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Research paper

Price and competition in emerging shared e-scooter markets

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ABSTRACT

The rapid deployment of shared dockless electric scooters (e-scooters) has resulted in attention from the public and regulators. Recurring issues include fleet size and the number of operators in the market. In this paper we study market development in two Norwegian cities and discuss how these experiences point towards future e-scooter regulation and ask if market regulation based on price competition in the e-scooter market is plausible.

We study this by focusing on two natural experiments. First, we analyse the market entry of a low-cost e-scooter company in Drammen. We discuss how that entry impacted two incumbent e-scooter companies and the total market. Second, we look at the change in e-scooter regulation in Oslo in September 2021. This change represents a movement from a laissez faire market approach to a fleet cap of 8000 divided evenly between 12 different e-scooter companies. We study these experiments using data obtained from selected e-scooter operators (GPS location, start/stop time, e-scooter id), municipalities (fleet size, trips) and a web page tracking e-scooter fares. We find that competition between e-scooter companies varies across user segments, with trips made for traveling purposes being less price sensitive, and joy rides being more price sensitive. Also, we find that there are substantial advantages in being a large actor.

1. Introduction

E-scooters are an innovation combining pre-existing mobility technologies such as the kick-scooter, electric motor, Global Positioning System (GPS), geographic information systems (GIS), smartphone and digital hailing systems, in a new package. Since the first dockless e-scooter service was introduced by Bird in autumn 2017, they have rapidly gained popularity and use. E-scooters have contributed substantially to increased market share of shared micromobility (NACTO, 2020). E-scooters have rapidly been introduced to new cities, in many cases literally overnight (Fearnley, 2020). This has caused tensions with incumbent mobility services, city authorities and society at large. In Norway the first e-scooter services were introduced in May 2019 by VOI and TIER (Fearnley et al., 2020).

The introduction of e-scooters in Norway was made possible by a series of amendments to the transport act in 2018 (Ministry of Transport and Communication, 2018). This included classifying small electric vehicles as bicycles, provided that they complied with a few criteria including a maximum speed of 20 km/h. Given the bicycle regulation in Norway, this meant that e-scooters became legal to use on streets and pavements, in parks and pedestrian zones, by people of all ages, without helmet and without insurance.

To classify e-scooters as bicycles is not unique. However, the Norwegian bicycle regulations are relatively liberal compared with most countries. In contrast with the liberal Norwegian regulations are countries where e-scooters are, per definition, motor vehicles and, as such, illegal to use on public grounds, such as in the UK (GOV.UK, 2020b). Since July 2020, however, as part of their response to Covid-19, the UK Department for Transport opened the possibility for trials of shared e-scooters (GOV.UK, 2020a), in which cities were able to set all rules of the game from day one, but privately owned e-scooters remain illegal to use in public space(GOV.UK, 2022a; 2022b).

From a research perspective, the Norwegian regulatory situation is interesting in that shared e-scooters were introduced in an open and totally unregulated market. The companies were able to set fleet size and prices according to their own strategies and to local market situations rather than in response to a regulatory framework. This allows us to study the effect of market entry and of regulatory interventions in a series of natural experiments.

In this paper we focus on two empirical events: the entry of a new

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low-price e-scooter company in the city of Drammen, and the introduction of a strict fleet cap on shared e-scooter companies in Oslo, Norway's capital city, in September 2021.

1.1. Background

As e-scooters are a relatively new phenomenon, there has been limited research on the topic, much of which uses US cases. A reoccurring issue has been the call for regulation of e-scooters, or more precisely, for public policies to mitigate the negative externalities created with respect to safety, accessibility, and littering.

There are few studies on price and competition in these markets. In fact, and rather surprisingly, we are not aware of any empirical studies of pricing strategies and price sensitivity of demand – despite a wealth of anecdotal evidence and industry talks of relatively low price-elasticity of demand in higher income markets such as western European countries. User surveys including Fearnley et al. (2020); (2022), suggest that e-scooters are rarely chosen because they are the cheapest alternative: Their first survey found that only six percent of users chose e-scooter on their last trip because it was cheapest. This rose to 13 percent in their second survey (respondents could indicate up to three main reasons for choosing e-scooter on their last trip and were given a dozen response alternatives including an open text field). Still, about 60 percent of all e-scooter trips in Oslo would cost less than a single ticket on PT (Fearnley et al., 2022).

Despite an expected small price elasticity of demand, we know from other passenger transport markets like local PT that large price reductions, or free-fare policies, can boost patronage considerably. This can be exemplified by local PT, where the general rule is that demand has low price sensitivity of demand; see, e.g. Balcombe et al. (2004). Still, large price reductions can boost patronage considerably, when the initial modal share is low Fearnley (2013).

1.2. Case cities

The cities of Drammen and Oslo are both located in south-eastern Norway (map Fig. 1).

The estuary city of Drammen has about 102,000 inhabitants and is located approximately 40 km southwest of Oslo in Viken county. Its main geographical feature is the river Drammenselva which cuts through the city from west to east, and the port at the head of the Drammen fjord in the east end of the city. The city was the administrative centre of Buskerud county till 2020 when Buskerud was merged into Viken county. Drammen is connected to Oslo by rail and a motorway.

Oslo is the capital city of Norway with about 1,000,000 inhabitants, of which 700,000 live within the city limits. Oslo is located at the head of the Oslo fjord.

1.3. The developments in Drammen and Oslo

E-scooters were introduced in Drammen in July 2019 when one company commenced operation. In the beginning of 2021, shared e-scooter services were offered by two actors, both multinational. The services operated in an open market with little formal regulation. However, both companies had regular interaction with the municipal planning body in Drammen. This communication enabled the parties to address issues such as misplaced e-scooters and complaints. A new actor entered the market in June 2021. This actor complied with the established procedures but followed a different business model, and entered the market with very low prices.

In Oslo, e-scooters were introduced in May 2019 with VOI and TIER being the first actors (Fearnley et al., 2020). However, the number of companies, e-scooters and trips increased rapidly – on average a doubling every year. In the summer of 2021, they reached a total

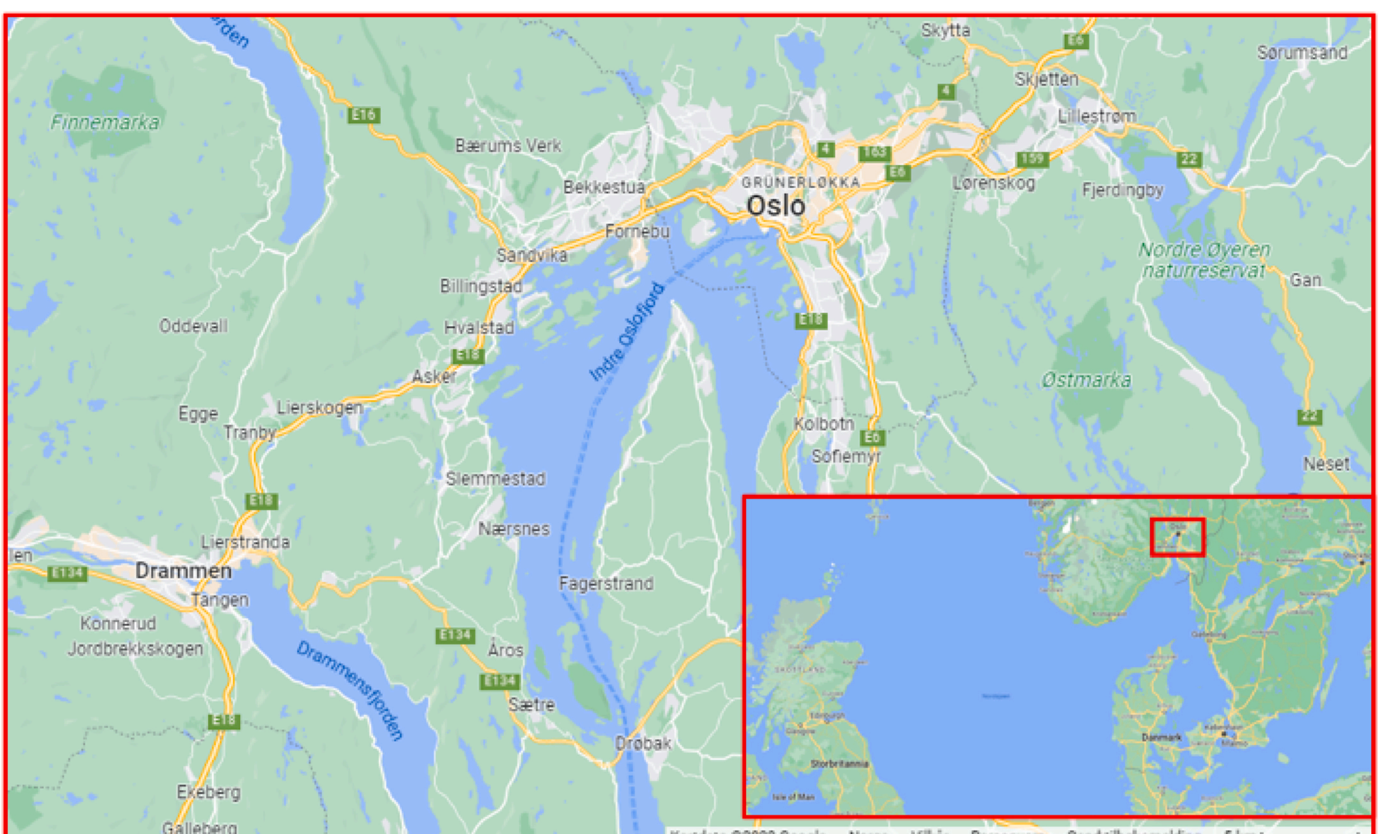

Fig. 1. Map location and key geographical features of Oslo and Drammen (Google Maps).

number of daily trips that was comparable to that of the tram system. Shared e-scooter supply exceeded 25,000 vehicles provided by eight e-scooter companies. This unchecked expansion lasted until a local regulation came into place in September 2021. The regulation prescribed a total fleet cap of 8000 vehicles, to be divided equally among all companies that were approved as service providers (Oslo, 2021). All qualified applicants were approved, and in total 12 companies were awarded a permit for 667 e-scooters each. They were free to decide on model and livery. Some companies chose to cooperate in operating their e-scooters. The permits were valid until March 31, 2022, when a new set of licenses were awarded.

Until the fleet cap regulation was introduced in Oslo September 2021, there were no formal regulations specific to e-scooters in either city. In Drammen there was active informal regulation through dialog, mainly related to parking and littering, whereas in Oslo not even this soft approach was the case. General regulations for bicycles, such as a requirement to be fit for riding (but not mentioning a specific alcohol limit), and to pass pedestrians at walking speed (not defined in km/h) when used on a pavement, were already in place. In 2021, there was no age limit for the use of e-scooters. Children could use them just like bicycles. All of these regulations were applied at the national level. However, e-scooter rental companies usually imposed a formal age limit of 18 years, and in a few instances, 16 years. These age limits were mainly justified because of payments by credit or debit cards. In the summer of 2022, a new legislation introduced a national age limit for e-scooters to 12 years. The same legislation imposed a helmet requirement for riders under the age of 15.

1.4. Impact of the Covid-19 pandemic

Norway was hit by the Covid-19 pandemic from March 2020. Broadly speaking, the chain of events in the case cities were as follows. In the early stages of the pandemic, there were heavy restrictions on movement. People were strongly advised to avoid commuting and discouraged from using PT. In Oslo the advice against PT use remained in force for much of 2020, and the use of masks was mandatory. In Drammen, which was less affected by the pandemic, more lenient policies were in place. In both cities, normal PT service levels were maintained throughout the pandemic. From spring 2021, all or most restrictions on commuting were removed, including the discouragement for using PT. However, people were encouraged to wear face masks on PT if there was crowding until summer 2021. Although Covid-19 restrictions were lenient in the time period used in this study, PT use was significantly lower than in 2019 in both cities (Ruter, 2021). In both cities, prices and availability of PT remained constant in the studied time-period (with some ordinary schedule changes in connection with school holidays).

2. Material and methods

Both the empirical analysis in Drammen and Oslo use trip observation data. The datasets used were compiled for the purposes of this study and were provided by e-scooter operators in Drammen and Oslo. The dataset includes the exact time and GPS-location for start and stop of each trip, time elapsed for each trip and other variables. The additional variables vary a bit between operators, but may include e-scooter ID, distance travelled, route followed and so on.

2.1. Drammen

For Drammen we have also used the monthly self-reporting sheets that the city requires e-scooter companies to submit. These include information on the actual number of vehicles available and the number of trips per day.

2.2. Oslo

For Oslo we have also had access to data from the e-scooter price monitoring website www.sparkesykkelpriser.no. Our data includes all the 22 updates from that webpage. The site was active from June 30, 2021 to April 05, 2022 and presented pricing information for single trips, day-passes, and monthly passes.

In addition to the quantitative data, we draw on interviews and informal talks with key actors through stakeholder meetings.

3. Theory

On the supply side, e-scooters have many parallels to ride-sourcing/transportation network companies (TNCs). This includes the fact that they are technology-enabled businesses that have software that communicates directly with the customer. Unlike ride-sourcing, e-scooter companies do not require a driver and are therefore less labour intensive and suffer less from issues relating to the gig-economy.[1] They are not immune to fluctuations in the labour market, but less affected than ride-sourcing. However, as stated by a number of representatives from the e-scooter companies, they did (and to some extend do) rely on venture capital financing.

The provision of e-scooters is a commercial activity. The industry is characterised by low fixed costs, limited possibility of differentiation of service, and initially at least, low barriers to entry. From conventional reasoning this should result in a conventional market with limited potential to make extraordinary profits. Any short-term profit will attract competition, which in turn will result in prices being pushed towards short run marginal costs and market instability (fluctuations in market entrants and prices). In the early periods e-scooter companies competed fiercely to become the largest operator and achieve economies of scale; this was amplified by extensive availability of venture capital (Button et al., 2020; Fearnley, 2020).

Price strategies are not only a question of demand responses and yield. As Button et al. (2020) point out, shared e-scooter markets resemble a large degree of contestability. Too high mark-ups of price over marginal costs would increase the risk of competitive entry. Therefore, supernormal profits from pricing well above marginal costs are hard to earn over longer periods of time. Using economic reasoning and open data from the US, Button et al. (2020) argue that, although they find the e-scooter markets fairly straight forward, in terms of being a commercial activity with low entry and exit costs and high levels of contestability, some empty core problems may exist, where revenue over time may fall below long-term costs, as the threat of entry removes any profits. They argue with parallels to ride-sourcing (Button, 2020) that there are fundamental issues with the e-scooter business model, such as environmental and safety concerns, and issues related to wider mobility policies, that the phenomenon is well suited to address current issues with city mobility in a good way.

Expanding further on the analogy with ride-sourcing and taxies, an expectation would be that e-scooter users have a substantial difference in their willingness to pay for the trip in question (Aarhaug & Olsen, 2018; Rose & Hensher, 2014). This means that we expect some market segments, in particular 'joyrides', to be more price sensitive, while trips for transport purposes to be less sensitive to price changes. This is because e-scooters are chosen when they offer a fast and convenient solution for the trip in question (Fearnley, 2022). In other words, they offer lower generalised costs.

Again with strong similarities to other transport modes, we expect to find strong economies of scale (or density) as demonstrated by Mohring (1972) for PT and Arnott (1996) for taxis. This implies that a larger

[1] While the early operations made extensive use of 'juicers' for the purpose of gathering, charging and deploying shared e-scooters, the current norm – at least in Norway – is to rely on subcontractors or inhouse management.

supply of e-scooters will increase the benefit for all users, as well as increased utilisation per e-scooter, stemming from increased availability.

From these lines of reasoning, we would expect that an actor entering the market with lower prices and extra e-scooters, would achieve higher utilisation rates, measured in trips per e-scooter per day, and longer trips, measured in minutes. That is, more joyrides (assumed to be more price elastic). However, this will have limited impact on the day-to-day travellers, as e-scooters are probably very competitive in terms of generalised cost, even without discounts in the Oslo case (Aarhaug et al., 2022). This contrasts the Portland case studied by McQueen and Clifton (2022), who find that the generalised costs of e-scooters are high compared with private car.

A fleet cap, as the one imposed in Oslo, reduces the number of e-scooters in a given network (organised by a particular operator) and, therefore, also reduces the attractiveness of shared e-scooters as a mode, both for joyrides and for trips made for traveling. The substantial reduction in supply following Oslo's September 10, 2021 regulation should, therefore, reduce the number of trips taken, both total and per e-scooter, according to the density effects. The pre-September 2021 situation was probably one in which open access resulted in more e-scooters than what was profitable for most operators in the long term. Therefore, the net effect on utilisation is uncertain. In line with the expectations in the taxi market, when supply is capped, we expect prices to rise until inter-modal price competition becomes a constraining factor, as there is no longer any intra-modal reasons for price competition. Consequently, there would be no market shares to be gained from reducing prices.

4. Results

4.1. Drammen

In Drammen, we use data from May 1, 2021 to September 30, 2021. Fig. 2 illustrates how many trips start or terminate within each 50-m hexagon in Drammen. The lighter the colour of the hexagon, the more trips are started or terminated in that area.

In the dataset, the trips seem to be well balanced, with little systematic difference between where trips started and ended. From the data we have had access to, there is no clear geographical differences between the e-scooter actors, although they have defined their geographical areas of operations independently. We observe (in Fig. 2) that there are lighter colours in the more central areas of the city, in particular, close to the main railway station. This means that most of the e-scooter activity is related to trips within, as well as to and from, the city centre. This is also shown to be the case in other cities.

During the period studied, the number of active operators in the city changed twice. Initially actor A operated alone. Then, on 19 May, actor B entered the market. In terms of number of e-scooters available, this market entry doubled supply (Fig. 3). Then, on 1 July, actor C entered the market.

Fig. 3 illustrates the number of e-scooters available on the streets of Drammen during the May–September 2021. It shows that the total number of e-scooters increased throughout the period. It also shows that all three actors are of roughly similar size, measured in e-scooters available per day. Actors A and B differ with respect to how they operate but they have charged similar and stable prices over the period, despite the market entries. For single trips all operators use the formula Fare $= P_1 + P_2(t)$, where P_1 is a fixed unlock charge and P_2 is a per minute charge. Acors A and B operated with tariffs that were stable and approximately $P_1 \approx €\ 1$ and $P_2 \approx €\ 0.25$ throughout our period. Actor C entered the market with a similar price structure but much lower costs with P_1 at or close to zero and $P_2 < €\ 0.1$. This means that the price for a 10-min trip with operators A or B would be about 3.5 times more expensive than with operator C (€3.50 vs. €1.00).

Our data shows that actor C experienced longer trips initially (Fig. 4) and a higher utilisation rate (Fig. 5).

Fig. 4 shows the relative average travel time between the actors (actor C/actors A + B). However, this changed as the prices converged towards the end of the period. After the school holidays (approx. 17 August) the distances travelled was approximately equal between A, B and C.

Fig. 5 shows that the lower prices of actor C correspond to higher number of trips per e-scooter per day, but also that actors A and B have been able to maintain their vehicle utilisation rates during the period. Together, Figs. 4 and 5 show that actor C initially attracted many trips which appear to be generated or induced rather than diverted from its competitors A and B. These were of longer duration than the trips made by users of actors A and B. However, the difference in utilisation rates

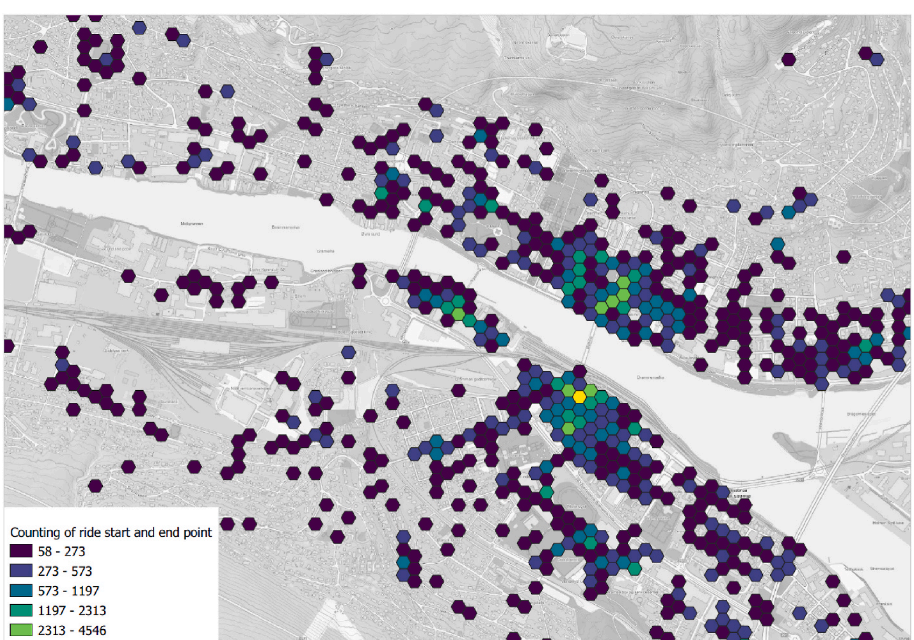

Fig. 2. Map of e-scooter activity in Drammen (sum origin and destination, operators).

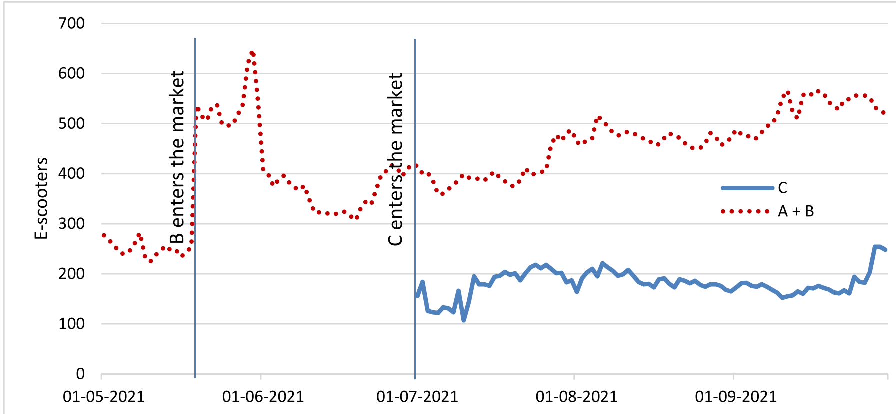

Fig. 3. Fleet size in Drammen (number of vehicles).

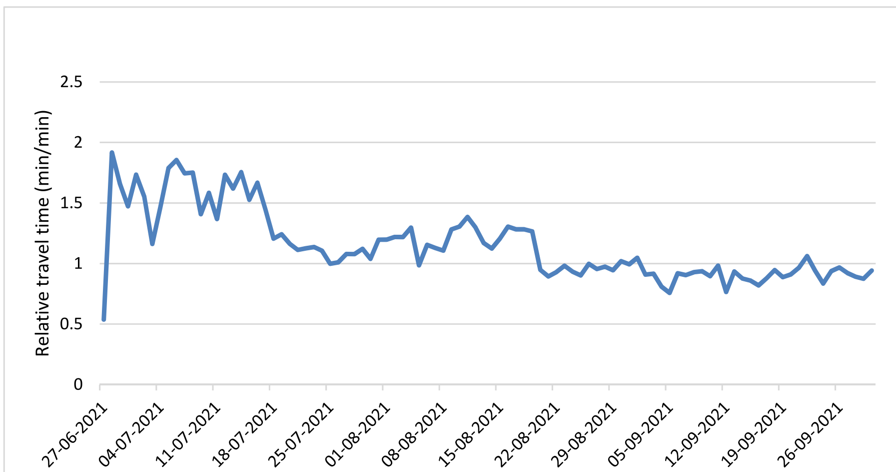

Fig. 4. Relative usage time ($\min_C/\min_{A\ \text{and}\ B}$, operators).

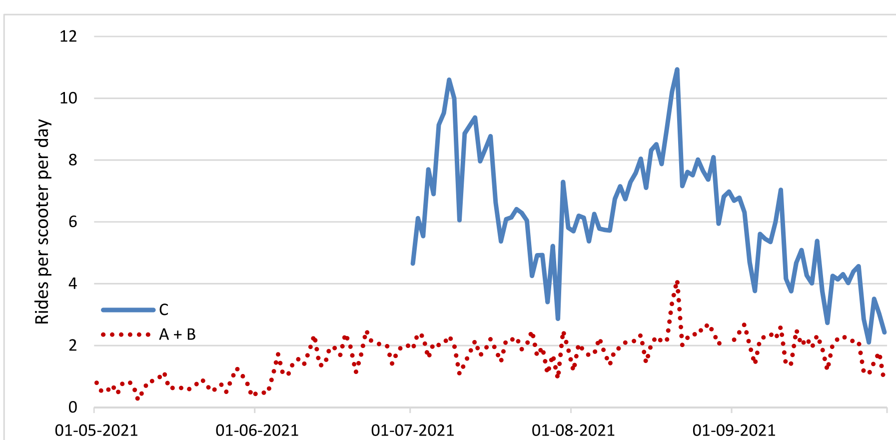

Fig. 5. Utilisation rates (trips per e-scooter per day, city).

decreases towards the end of the period. The apparent stable utilisation rates of actors A and B in the period when actor C entered the market may mask a loss as a growth in utilisation rates during the summer months would have been expected.

4.2. *Oslo*

For the Oslo case we have compiled a trip dataset for the period 1 August to October 31, 2021.

Fig. 6 shows that there was e-scooter activity within most of the densely populated area of Oslo. Highest density of use was in the central areas and, in particular, along the waterfront, in CBD areas with car

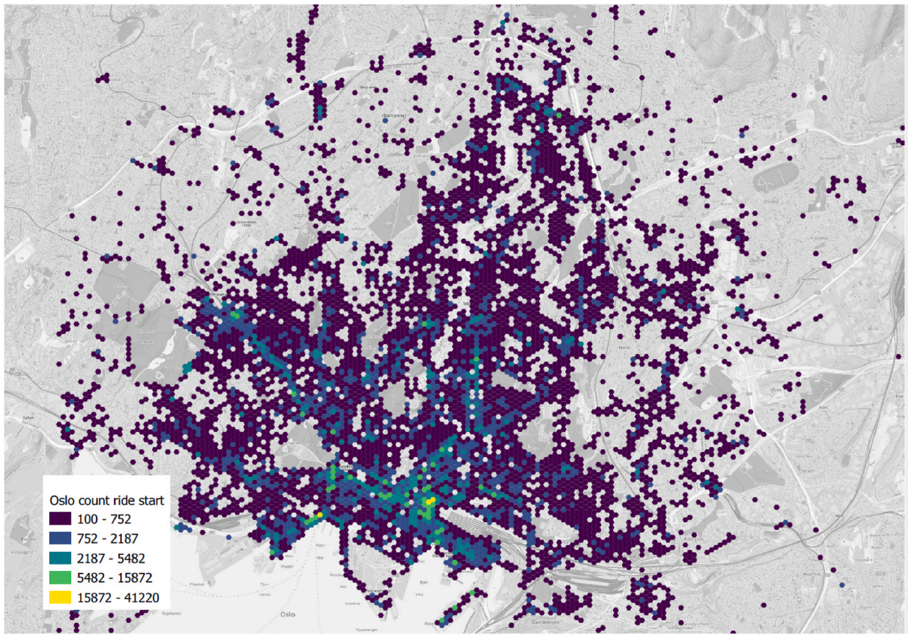

Fig. 6. Map of e-scooter activity in Oslo (start point, August 2021 eight operators).

restrictions, and areas close to PT hubs.

4.2.1. *E-scooter prices in Oslo*

As in the Drammen case, e-scooter fares in Oslo consist of a fixed unlock charge P_1 and a per minute charge P_2. Table 1 shows the price development for reference e-scooter trip. Based on the actual trip data, we have used a 10-min ordinary price trip as comparison.

Table 1 Shows that prices are remarkably stable over time, with one clear exception: Operator E. The prices of Operator E converge towards the other companies' prices around the policy change that happened September 10, 2021. The prices further converge in the period towards the second policy change on April 1, 2022.

When we decompose the prices, we find that P_1 varies between operators, but is mostly unchanged throughout the period. An exception is operator F, which changed its price mix (but the effect nulled out on our 10 min reference trip). Looking at the per minute charge P_2, we see, once again, large variation between operators (from NOK 0 to NOK 10) but consistency over time for each operator. An exception is company E, which changed their minute price from NOK 0.1 per minute to NOK 2.5 per minute.

In addition to single trips, e-scooter operators also offer multi-trip passes, typically valid for a day or a month. These passes allow the holder an unlimited number of trips, but each trip is typically capped on duration at, for example, 45 min. The prices for monthly passes were constant over the period in question, ranging from NOK 299 to NOK 400. There is some variation in the maximum duration of the included trips.

The price for day passes varies somewhat (Table 2). There is also some variation in terms of whether the companies offered the pass or not. However, the prices are relatively stable and increase a bit over the period.

4.2.2. *Fleet size and utilisation rates*

The September 10, 2021 regulation, which capped the total number

Table 1
E-scooter reference trip (10 min) prices in Oslo June 30, 2021 to April 5, 2022 (NOK). "X" means not in operation. (NOK10 ≈ €1).

	Operators								
	A	B	C	D	E	F	G	H	I
30.06.2021	35	35	35	35	1	30	x	x	x
02.07.2021	35	35	35	35	1	30	x	x	x
09.07.2021	35	35	35	35	1	30	x	x	x
14.07.2021	35	35	35	35	1	30	x	x	x
27.07.2021	35	35	35	35	5	30	30	x	x
30.07.2021	35	35	35	35	5	30	30	x	x
03.08.2021	35	35	35	35	5	30	30	x	x
19.08.2021	35	35	35	35	5	30	30	x	x
23.08.2021	35	35	35	35	5	30	30	x	x
02.09.2021	35	35	35	35	15	30	30	35	x
03.09.2021	35	35	35	35	20	30	30	35	x
10.09.2021	35	35	35	x	20	30	30	35	x
16.09.2021	35	35	35	x	20	30	30	35	30
28.09.2021	35	35	35	x	20	30	30	35	30
08.10.2021	35	40	35	x	20	30	30	35	30
19.10.2021	35	40	35	x	25	30	30	35	30
26.10.2021	35	40	35	x	25	30	30	35	30
18.11.2021	35	40	35	x	25	30	x	35	30

Table 2
Prices for day passes in Oslo, June 30, 2021 to April 5, 2022. "X" means not available. NOKs (NOK10 ≈ €1).

	Operators							
	A	B	C	D	E	F	G	H
June 30, 2021	69	99	35	45	45	35	x	x
July 02, 2021	59	99	35	35	45	35	x	x
July 09, 2021	59	99	35	35	45	35	x	x
July 14, 2021	59	99	35	35	49	35	x	x
27.07.2021	59	99	35	35	49	35	60	x
30.07.2021	59	99	35	35	49	35	60	x
03.08.2021	59	99	35	35	49	35	60	x
19.08.2021	59	99	35	35	49	35	20	x
23.08.2021	59	99	35	35	49	35	20	x
02.09.2021	59	99	35	35	49	35	20	x
03.09.2021	59	99	35	35	49	35	20	x
10.09.2021	59	99	49	49	49	35	20	59
16.09.2021	59	99	49	49	x	35	20	59
16.09.2021	59	99	49	49	x	35	20	59
28.09.2021	59	99	49	49	x	59	20	59
08.10.2021	59	x	49	49	x	59	20	59
19.10.2021	79	x	49	49	x	59	20	59
26.10.2021	79	x	49	49	x	59	20	59
18.11.2021	79	x	49	49	x	59	x	59

of e-scooters in the city, and thereby, also the number of vehicles allocated to each operator, had an immediate and dramatic effect on the e-scooter market (Fig. 7).

Fig. 7 shows that the total number of rides from the three operators in this dataset decreased from approximately 30,000 rides per day, to between 5000 and 10,000 rides per day. Some of this reduction, from August to October, would be expected from weather change; there are also fewer bicycle trips in autumn and winter (Lunke et al., 2018). Also, the city of Drammen, which has the same weather as Oslo, did not experience a similar drop in use during the same time period. Further, only two of the actors increased their prices for day passes at that point in time. There was no change in the cost of the reference trip. We, therefore, assume that the drop in use is a result of the regulatory intervention and not changes in price or the outside factor of weather. The number of e-scooters operated by these companies was reduced from around 7–8000 to 2000. Some of this reduction took place in the week preceding the regulation. Interestingly, the utilisation rate (trips per e-scooter per day) increased from about four trips per e-scooter per day in August (prior to the regulation), to eight per day in mid-September (immediately after the regulation). Utilisation then dropped back to between four and five per day in October.

5. Discussion

Our data from two city cases have illustrated some notable aspects of the market for shared e-scooters.

First, from the outset, one would have expected that e-scooters from different companies are extremely close substitutes, considering that, apart from branding, different companies' e-scooters are essentially identical. Interviews show that they regularly buy the same model from the same factory. Therefore, cross elasticities between different e-scooter companies should be high. A small price advantage in one company should cause a considerable shift in demand between the two operators. This assumption is parallel to what is observed in local PT demand. Demand for a particular ticket type is generally much more elastic than aggregate demand, or to put it more formally, conditional price elasticities (i.e. when all prices change by the same proportion) are much lower than unconditional elasticities (when only one price, e.g. the single ticket, changes))(Fearnley et al., 2018).

However, we have observed very different demand patterns in our data. In Drammen, a radical price reduction from one entrant gave a big boost to aggregate demand. Interestingly, it did not appear to reduce demand for the other operators, whose usage rates remained largely unaffected and whose prices also remained surprisingly steady despite being challenged by an apparently aggressive market entry. These observations suggest that the two incumbent operators did not consider price to be the main source of competition. This observation suggests that other factors are more important.

Besides price, the most obvious factor for choosing e-scooters is availability, which indeed has been the most visible element of competition in Norwegian cities: The battle to become the largest and, therefore, most easily available and attractive operator caused Oslo to be the European city with the highest e-scooter offer per capita during summer 2021 (Fluctuo, 2021). Another, maybe less obvious factor is customer loyalty. The most successful e-scooter companies in Norway have spent much effort to gain and keep customers through active branding and numerous marketing campaigns. There may also be a case of "app inertia", where there is time and mental costs associated with downloading and getting familiar with new apps.

The development in the city of Drammen is not disproved by events in Oslo. Rather it is supported. In fact, the experience from Oslo suggests that a lower price results in no major lasting competitive advantage; it may well have been perceived as a marketing campaign. As a result, prices between operators converge towards the higher prices in the observed price range. There are some signs in Oslo that companies experiment with different prices, but the overall impression is that it happens to a very limited extent, and with very limited effects in the market. Still, in the unregulated situation in Oslo, there were much larger variations in fleet size compared to Drammen.

Second, in line with expectations, the size of the fleet matters. When the number of e-scooters available for any given operator was capped, it initially resulted in increased utilisation rates. This subsequently dropped to similar levels as in the unregulated market following a drop in demand. This means that the elasticity of demand with respect to supply in this case is close to 1. Demand appears to be dependent on both aggregate and operator specific fleet size. The larger the fleet, the higher demand. This is again supported by our comparison of the two cities. The number of e-scooter trips in Drammen increased steadily as the fleets of the conventionally priced actors increased. Their utilisation rates remained more or less constant over time.

When all fleets were of equal size in Oslo, there were little or no incentives for the operators to attempt to compete on price. Communication with the operators suggests that they chose to remain in the market in expectation of a new regulations in 2022. The new regulation

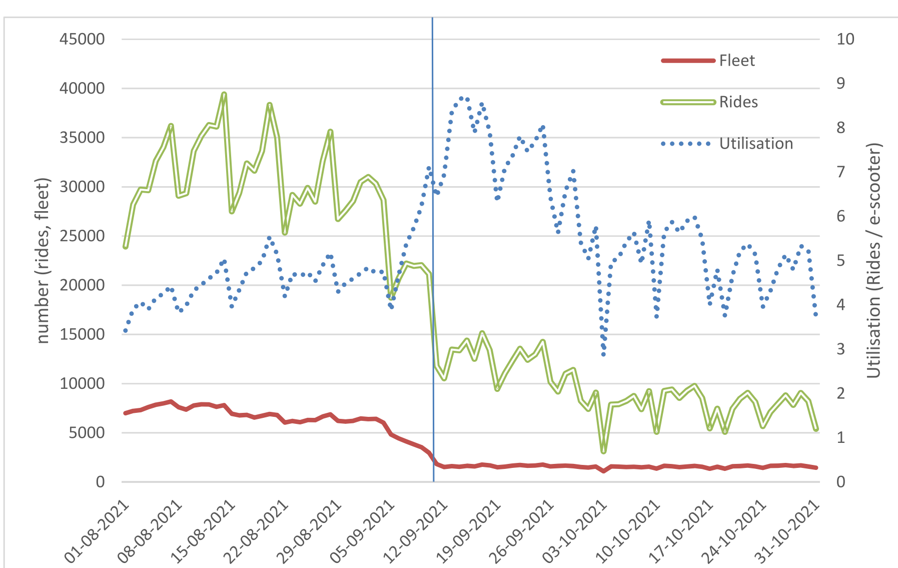

Fig. 7. Rides, fleet size (unique e-scooters per day) and utilisation (righthand axis) (sum three operators).

from 2022 kept the aggregate number of e-scooters unchanged at 8000 for the city but limited the number of operators to three such that each could provide up to 2667 e-scooters.

In addition to the effects of price and fleet size, there are seasonal variations in the use of e-scooters. Broadly speaking, they follow similar patterns to what is observed in cycling (Lunke et al., 2018), with higher use in spring, summer and autumn and lower in winter. Comparing the drop in use between summer and winter in the two case cities in 2021, the pattern however is slightly different from expectations. The drop in use in Drammen is observed when the school year starts in the middle of August. Here utilisation rates drop, while the fleet sizes remain constant. Contrastingly, we observe the drop in aggregate use in Oslo between 1 September and 10 September (when the fleet cap came into force), which was followed by increased utilisation rates. Our explanation is that the fleets shrank following the regulation, demand lagged, and resulted in higher utilisation rates. Ultimately, utilisation rates dropped and reached pre capping levels in middle to late October. We suggest that this drop is either a result of seasonal variance or a time lag in the demand response to the reduction of fleet sizes.

A particular issue in Norway is that the current legal framework (Ministry of Transport and Communication, 2021) bans public right of way fees in excess of direct cost associated with regulation. This prevents a Coase (1960) approach by preventing the cities from including negative externalities (including land use) in the fees they charge operators. As there is little observed evidence of price competition and the regulations in force from 2022 restrict market entry, there is clearly a risk of regulatory capture. A few operators may end up as private oligopolies with extraordinary profits that would not be obtainable in an open entry market. Such profits are induced by regulation (entry regulation) which operators inside the market are likely to defend scrupulously. We suggest that the current national regulation which prevents the inclusion of negative e xternalities in the fees charged by the cities to be reconsidered.

6. Conclusion

From our data, we find some, but limited, evidence of intra-modal price competition. The market shares gained from reducing prices seem to mostly consist of joyrides and induced demand. The short-term gain from aggressive pricing is not offset by increased market shares when the prices are increased to a cost covering level. There is, however, probably a scope for intermodal competition on price, in particular vis-à-vis walking and PT.

The regulatory reform in Oslo in September 2021 strongly suggests that the size of the fleet of an individual operator is relevant for the attractiveness of e-scooters as a mode.

We observe a strong network effect, where search costs or waiting constitute a substantial amount of the generalised cost of a trip (Arnott, 1996; Mohring, 1972). Too few e-scooters per operator, therefore, results in e-scooter operation being inefficient and unattractive. Together, this suggests that a regulatory solution should include few and relatively large operators in the e-scooter market (Fearnley, 2020). Experience form Oslo supports this.

The limitations of this study include the time period covered by the data during the late pandemic early stages afterwards. Even though there were no official policies that discouraged mobility or the use of PT at the time (Ruter, 2021), it is likely that concerns about the virus still influenced the behavior of some users.

CRediT authorship contribution statement

Jørgen Aarhaug: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Project administration, Funding acquisition. **Nils Fearnley:** Conceptualization, Investigation, Writing – original draft, Funding acquisition. **Knut Johannes Liland Hartveit:** Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Espen Johnsson:** Formal analysis, Investigation, Visualization.

Declaration of competing interest

None.

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