information	**Demand** [illegible]	[illegible]
	Travel mode choice [illegible]	[illegible]
	Time [min] [illegible]	[illegible]
	Ratios [illegible]	[illegible]
	# of Vehicles	[illegible]
	[illegible]	[illegible]
Travel Behaviour	**Shift** [illegible]	[illegible]
	Accessibility [illegible]	[illegible]
	Travel Willingness [# people]	27

Overall: [illegible] varying among the [illegible] frequency (18/34 for all [illegible] ying demand in terms of [illegible] ur, number of trips/day), [illegible] n transit, private [illegible] time, the latter ones are [illegible] be happening due to the [illegible] scope of the research. [illegible] Travel willingness [27] [illegible] her dependent variables. [illegible] survey, as in [27] there [illegible] based model is [illegible] e of the article is [illegible] paper only (travel mode, [illegible] e, as they might be [illegible]

INDEPENDENT VARIABLES

Value Type	Value Name	Paper Association
Trip Information	**Time:** **- start/end time** **- date** **- length**	1, 5, 7,9,11, 15, 19, 20, 22,25, 26, 27, 28, 33
	PT Route	1, 32
	Shared Micromobility Stations/Parking	**[coordinates]:** 18, 25, 30 **[dummy]:** 2,7, 18 **[# stations/area]:** 19
	Trips	2,7, 26, 35
	Origin & Destination	4,9, 22, 25, 29, 35
	Mode	11
	Distance	5,11,20, 22,25, 27, 32
Environmental	**Infrastructure, also: distances to the nearest pt, to city center**	**PT [coordinates] (of a PT station/stop):** 25, 30 **[m] (distance to transit):** 28, 21, 27, 35 **[# PT sations/area]:** 15, 19, 36 **[area]:** 18 **[dummy]:** 20, 21
	Land Use	5, 7, 18, 20, 21, 26, 28, 30, 36
	Population , also: Density	7, 21, 28
Weather	**Weather, might include:** **- temperature** **- wind** **- percipitation** **- season**	5,7, 15, 19, 27
Socio-Demographic	**Age**	3,10,11,15,18,24,27,28
	Education	3, 10,11,26, 27, 28
	Environmental Concern	3, 24(as motivation), 26
	Gender	3,10,11,24,26, 27, 28
	Nationality	11, 18
	Occupation	10, 15, 21, 24, 27
	Vehicle Ownership	11, 27
	Discounts	11
	Income	3, 10,11,24,27, 28
	Subscriber Type	20, 24
Other	**Motivation**	11,24,26

Overall: As to the mentioned in the articles variables, 22/34 use shared micromobility trip information, 15 use environmental variables. Infrastructure is included into that variable type, because the relationship between the shared micromobility services and current network is mainly studied via spatial associations. 5 papers are exploring how weather is impacting the shared micromobility use and the mode shift between it and some other modes. 10 articles also retrieve socio-demographic data about population. Lastly, 3 study the drivers of either use or non-use of the micromobility services.

As for the trip information, 14 papers are using travel time as one of the independent variables. Such a wide use might be a result of first of all, travel time importance for the shared micromobility services, as it is also one of its limitations, and secondly, to the relatively easy retrieval of the data using API. Route (PT) is one of the least popular independent variables: in [1] it is probably used, because the dependent variable is actually the bus ridership and the paper is studying how the shared micromobility services are affecting it; in [32] the impact is unclear, as the other limitation of the shared e-scooter would also be the price variation around the time spent on board, but there are some possible suggestions, that are later mentioned in "integration results".

Weather impacts are studied in [5], [7], [15], [19], [27] from which 3 are marked as relevant papers. As the scope of this research is the shared *micromobility* services, this might be one of the most important factors driving people away from using unsheltered modes in an unpleasant environment or during the weather that would make the experience uncomfortable (e.g. heavy rain is one of the most statistically significant variables in [3]).

Different types of shared micromobility services have been studied and some of them were docked, sometimes even compared to dockless: for example, [3].

It is important to note, that socio-demographics are used by the relevant papers, where the only exception would be [26], where the mode switch does not suggest any integration and choice towards the shared bicycle is made due to other modes being unavailable (traffic congestion, lack of transport). Age (8/34), education (6/34), gender (7/34), income (5/34) and occupation (6/34) are the most commonly used socio-demographic variables, which might be due to their overall significance in the model and availability via public databases. In [3], [24] and [26] environmental concern is added as one of the factors affecting the use of shared micromobility services. It is not so commonly used among the reviewed papers, but might be an important driver, because environmental concern might be helpful in the mode shift for building up a sustainable society.

Discounts are mentioned only in the case study of Delft [11] which is trying to integrate shared bicycles into the transit system by merging payment systems and offering discounts for the joint use of the included modes.

As for one of the mostly aggregated variables, motivation, [11] gives quite an insight into some of the factors driving demand of the shared micromobility services, among which are: price (compared to other modes

LEVEL OF RESOLUTION

Value Name	Value Description	Paper Association
None	Without resolution (Modal Choice, e.g.)	1,2,3,4,7,8,9,11,12,18,22,24,26,27,34
Time	1 min	30,31,33
	15 min	5
	1 h	19
Space	Buffer … zone around some place is studied (hubs, docks, subway stations), also: - data within kernel density	1,15, 18
	Thiessen Polygons … zones (around subway stations,e.g.) are divided by thiessen polygons and data is aggregated according to its spatial position	16, 20
	Vector	29,6,10,13
	Square Grid	25(400 grids 3.5 square km),30 (1 square m),35 (1 square km),36 (around 200 square m)
	Hexagonal Grid	28, 32
	Raster	21
Space-Time	Space-Time Irregular Graph	14 (75m x 33m x 40.8 min)

Overall: The papers mostly do not have any resolution (neither spatial, nor temporal) due to the models representing rather preferences for the whole area(-s): this is true for 15 out of 34 reviewed articles.

Otherwise, the choice apparently depends on the available data and on the preferences/limitations (e.g. legal) of the researchers: as in [30], [31] and [33] 1 minute time resolution is chosen due to the data limitations (a record every minute), in [5] 15 minutes are chosen in order to avoid using faulty records, that are not actual rides.

As to spatial resolution, data is mainly split into zones and one of the most interesting solutions is to perform the separation into Thiessen polygons as in [16] and [20], which might catch the effect of the station more precisely. However, this might be also causing some issues, because areal partition might be affected by some other unobserved characteristics.

Sometimes choosing a grid is a necessary measure for data security, as in [28], where the major goal is to protect private data of the users by not disclosing exact coordinates and time, for instance.

As to [14], space-time irregular graph is believed to be the most exact solution for the result representation of the three-dimensional Wavelet Decomposition.

Probably the majority of papers does not have any resolution due to studying effect of variables in the model, which later allows to calculate a number of economic parameters and not depending so much on the spatial representation.

GEOGRAPHICAL STUDY AREA

Value Name	Value Description	Paper Association
the USA	New York City	1,2,9,16,20
	the City of Chicago	5, 32
	Fargo, North Dakota	7
	Minneapolis-Saint Paul	8, 18
	Indianapolis	22
	Austin, TX	28, 36
	Washington, DC	8,12,19,31
Canada	Montreal	8.34
	Toronto	8
	Hamilton, Ontario	15
PRC	Nanjing	27,29,35
	Hong Kong	30
	Beijing	3,10,14,25
	Tengzhou City	33
Singapore	Singapore	13
Australia	Melbourne & Brisbane	6
the Netherlands	Amsterdam	4
	Delft	11
Switzerland	Zurich&Berne	21
Spain	-	24

Overall: Out of 34 reviewed papers 17 are studying cities of the United States, 4 - Canada, 8 - People's Republic of China, 1 - Singapore, 6 - Australia, 2 - the Netherlands, 1 - Switzerland and 1 - Spain. Some of them are studying different countries (e.g. [8] - the US and Canadian cities).

It is difficult to estimate this dimension, as some of the papers have been found "in a chain": while one is a result of the search, the others are appearing as suggestions for further reading. Therefore, geographical are clusters might appear as the result of that. However, an interesting fact is, that in [8], [24] and [25] the authors are arguing about one-sided nature of the

INTEGRATION RESULTS

Value Name	Value Description	Paper Association
Complimentary … as transit feeders	Might be a last-/first-mile vehicle	8(for downtown, switch: bus->train),10,11,15(suggestion),16,20,21,25,27,28,29(the whole paper is estimating shared e-mobility in the area of subway stations),35,36
	Might fill in the gaps in the current network	24,25,27,32
	Theoretically it is better to use bike+PT	4
Competitive … shared micromobility services as a replacement to other modes (mainly PT)	It is **believed**, that people within reduced fare are less likely to use the bikesharing system, because those are either above 65 years old or the ones who have applied for reduced fare due to some disabilities	1
	Rather replaces than compliments/lower demand where transport accessibility is higher	3,5,6,8(for suburbs),19,24(to private vehicles), 25
Non-Significant		15(statistical result)

Overall: In total, there are 24 papers that are studying shared micromobility service integration to some extent. Out of those, in 1 [15] the variable for public transportation is found insignificant. In 9 articles it is revealed that the newly added mode is more of a competition to the current transit system, as this was of most concern for the researchers. One out of nine papers [1] seeing the negative effect is assuming that the impact of incents (reduced fare for PT) is extremely significant due to it being proposed to people who might find it difficult to use micromobility services because of either lack of knowledge or health restrictions. 18 out of 24 articles conclude that shared micromobility services would be complimentary to the current network with being a first-/last-mile solution in 14 articles and being able to fill in the existing gaps in the network (according to the authors of the papers, who are more familiar with the current situation in the area of study) in 4 papers. As it follows, some of the articles (3 in total: [8], [24] and [25]) are revealing the dual nature of the shared micromobility services and the old network.

In some cases, the differences between places have to be studied in order to understand processes caused by shared micromobility activities. As in [8] four cities of the North America are studied and some of them have a completely different mode change. For example, while in Washington, DC shared bicycles substituted shorter trips and, therefore, there appeared switch from train, in Minneapolis-Saint Paul, on the contrary, use of shared bicycles is causing an increase in the walk and train trip numbers by switch from either car or bus: 38% of people preferred to walk more (with a loss of 23%), 15% - to use rail (with a loss of 3%), 52% to drive less (with a gain of 0.3%) and 17% to use a bus less (with a gain of 15%). In [11] a higher number of commuter rail is also depicted, however, other public transportation modes happen to be neglected by the users. In that paper it is explained by the merge of the payment systems and relative proximity of destinations after reaching the main station.

Some of the articles are exploring the possibility of shared micromobility services being a nice substitution for motorised vehicles within the area of first-/last-mile modal choices. In [20] and [21] proximity to commuter rail and subway stations, respectively, generates more bicycle trips, although in the latter one it is the opposite during October and February due to the weather. In [10] the estimated model also supports this theory by the change in modal share after implementing the shared micromobility service; furthermore, this paper's results indicate that convenient location of the shared micromobility service may become a driver for switch towards more sustainable modes of transport. According to it, there is about a 10-20% negative change for car use as a first-/last-mile choice within people using car for those purposes once in one or two days with a proportionate growth within people using private bicycle 1-3 times/week and a drop of 15% within those who use it almost every day. Presence of subway station is positively correlated regardless other factors in [16]; it has some slight variations dependent on land use and socio-demographic variables being included.

In [25] it is also found that shared bicycles substitute the public transportation but generate more re-entries for trips less than 2km, thus being used in the transit chain as well as in the [28] (with 62% use decrease when being more than 1km away from the transit area), [31] and [27]. However, in the first one more trips are conducted within the 2-6km distance, therefore, shared bicycles contribute to sustainable development by increasing accessibility of places. In [27] it is preferred to use bicycle 1-2 times/week: the estimate in the model is 9.42.

It is also interesting, that in [15] shared bicycles as a first-mile trips are not a popular choice (the variable for proximity between PT and shared bicycles is statistically insignificant). Nevertheless, it is quite the opposite with the last-mile choice. As it is suggested by the authors, this might be happening due to the last part of the trip being more important in the perception of the travellers. Apparently, this is a situation happening in different places and with various shared micromobility services, because in [35] e-scooters are also preferred as rather a standalone or last-mile mean of transportation.

Some of the studies go further by claiming that micromobility services might be able to fill in the gaps in the current system. As in [24], for example, where according to the results of study some preliminary knowledge of similar modes (scooters and motorcycles, carsharing) would lead to use of e-scooter sharing (with those groups being 500% and 20%, respectively, more likely to ever use scooter-sharing). Otherwise scooter-sharing has some complimentary effects on pedestrian and bike mobility by the private motorised vehicle substitution. As to the date of study, there were no clear effects on the public transportation in urban areas of Spain. In [32] e-scooters are believed to be 55-66% (depending on the part of the city) competitive in the areas with parking constraints for the trips in range of 0.8-3.2km.

If the previous studies are mainly unraveling the positive or dual nature of integration of shared micromobility services and current modal chain, there are a few that are discovering the new mode of transport to be a competition to the others, i.e. to substitute from the other modes, which would mainly be walk, PT and cycling. An interesting research is being ran in [3]: both e-bikesharing and bikesharing are included in the model. According to the paper, due to probably different accessibility modes have different types of behaviour: while bikesharing is drawing people from unsheltered modes (walk, bike, bus), e-bikesharing has a significant positive utility of replacing bus links, however, it could contribute to increasing accessibility for people living far away from transit areas and, therefore, increase their quality of life through allowing them to get to work in better places. In [6] public transportation accessibility is affecting the shared bicycles use in a negative manner. For that case study of Melbourne and Brisbane shared bicycles are being a competitive mode of transport not a complimentary one. Another limitation that is difficult to overcome is the trip length for shared micromobility services: in [19] the number of trips is negatively affected by the number of subway stations, while their length remains within the same range.

Importance of well-developed infrastructure cannot be left without a notice as well: in two studies ([16] & [20]) conducted in the New York City the variable of bicycle lane is statistically significant indicating that lanes' proximity generates more shared bicycle trips. The same effect is observed in [36], where both bicycle lanes and bus stops are positively associated with both departure and arrival (lanes: 0.294 and 0.260, respectively; bus stops: 0.507 and 0.417, respectively) of electric scooters. In Nanjing [31] density of the network is also positively correlated with the bikeshare use.

Unfortunately, acceptance of the shared micromobility services as an element of the multimodal chain is not finished yet. Therefore, not many papers have been found, that would take into account incentives stimulating integration of the new service with the public transportation chain. However, in the Delft case study [11] it is suggested to use the same payment system and discounts for people using two transport modes, which results in a shift towards commuter rail and increases the number of bikeshare trips, as

CLARIFICATIONS

Paper Numeration

Title	Paper number
Sharing riders: How bikesharing impacts bus ridership in New York City	1
Predicting station-level hourly demand in a large-scale bikesharing network: A graph convolutional neural network approach	2
Factors influencing the choice of shared bicycles and shared electric bikes in Beijing	3
Characterisation of and reflections on the synergy of bicycles and public transport	4
Bike-sharing or taxi? Modeling the choices of travel mode in Chicago using machine learning	5
Barriers to bikesharing: an analysis from Melbourne and Brisbane	6
Bike share in Fargo, North Dakota: Keys to success and factors affecting ridership	7
Unraveling the modal impacts of bikesharing	8
Predicting bike sharing demand using recurrent neural networks	9
How Have Travelers Changed Mode Choices for First/Last Mile Trips after the Introduction of Bicycle-Sharing Systems: An Empirical Study in Beijing, China	10
Bike-sharing systems' impact on modal shift: A case study in Delft, the Netherlands	11
Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C.	12
Understanding spatio-temporal heterogeneity of bike-sharing and scooter-sharing mobility	13
Demand cycles and market segmentation in bicycle sharing	14
What factors influence bike share ridership? An investigation of Hamilton, Ontario's bike share hubs	15
Bikeshare trip generation in NY City	16
A Review on Bike-sharing: The Factors Affecting Bike-Sharing Demand	17
Modeling Bike Share Station Activity: Effects of Nearby Businesses and Jobs on Trips to and from Stations	18
The impact of weather conditions on bikeshare trips in Washington, DC	19
Bikesharing Trip Patterns in NY city: Associations with Land Use, Subways and Bicycle Lanes	20
Expanding a(n) (electric) bicycle-sharing system to a new city: Prediction of demand with spatial regression and random forests	21
Analysis of E-Scooter Trips and Their Temporal Usage Patterns	22
The drivers of demand for free-floating car-sharing	23
Exploring the adoption of moped scooter-sharing systems in Spanish urban areas	24
Competiotion and Cooperation between Shared Bicycles and Public Transit: A Case Study of Beijing	25
College Students' Shared Bicycle Use Behaviour Based on the NL Model and Factor Analysis	26
Mixed Logit Models for Travelers' Mode Shifting Considering Bike-Sharing	27
Understanding the Shared E-Scooter Travels in Austion, TX	28
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Considering user behavior in free-floating bike sharing system design: A data-informed spatial agent-based model	30
Urban mobility in the sharing economy A spatiotemporal comparison of Shared Mobility Services	31
E-Scooter Scenarios: Evaluating the Potential Mobility Benefits of Shared Dockless Scooters in Chicago	32
Analysis of Spatial and Temporal Characteristics of Citizens' Mobility Based on E-Bike GPS Trajectory Data in Tengzhou City, China	33
Shared micro-mobility patterns as measures of city similarity	34
Estimating Urban Shared-Bike Trips with Location-Based Social Networking Data	35
Spatial associations of dockless shared e-scooter usage	36

Colours Explained

Colour	Meaning
Black	Articles conserned about the integration
Red	Papers that have been discarded from further research due to being out of the scope
White	Reviewed papers that do not take into account integration