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Economic regulation and E-scooter networks in the USA

Kenneth Button, Hailey Frye, David Reaves

Schar School of Policy and Government, George Mason University, USA

ARTICLE INFO

JEL codes:
L91
L98
R40
R41
R48

Keywords:
E-scooters
Sharing economy
Economic regulation
Technical externalities
Economic core
Gig-economy
Nudging
Disruptive innovations

ABSTRACT

This paper looks at the challenges in the economic regulation of stand-up electronic scooters, or “e-scooters”. The e-scooter represents one of several innovative modes that have emerged to cater to transportation needs in urban areas. They provide connectivity linking local origins and destinations, as well as interconnectivity linking urban locations to inter-urban networks. These vehicles are marketed as a micro form of public transportation designed to meet the needs of fit and able people wishing to make trips of two miles or less. They are sought as part of “micromobility” complementing existing transportation networks. This paper reviews the gray and limited academic economic literature looking at the viability and economics of e-scooters within the context of the regulatory environment in which they operate in US cities. It considers the ways regulatory structures are evolving as the authorities learn of the attributes and limitations of the mode. In doing this, the paper also makes comparisons with some of the other “novel” forms of local transportation that have emerged, including those offered by transportation network companies. The paper focuses on the pre-Covid-19 period.

1. Introduction

While the professional journals and the informed press have invested a lot of time looking at the economic prospects and implications of e-scooters, the study of the mode in the core economic journals has been piecemeal and mainly of the case-study variety. This is not surprising, the introduction of this micromobility mode is recent, although the speed of its uptake has been exponential in many places. Urban regulatory authorities, partly because of the novelty of e-scooters, but also because of the way companies have introduced their services, have been slow to react to their arrival. In fact, regulators have often been chasing events rather than leading with proactive policies. The implications of this are that there has been little time for academics to collect and analyze time series data, or for journals to go through full refereeing processes and to publish. The Covid pandemic has, however, introduced a sea-change to the urban transportation market offering an ideal opportunity for a consolidation of what we do know.

This paper pulls together the insights that have been obtained regarding the economics of e-scooter markets. It also considers the political-economy of the regulatory approaches urban authorities in the US have adopted to steer the market in e-scooters. To do this, it sets out an economic framework making use of both what is to be found in the mainstream academic journals (often parochially called “the literature”) and in the “gray literature” (reports, professional journals, serious newspapers, Web contributions, etc.). It outlines and critiques some of the ideas that have been advanced regarding the types of markets e-scooters serve and the managerial economic models that suppliers have sought to adopt. This then forms a basis for considering the economic rationale for market interventions, the forms these interventions have taken, and, where possible, their short-run outcomes.

* The authors would like to acknowledge the extremely useful comments offered by the journal’s referees. These added considerably to the content and structure of the final paper, although the final responsibility lies with the authors.

* Corresponding author. University Professor, Schar School of Policy and Government George Mason University (MSN 3B1), 3351 Fairfax Drive, Arlington, VA 22201, USA.

E-mail address: kbutton@gmu.edu (K. Button).

1 E-scooters should not be confused with small, electric motorbikes on which the rider sits and are also sometimes called electric scooters. Stand-up electric scooters, or e-scooters, look like children’s scooters but powered by small engines.

2 There is no agreed definition of micromobility. It is generally seen as embracing a mode of transportation that can occupy space alongside bicycles. The mode is suitable for dedicated bike lanes and roadside areas used by bicyclists travel but unsuitable for sidewalks.

https://doi.org/10.1016/j.retrec.2020.100973

Received 12 April 2020; Received in revised form 26 July 2020; Accepted 21 September 2020
Available online 9 October 2020

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As noted, a variety of sources are used that extend beyond the narrower confines of most of the contemporary economic literature. Lack of traditional refereeing and incomplete reporting suggests that much of the material found, for example, on the Web and in some professional journals has been less rigorously assessed than that in peer reviewed academic articles or official reports. In many cases there is also advocacy. It does, however, provide insights and, as Robert Shiller (2017) points out in his presidential address to the American Economic Association, often contributes to the narratives that influence economic policy makers.

The approach adopted is also largely inductive in its orientation. It is a piece of what Stanley Jevons (1871), generally considered the founder of modern mathematical economics, would call in a non-derogatory way, “descriptive economics”. It begins by looking at the general nature of the e-scooter product and fits this into the wider transportation arena. Given the lack of technical work to date, the “fitting” involves a considerable application of argumentum ad absurdum to be allow dismissal of less reasonable arguments. It moves to consider, adopting Harvey Leibenstein’s (1979; 1987) terminology, the micro-economic behavior of those who have been supplying e-scooter services. Without knowledge of their motivations, and the business environments in which they operate, it is difficult to understand the implications of economic regulations when imposed on e-scooter companies. Essentially, this material highlights the raison d’être for public policy interventions. Matters of economic regulation are then considered in terms of their deployment to limit negative externalities, and for ensuring a stable supply to meet the expectations of users of their services – “transaction-cost regulation”. The implications, as far as possible, of the various regulatory actions are then assessed.

To put the paper into a contemporary context, the Covid-19 pandemic from early 2020 has clearly affected the e-scooter market. The availability of e-scooters has been reduced considerably to avoid contagion being spread across multiple users. In some cities, they have been banned for the duration of the pandemic. The shift to working at home in much of the service sector has, at the same time, reduced demand in one of scooters’ major market segments. One quantification of the Covid-effect is seen in an analysis of credit card data by Leatherby and Gelles (2020). This shows spending on scooter rentals in New York has since the outbreak of Covid-19 fallen the most of all transportation modes - by nearly 100 percent. The analysis here, however, looks at the scooter market prior to March 2020 focusing on its fundament nature and its underlying structure. There is minimal speculation concerning what the post-pandemic situation will look like.

2. The demand-side of the market

The market in the US for innovative modes supporting short-distance trip making has grown with increases in urbanization and its associated traffic congestion. Constraints on parking, limitations of conventional public transportation systems and taxes, and changes in location patterns, demographics, and employment structures in cities have provided a complex web of economic forces behind this. While the advent of App-based ride-hailing services such as Uber and Lyft have been important in satisfying part of this demand, shorter-trips have not been effectively catered for.

This is not to say that there have been no attempts by individuals or commercial suppliers to offer greater very-short trip mobility. Recent history has seen fads such as roller-skating, rollerblading, and skateboarding, but they have been limited in their up-take. Viable new commercially driven micromobility options for coordinating local trips began with short-term rental of bicycles; first in Copenhagen in 1995 but then spreading to Washington, DC and other US cities (Fishman et al., 2013). By 2016 there were 42,000 shared bicycles across the US enjoying a considerable amount of public investment. In 2000, Razor USA produced a collapsible manual kick-scooter targeted for adults and short-distance commutes. While the early versions did not meet market expectations, they did familiarize people with scooters, and were popular with the younger generation (Kostrzewska & Macirowski, 2017).

In the broader context, at about this time there was a lot written regarding the subject of the “sharing” economy and e-scooters are sometimes cited as part of this; indeed, the moniker “shared-scooters” is often used (e.g., Manfredi, 2018). The term sharing economy has generally been seen as descriptive of economic transactions involving on-line activities. But perhaps of more utility, is the idea that a sharing economy is an economic model involving acquiring, providing or sharing access to goods and services that are facilitated by a community and based on an on-line platform (Hämari et al., 2016). Uber, and other transportation network company (TNCs), were early movers into this sort of market. And indeed, some early entrepreneurs in the e-scooter industry, such as Travis VanderZanden who had been an executive at Uber and Lyft, had experiences with TNCs, and others moved into the scooter business later, including David Richter from Uber to Lime. But dockless bicycles and e-scooters differ somewhat from the TNC model. The vehicles are owned by companies that also “fuel” and maintain them as well as setting the prices users pay.

A key development occurred in 2013 when dockless bicycle sharing was offered by Jump. Dockless bicycles use smartphone Apps and GPS trackers creating the ability to rent a bicycle and leave it virtually anywhere in a city. Low initial and operating expenses, combined with local authority financial support in some cities, made the mode convenient and economical for customers. Dockless systems and alternate forms of payment also allowed for increased access to more impoverished communities expanding the potential market size for suppliers as well as meeting social needs. The arrival of the e-scooter soon followed and quickly superseded the dockless bicycle in many places (Clow, 2019). The notion sometimes expressed that scooters were a disruption innovation, however, overstates the situation. They were more evolutionary and did not move into a market abandoned by other existing products as Bower and Christensen (1995) categorization of disruptive innovation requires.

Bird, a company based in Santa Monica, California, first deployed e-scooters in 2017. In a year, the company expanded to over 100 US and 11 international cities and supplied over 10 million rides. Spin based in San Francisco started as a bike-share business and began to switch to e-scooters when Ford Motor Company purchased it for nearly $100 million in 2018. Another large US company in e-scooters is Lime, also based in San Francisco, that started as a bicycle-sharing business before expanding into e-scooters in 2018. By early 2020, Lime was doing business in over 100 cities in the US along with 27 international cities. It

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5 From a practical perspective, referencing to Web-sites often does not conform to the Harvard citation method. In such cases, the sites are provided as footnotes. More conventional Harvard style citing is deployed for academic sources.

6 Declines in other cities are also severe although some cities like Denver, Tampa, and San Francisco have classified e-scooter businesses as essential, and Portland announced a deal with Spin, in which it would temporarily waive daily scooter fees of $0.20 per unit and $0.25 per trip in exchange for Spin reducing the cost for a ride by 50% (https://www.theverge.com/2020/5/13/ 21257307/electric-scooter-bikeshare-covid-19-bird-lime-uber-subsidies).

7 In May 2020, for example, Uber sold its dockless bicycle business to Lime, a major e-scooter company, with the result that thousands of bikes were destroyed (https://www.bbc.co.uk/news/technology-52832791).

8 https://www.theverge.com/2018/9/20/17878676/electric-scooter-bird-lime-uber-.
had accumulated over 11.5 million rides. Table 1 provides some indication of the rapid growth in e-scooter provision in the US looking at a number of cities of various sizes and urban forms.

Originally, the operators mainly used off-the-shelf e-scooters being sold retail. As the e-scooter companies expanded they developed purpose-built models. These are more robust, provide easier maintenance, have longer ranges, are more stable, and offer improved features of scooters, but also the elasticity of demand for its use and its wider acceptance.12

3. The supplying industry

Unlike TNC products, the user of an e-scooter also serves as driver. Uber, Lyft, and other TNCs provide a coordinating function between those individuals that have transportation and driver services they wish to hire out and those individuals who are seeking a ride.13 E-scooter providers have a different coordination function. E-scooter companies have the hardware and they coordinate directly with the customer who then provides the labor of a driver. This latter structure removes from the scooter companies both the costs of finding and then managing labor, but adds the direct responsibility of having to supply and maintain the scooters. In both the TNC and scooter cases the company provides the coordinating information software. In practice, one of the major challenges for TNCs is the finding and retention of drivers (Button, 2020). E-scooter companies’ main labor challenge, in contrast, is to find chargers. A problem of an entirely different order of magnitude in the very short term.14

In these senses, e-scooter companies are close to the broader access economy concept whereby goods and services are traded based on access rather than ownership (Bardhi & Eckhardt, 2012). Essentially, suppliers rent “things” temporarily rather than selling them permanently. There is nothing new in this, the underlying business model is used across countless everything from rental markets for wedding tuxedos, carpet cleaners, to private jets. The e-scooter market is distinguished in terms of ease of market access and the ability of users to leave cooters at any location. But these characteristics are matters of degree rather than rigid parameters.

In terms of market structure, the provision of shared e-scooters in the US is a commercial activity – there are no subsidies – involving a highly competitive, although imperfect market. It is an industry that has very few fixed costs where investments can get stranded. The mobility of the hardware, the scooters, together with their relatively low-unit costs, makes entry and exit to various markets relatively easy. The prices charged users and the nature of the services offered are transparent. There may be some first-mover advantages because of the need for drivers to process the appropriate App, but Apps are easily obtained, and their use is universal across any individual e-scooter’s network. Although there is no analytical work on the subject, there would also seem to be a degree of contestability in the market involving potential competition. The openness of the scooter market likely means that incumbent companies (even when this involves a monopoly) are limited in the prices they can charge by the fear of new entry and their relative inability to fend off new entrants. They, therefore, lack the power to earn supernormal profits (Baumol et al., 1982).

But having said this, there are some sunk costs, and scooter markets are not perfectly contestable. There are, in fact, technical features of the e-scooter market suggesting empty core problems may exist (Edgeworth, 1881).15 These occur when competition is so intense that suppliers

9 https://www.wired.com/story/lime-scooter-gen3-design/.
10 https://www.ridefatdaddy.com/the-economic-impact-from-electric-scooter-sharing/.
11 Although often not welcomed, e-scooters provide mobility on many campuses. Within a month of banning them on its Tempe campus, Arizona State University collected nearly $80,000 in impound fees for 888 e-scooter. Bird paid $61,000 and Lime, $10,225.
12 Gaining policy relevant information on scooters was not easy. Hollingsworth et al. (2019) demonstrate some of the challenges of estimating the environmental implications in a Monte Carlo simulation, life-cycle assessment. Weiss et al. (2015) offer a more general framework including the impacts of technology development on the price of e-scooters.
13 Originally Uber was marketed as providing a service facilitating better utilization of personal automobiles and to take traffic off roads. It is now seen more as a commercial platform with many of the drivers engaged using the platform full time (Button, 2020).
14 Just prior to the onset of the Covid-19 pandemic, Lime began to experiment in Paris with swappable batteries to add flexibility to its labor cost function.
15 There are arguments that empty cores are a serious market failure in the supply of other forms of transportation; e.g. the scheduled airline (Button, 1996) and scheduled merchant shipping (Pirrong, 1992).
continually enter and leave the market resulting in uncertainty for potential users of scooters. If an incumbent operator makes any degree of short-run profit, this will attract competition. The increase in competition will then push prices down to short-run marginal costs and some suppliers will be forced to leave the market. The cycle then repeats itself. If an incumbent operator makes any degree of short-run profit, this will attract competition. The increase in competition will then push prices down to short-run marginal costs and some suppliers will be forced to leave the market. The cycle then repeats itself.

Putting this into a more dynamic context, in the longer term many products’ life cycles involve continually adapting technology or modifying business models to extend the life of the product. Suppliers seek to increase the temporal durability of a market, even in the face of competition, by pushing out their growth paths. Taking Kelvin Lancaster’s (1966) economic framework, by changing the package of product attributes it offers, a supplier can enter new markets or defend existing markets. This sort of outreaching and updating, for example, has been a clear strategy with Uber (and some other TNCs) with its spreading out from UberCAB, virtually a limousine service, to UberX, a basic App-hailing service, to UberPOOL, a shared App-hailing service, to UberEAT, an App-based food delivery service, and so on. E-scooters, on the other hand, would seem to have little scope for morphing and providing a range of diverse services. They may be safer, easier to drive, and so on but in the end, they are simply carriers of a stand-up rider, and so on but in the end, they are simply carriers of a stand-up rider, provider of a range of diverse services. They may be safer, easier to drive, and so on but in the end, they are simply carriers of a stand-up rider, provider of a range of diverse services. They may be safer, easier to drive, and so on but in the end, they are simply carriers of a stand-up rider,

16 From a slightly different theoretical perspective, the situation is similar to that where Bain’s (1949) limit pricing proves ineffective in cost recovery.

17 This is essentially second-degree price differentiation or product versioning. It involves creating slightly different products, a vertical product line, for the purpose of price differentiation (Phillips, 2005).

### Table 1
Selected US electric scooter markets (Spring 2019).

| City          | Business license | Allows city ordinance | Safety requirements/restrictions | Population | Density (sq. miles) | Typical user | alternatives | Services offered | Competitors | Year arrived | Scale (scooters) |
|--------------|------------------|-----------------------|---------------------------------|------------|---------------------|--------------|-------------|------------------|-------------|--------------|------------------|
| Washington D.C. | Permits         | Yes                   | 18 years old                     | 693,972    | 10,528              | Local commuters | E-bike; bus; train; metro; taxi | App based; GSP enabled; 15 mph; lithium battery | Skip, Spin, Bird, Lime Ridecell, HOPR/ Cyclehop, Jump, Skip, Wind, VeoRide, Razor, Riide and Lyft | 2017         | 600 per company |
| New York City | Not enforced     | No                    | Helmet; 18; 18 years old.        | 8.62 million | 27,000              | Local commuters | E-bike; bus; train; metro; trains; taxi | App based; GSP enabled; 15 mph; lithium battery | Bird         | 2018 (Currently not legal) |
| San Francisco | Permits         | Yes                   | Helmet; 18 years old; not block/obstruct; photo at end of trip. | 884,363    | 18,860              | Local commuters | E-bike; bus; train; light rail; cable cars; taxi | App based; GSP enabled; 15 mph; lithium battery | Skip, Scoot | 2018         | 625 per company |
| St. Louis     | Permits         | Yes                   | Helmet; 18 years old; barred from sidewalks | 308,626    | 4986                | Local commuters | E-bike; bus; train; metro; taxi | GSP enabled; 15 mph; lithium battery | Lime, Bird  | 2018         | Over 2000        |
| Baltimore     | Permits         | Yes                   | Helmet; 18; 18 years old; barred from sidewalks; driver’s license | 611,648    | 7556                | Local commuters | E-bike; bus; train; metro; taxi | GSP enabled; 15 mph; lithium battery | Bird        | 2018         | 60               |

Sources: Washington DC: https://dc.curbed.com/2018/8/31/17806012/dc-dockless-bikes-scooters-lime-pilot-program; San Francisco: https://abc7news.com/society/electric-scooter-dos-and-donts-in-san-francisco/4491522; https://www.cnbc.com/2018/08/30/san-francisco-denies-scooter-permits-to-big-players-picks-scoot-skip.html; Baltimore: https://www.bizjournals.com/baltimore/news/2018/06/28/bird-brings-fleet-of-rentable-electric-scooters-to-baltimore.html; New York: https://nypost.com/2019/01/26/push-to-make-e-scooters-legal-in-nyc-despite-safety-concerns/;
is an inevitable degree of commercial confidentiality surrounding the overall costs and revenues associated with providing scooters services. The novelty of the product also inevitably means that there is trial-and-error in the way businesses have approached the market. Some general patterns though do seem to have emerged.

Most US e-scooter firms, when start-ups, were located in major cities, with some such as Bolt, which started as a taxi platform in Estonia, and Lime which first offered conventional bicycles, emerging from other transportation ventures. Expansion, which was rapid for the main companies, came with support from a number of financial sources. Several scooter companies as a result, quickly become categorized as “unicorns” – privately held startup companies with valuation of over $1 billion. The motivation for investors, besides simple rent seeking, was often associated with them having a broad knowledge of urban transport-markets or the perception that there were significant synergies between their existing “product ranges” and e-scooter services. Indeed, several have strong ties with other players in transportation markets, e.g. Jump with Uber, Bolt with Didi Chuxing, and Spin with the Ford Motor Company.

The integration of some e-scooter firms with larger, established transportation companies, including TNCs, makes the assessment of the situation more complex. The presumed supposition of the companies involved is that there are synergies from operating a two-sided economic model. A two-sided market exists when a platform can positively affect the volume of transactions by charging more to one side of the market and reducing the price paid by the other side by an equal amount (Rochet & Tirole, 2006). In the case of e-scooters, combining their availability with a TNC service on the same App could be thought to potentially allow the supplying company to jointly maximize its profits, even if this means losses on one side being cross-subsidized by enhanced profits from the other side of the market. The problem is that such benefits do not seem to have materialized, or at least not easily. The nature of the scooter business, as we have seen, is different to that of TNCs. Uber’s development of the scooter side of Jump, for example, which it purchased in 2018, proved problematic. It was transferred to Lime in 2020 as part Uber’s larger $170 million investment in the latter. A large number of scooters were scrapped in the restructuring.18 The post-pandemic model posited by the companies will allow the user of the Uber or Lime App to access a scooter. Whether this will help the scooter companies will depend upon the extent scooters and THC services are complementary or competitive to each other. Little serious academic econometric analysis has, however, looked at this.

Venture capital has also played a major role in the development of the industry. Lime, for instance, enjoyed $12 million of funding from Andreessen Horowitz at its foundation, while Bolt had angel investor assistance when it was established in Estonia. Bird raised a $3 million seed money in its first month of operation in June 2018, followed by another $15 million eight months later and then $100 million. These large injections of finance enabled the companies to introduce large networks of services, with the associated economies that go with this, rather than just offering boutique products. To give some indication of market valuations of thes coompanies, as of 2019, Lime had raised $455 million and had a valuation of $1,000, Bird had raised $415 million and had a valuation of $2000 million, Skip had raised $31 million and had a valuation of $100 million, and Spin had raised $8 million when Ford bought it for $80-$90 million.19 The global electric scooters market’s potential size, estimated at $18.6 billion in 2019, was a key attraction to the investors. Grand View Research Inc, for example, forecast it could reach over $40 billion by 2030.20

On the labor side, e-scooter companies make use of both the conventional and gig economies, although firms do differ in their mix. Bird, for example, uses private contractors, “chargers,” to locate and charge the scooters overnight before placing them at designated “nests” throughout the service area in the morning.21 They have “bird watchers” to manage the scoot fleet. Lime has “juicers” who leave scooters in “groves”. Much of this work is done at night, is unskilled, and needs minimal amounts of equipment. Many the workers use their income to supplement other sources, although others, and notably those doing semi-skilled jobs for the scooter companies, are salaried. Charging, for which pay is normally based on performance, can become competitive, especially when the equipment used is interchangeable between companies.22

The methods of remuneration differ. The amount paid (the “bounty”) by Bird to a charger for tending a scooter is dependent on how long the hardware has been sitting out after being flagged as in need of service and before the charger relays the scooter in an App to claim the bounty. A typical bounty is between $5 and $6 per scooter, although it may be higher. Chargers lose 50% of their bounties if they fail to turn-in and record a fully charged e-scooters by a 7 a.m. If the scooter is not adequately checked in or goes missing, the contractor could be fired and have the value of the scooter deducted. A fully discharged scooter may take 5 h to recharge. Chargers pay Bird $10 a piece for each unit of equipment they buy for charging scooters.24

As with any commercial undertaking, a scooter company seldom releases more than the minimum amount of financial information publicly required. The estimates that have been made about their finances need to be taken with caution, although there is a certain consistency across them. For example, broad calculations of Bird’s costs have been attempted but are here offered only as indicative (Trefis Team, 2018).25 Bird’s costs vary between city, change over time, and are affected by local taxes. Bird’s capital cost of a scooter together with the costs of acquiring GPS tracker and installation in 2018 was about $400 or $1.33 per ride based on Bird’s assumption of a 300-trip life of a scooter. The average daily cost to Bird of charging a scooter was $20, with Bird reimbursing users $5 if they did the charging. About 50% of charging was done by users with the remainder by charging companies that picked-up scooter from diverse current locations, took them to the nearest charging point, and returned them to appropriate locations once charged. This yielded an average daily charging cost of $12.50 or $2.50 per trip based on 5 trips per day. There were also maintenance costs of about $0.29 per ride and a small payment fee per trip assumed to be 3% of the trip fare or an average of $0.14 per ride. This calculation gives an overall cost of about $4.26 per ride. But this is just an averaging of the costs of one company, and operating costs can vary considerably.

Turning to pricing, in general in the US a driver pays a base access fee of $1 and a marginal fee of from $0.15 to $0.20 a minute.26 In the case of Jump, there was no unlock fee but a per minute fee of $0.25. Looking at

18 https://www.bbc.co.uk/news/technology-52832791.
19 https://www.forbes.com/sites/adeyemiajao/2019/02/01/everything-you-want-to-know-about-scooters-and-micro-mobility/#a156b88b55de6.
20 https://www.grandviewresearch.com/press-release/global-electric-scooters-market.
21 A gig economy involves temporary, flexible jobs with companies hiring independent contractors and freelancers; see Abraham et al. (2019).
22 https://expmag.com/2019/05/inside-the-shadow-world-of-scooter-chargers/.
23 Responding to this competitive feature, in September 2018, Bird reduced the minimum it paid chargers in Kansas City from $5 to $3 per scooter (https://www.theguardian.com/2019/3/15/18267128/lime-electric-scooter-charging-juicers-harvesting-business).
24 https://www.theatlantic.com/technology/archive/2018/05/charging-electric-scooters-is-a-cutthroat-business/560747/.
25 For other estimates of unit costs see, https://www.bcg.com/publications/2019/promise-pitfalls-e-scooter-sharing; https://www.bcg.com/publications/2019/promise-pitfalls-e-scooter-sharing.
26 https://help.bike/her/en-us.
returns, taking one example, Bird assumes an average trip duration of 25 minutes yields revenue of $4.75 and a net profit of about 11% which is well below that required for financial sustainability. On the revenue side, in a bid to get closer to the market, in April 2019 Bird lifted per-minute rates in Detroit to $0.33 from $0.15, in Baltimore to $0.29, and Austin and Los Angeles to $0.25, but dropped them to $0.10 in at least three other cities. A $2.00 transportation charge was alsooaded in Raleigh to offset regulatory fees imposed by the city.Bird left that market. There may also be ways of reducing costs, for example by encouraging more users to charge e-scooters or to improve the efficiency of thechargers that collect and recharge scooters overnight. But these types of economies have been difficult to achieve.

There is inevitably some degree of variation in rides levels. Weather is important. Perhaps not surprisingly, it appears that winter and cold weather have a significant dampening effect on scooter use (Weinberg, 2019). The number of Bird rides processed by credit cards in the US fell by 23% between October and November 2018, and by an additional 27% in December. For Lime, ride transactions, declined by 27% from October to November and by a further 17% in December. At the more local level, Baltimore, where Bird and Lime had a combined fleet of about 1400 scooters, the number of rides per week drop by a third from October to November 2018, and by 28% in Charlotte, North Carolina from the first to the last week of October. These fluctuations in ridership considerably reduce the seasonal time widows in many cities when otherwise e-scooters are an attractive mode of transportation. In contrast, the demand for App-based ride-hailing often increases with inclement weather and the companies involved can charge surge prices to maintain their services (Brodeur & Nield, 2018).

At the more macro level, some of the initial revenue assumptions of e-scooter companies may have been optimistic. The premise of a life of 300 rides, especially in areas where vandalism and theft, was often too high. Lime initially experienced several problems with quality control of the hardware with breakdowns and a lack of durability during use. Certainly, despite rapid growth, the e-scooter companies have not always fulfilled their revenue forecasts. Lime, for instance, in mid-2018 told potential investors that by the end of the year it would be generating global revenue at an annualized rate of $500 million, or $40 million a month. The company, however, fell short of this. In December 2019 it reported $250 to $300 million in annualized revenue, or about $20 to $25 million a month (Weinberg, 2019). From a financial perspective, even before the Covid-19 pandemic appeared there were concerns in the financial press about whether a bubble had emerged, and e-scooter companies were being over-valued.

5. Regulation of negative externalities

There are issues of both social and economic matters involving e-scooters that have raised a series of regulatory questions. Like all modes of transportation, scooters pose environmental and safety problems. As a response, urban authorities have gradually developed regulatory regimes to handle local scooter issues in association with wider policies governing existing modes. There are established chains of communication between the various stake holders – transportation providers, local authorities, residents, and users – regarding on-going adjustments to regulations and their implementation. Such chains are slowly the integrating e-scooters but, and not surprisingly, these integrations are still embryonic in nature.

The interactions between scooter companies and the regulatory authorities, have been developed differently to many other new product markets. At its inception, the e-scooter industry saw suppliers pursue a path of “forgiveness”. Rather than seek permission to provide services and to conform to regulations pertaining to similar industries, they entered markets and waited for the authorities to respond. A company delivered scooters to streets in its target market and then waited for reactions from any relevant regulatory agency. Commercially, this may give some advantages to the companies but it has brought forth mixed reactions on the part of regulators. Most authorities, confronted by unforeseen outcomes such as irresponsible riding, cluttering, or vandalism have, as chronicled by Stefan Gössling’s (2020) study of 10 cities across the globe, struggled through trial-and-error stages in their search for appropriate legislation.

This wait-and-see approach was often adopted by e-scooter companies because it was unclear which is the appropriate supervisory authority, but it also allowed them to familiarize the potential market with their products and to develop coalitions of support. Along the lines of George Stigler (1971), it allowed a degree of regulatory capture on the part of the scooter companies which enjoyed first-mover advantages and had greater access to information regarding potential users. But it was not a strategy without risk. Backlash from local authorities, for example, led Bird to introduce a “GovTech platform”. This seeks to appease authorities by allowing them to designate no-ride and no-park zones, set speed limits, and display safety messages on scooter dashboards.

While there is evidence that many people view scooters favorably, or at least they do on the scale that they are currently available, there are matters pertaining to both environmental externalities and safety. Idle scooters are free standing and are generally available on sidewalks and other locations where previous customer have left them. These locations are not random but bias towards sites where there are attractions for individuals who may want to use scooters, e.g. retail outlets, metro stations, and restaurants. But while convenient to the user, the results are hardly aesthetically attractive, especially if the hardware end up just lying on the ground. Also, there are problems with abandoned and damaged vehicles that are sometimes dumped on public or private property. Additionally, e-scooters, both when in use and idle, can impede the ability of pedestrians, and especially those physically impaired, to use sidewalks.

Many of the underlying social issues relate to the legal status of scooters, and who has the right to regulate their use. To economists this largely revolves around the well-established Coasian property rights problem (Coase, 1960). In this case, it involves who has the right of way on roads and sidewalks. Issues that have also arisen at the state level include whether e-scooters should be classified as motor vehicles and

27 The majority of the chargers are in the gig economy combining their income from charging with other sources. The amount made various with the time devoted to collecting/dispersing scooters and the area over which the scooters needing recharging are spread. If e-scooters are used for trips away from the urban center or social “hot-spots” then collections/relocations are longer.

28 https://www.telegraph.co.uk/technology/2019/12/29/electric-scooter-bubble-fears-mount-funding-top-1bn/; https://www.marketplace.org/2018/06/21/e-scooter-craze-more-bubble-business/; https://www.in.com/alex-moa/zed/scooter-rentals-are-a-fad-heres-why.html.

29 Some, such as Petersen (2019), have also raised security and privacy concerns. The mobile Apps and scooter-mounted GPS units essential to the functioning of the e-scooter business models, provide access to a wide-variety of consumer data. While important this is not considered here because this is not a scooter-specific issue.

30 While the examples are now somewhat dated, Kahn (1970) still provides the best comprehensive picture of these sort of arrangements.

31 Washington Post.https://www.washingtonpost.com/local/trafficandcommuting/dockless-bike-scooter-firms-clash-with-us-cities-over-regulations/2018/08/04/0db29bd0-9419-11e8-a679-b09212f69c2_story.html.

32 In 2018 Bird “dropped” hundreds of scooters in Richmond in violation of local ordinances. They were later impounded and later sold off by the authorities.

33 For a survey, a number of 7000 people across 10 US cities conducted in May to July 2018 found 79% in favor of then in Atlanta, 76% in Austin and Denver, 75% in Chicago, 72% in Washington DC, 71% in Los Angeles, 69% in San Jose, 68% in Seattle, 67% in New York, and 52% in San Francisco. (Richter, 2018).

34 Fang et al. (2018) offers discussion of this together with some visuals.
where they may be used – e.g., whether they are allowed on bicycle lanes. There are also technical matters relating to braking systems, lights, and maximum obtainable speeds, as well as safety issues such as the need to wear helmets or have prior driving experience. Practically, subsidiarity is tending to push matters of parking, no-go areas, etc. down to the local level.

Safety of users and third parties is an increasing concern. National studies of e-scooter crashes are, however, scant. Accident numbers seem high, with one report (SelCraig, 2019) itemizes seven fatalities involving e-scooters between August 18, 2018 and March 15, 2019 – by way of a benchmark, one person has been killed in the US in a commercial airline incident in the past decade. More recently a study by Nikan Namiri et al. (2020), making use of the US National Electronic Injury Surveillance System, found that between 2014 and 2018 more than 39,000 e-scooter injuries occurred, with the number involving millennials increasing from 582 to 5309 over the period. One quarter of the injuries involve a broken bone, and one-third were to the head, double the rate for that of bicyclists’ injuries.

At the micro level, a detailed case study by Tarak Trivedi et al. (2019) analyzed data from two emergency departments in Southern California between September 2017 and August 2018 regarding e-scooter related accidents and fatalities. They found that 249 people required medical care after e-scooter related accidents, with a third of having to be transported by ambulance for treatment. Over the same period, there were 195 visits for bicycle injuries and 181 for pedestrian injuries. The accidents include falls, collisions and getting struck by a moving vehicle. The data shows that the most common injuries were bone fractures (40%) and head trauma (31.7%) with the remainder involving cuts, sprains and bruises.

There are hard regulations aimed at improving safety (see again Table 1) as well as softer boosts and nudges (Thaler, 2016) aimed at changing behavior without compulsion. Certain common threads are discernable. For driver safety helmets are often compulsory, as are driver’s licenses, and the compliance with speed limits, generally of 15 mph, with companies installing governors to ensure scooters do not exceed them. Passengers are normally not permitted. To protect the safety of others, there are often traffic separation regulations, including banning e-scooters from sidewalks and other areas largely used by pedestrians. But compliance and enforcement are variable. Although most e-scooter companies recommend wearing a helmet, and some offer them, state-wide laws requiring helmets vary, as does enforcement. For example, in Trivedi et al.’s study cited earlier only 4.4% of riders were wearing a helmet when their incidents occurred. In many cities there are designated hours when scooters may be used. This often involves a night curfew.

Softer nudges and boosts are often provided by the urban architecture. As an aide memoire to the hard regulations governing domains, routes are frequently highlighted where scooting is permitted, and in Washington DC, preferred, but not compulsory, scooter parking areas are clearly marked. Hard regulations can also act as nudges or boosts (Eyal, 2014). The simple fact that there are speed limits and protective headwear is required offers a nudge to the fact scooting is a dangerous activity and can potentially be harmful to others. The increasing number of warnings printed on scooters, as well as publicly available on-line guides for scooter users, provide a boost to this.

In terms of compensation for victims, there are considerable differences in liability and insurance laws between companies. In the US, Bird and Lime generally place the responsibility for accidents on riders by listing in their rental agreements that riders relieve the companies of liability. Users are, however, fully covered for claims resulting from faulty scooters. The same is true in Sweden, but in Germany, e-scooter start-ups are required to carry wider policies. The practical problem is that there is very little case law to test the validity of these alternatives.

6. Stimulation of positive externalities

While, as we have seen, much of the economic concern with scooters has to do with the negative externalities they generate, there are also, from a different perspective, concerns over the stability of underlying e-scooters business model. Many individuals’ decisions are dependent of their wider economic environment. In particular, when it comes to long-term decisions relating to where a household should live or a firm locate, guaranteed local transportation availability can matter. Good and quasi-guaranteed access to destinations positively influences long-term decisions; it is a positive externality. Authorities, therefore, often regulate transportation to ensure continuation of suitable services to the point of maximum overall social efficiency. This is transactions-cost regulation that, in this case, limits the uncertainty surrounding possible changes in the quality of local access, including that by scooter (Crocker & Mastin, 1996; Spiller, 2013).

One way of increasing the benefits associated with a constant level of accessibility within a city is to ensure a stable market. In the case of e-scooters, without state ownership or providing direct subsides, this means ensuring through regulation that private suppliers earn a normal profit. Unfortunately, e-scooters in the US have yet to prove themselves capable short-run cost recovery, let alone earn a viable long-run return. Hard numbers are difficult to come by, but Lime, which was trying to shift quickly from running a bike-share business to one focused on e-scooters, lost an average of $6 million a month the first half of 2018 and by October its net loss that month had swollen to $23 million as it sought to compete with Bird.

In response to these sorts of problems, numerous cities have limited the number of e-scooter companies or their scooters. Washington DC, for example, in 2017 initially limited the number of scooters per operator to 400 but from the end of 2018 this rose to 600 and, with the regulators’ approval, fleets could then be expanded by 25% every three months. The policy changed for 2020 when only Jump, Lyft, Spin and Skip, each with a maximum of 2500 scooter, were allowed to serve the city. Denver in 2018 gave permits to five scooter companies to initially operate 350 scooters each over a trial period. Similarly, in San Francisco in early 2018, after several companies started e-scooter operations without permission, the city passed laws requiring a permit. The new regulation saw 12 applications for temporary permits, with Scoot and Skip being accepted to the scheme. The original companies that had launched services without permission, were snubbed, although Jump, Spin, and Lime were later granted market access.

These policies are, however, not without potential pitfalls. There is the initial question of exactly how many scooters and/or scooter suppliers are optimal, and how these aggregates are be decided in future as circumstances change. What these initiatives also lack is a mechanism to ensure the preferred scooter companies minimize costs, and thus their

35 There are some indicators that these recommendations are not supported with nudges (Allem & Majumdar, 2019). Posts to Bird’s Instagram account, for example, rarely show e-scooters being used with protective gear. Bird’ reposts of photographs accompanying customers’ experiences also seldom feature protective gear.

36 Covid-19 has demonstrated the problems of scooters as a stable source of transportation services. While conventional public transportation services have been reduced in many cities, the scooter companies have often withdrawn all services. They are private entities and have that right. This does not mean that all forms of micromobility have been withdrawn. In cities where there are public bicycle schemes some have, with modifications, remained operational. Such modes, however have traditionally been heavily subsidized. In 2016, riders covered 77% of Washington DC’s bike-share system, in Boulder it was 35%, and in Chicago 85% (https://economics21.org/html/capital-bikeshare-does-not-need-subsidies-2738.html; https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2016/03/24/ despite-popularity-bike-share-programs-often-need-subsidies).
charges. The companies are dealing more with bureaucratic managers and less with market forces. There has, in particular, been little exploration of the merits of introducing genuine competition for the market along the general lines proposed by Harold Demsetz (1968) using auction mechanisms to allocate a limited number of licenses. In most cities, decisions on which companies can operate are based on meeting an administrative list of criteria. In other words, the regulators are deciding what the consumers want rather than market forces. It is also unclear how any future increases in capacity is to be decided. The historical record of the medallion systems used in many cities, and most notably New York, to regulate taxi cab supply was hardly sterling in this respect.

7. Conclusions

The Nobel Prize Winner, Esther Duflo advocates in her 2017 American Economic Association’s Richard T. Ely Lecture that economics should, in a very positive way, involve “plumbing”. What she means is that there is a greater need, “…to focus on many details about which [economist’s] models and theories do not give much guidance.” But to do this there is a pre-requisite. There is a need to isolate the key areas where analysis would be socially rewarding. Remaining with the hydrology analogy, to plumb usefully you need to know where the leak is. This paper has thus been concerned with narrowing down the key topics economic “plumbers” need to delve into regarding the e-scooter market to best assist policy-makers and regulators. By default, it also isolates pipelines which can be left dry.

We were gradually learning about the role e-scooters were playing in urban transportation networks, and the roles they may play in the future, when Covid-19 struck. The economic shut down has provided a very rare chance for industry suppliers, policy makers, and academics to take stock of a situation and consolidate this knowledge. The limitation, of course, is that scooters had only been an urban transportation mode for something under three years. But even over this short time, there have been considerable changes in the ways their services have been offered and the rules scooter companies have had to conform to. Additionally, much of the quantitative evidence available on outcomes does not conform to normal statistical rigor. There are, nevertheless, some clear experiences to be drawn on regarding the economics of e-scooter transportation.

On the public policy side, it was clear that the authorities were finding it difficult to develop regulatory structures even before Covid-19 intervened. Compromises that allow both for the benefits of enhanced personal mobility that scooters afford and at the same time assuring passengers will deter mass urban transportation ridership (Tirachini & Cats, 2020). In addition, the large reductions in car traffic during lock-downs has provided strong demonstration effects in terms of decreases in urban pollution levels (Isafian, 2020). Some authorities are thus looking to e-scooters to partially fill the transportation gap with more environmentally friendly vehicles. Indeed, some countries, such as the UK, have initiated national actions to allow experiments whereby e-scooters have easier access to streets. Whether the scooter business model is economically sustainable, even with relatively attractive regulatory structures, is perhaps, however, the crucial underlying question.

References

Abraham, K. G., Haltiwanger, J., Sandusky, K., & Spletzer, J. (2019). The rise of the gig economy: Fact or fiction? The American Economic Review, 109, 357–361.
Allem, J. P., & Majmundar, A. (2019). Are electric scooters promoted on social media with safety in mind? A case study on bird’s Instagram. Preventive Medicine Reports, 13, 62–65.
Bain, J. S. (1949). A note in pricing in monopoly and oligopoly. The American Economic Review, 39, 448–464.
Bardhi, F., & Eckhardt, G. (2012). Access-based consumption: The case of car sharing. Journal of Consumer Research, 39, 881–896.
Baumol, W. J., Panzar, J. C., & Willig, R. D. (1982). Contestable markets and the theory of industry structure. New York: Harcourt Brace Jovanovitch.
Bower, J. L., & Christensen, C. M. (1995). Disruptive technologies: Catching the wave. Harvard Business Review, 73(January-February), 43–53.
Brodeur, A., & Nield, K. (2018). An empirical analysis of taxi, Lyft and Uber rides: Evidence from weather shocks in NYC. Journal of Economic Behavior & Organization, 152, 1–16.
Button, K. J. (1996). Liberalising European aviation: Is there an empty core problem? Journal of Transport Economics and Policy, 30, 275–291.
Button, K. J. (2020). The “ubermobility” of ridesharing: The myths and the reality. Transportation Reviews, 40, 1–19.
Clevlow, R. (2019). The micro-mobility revolution: The introduction and adoption of electric scooters in the United States. Washington, DC: Presentation to the Transportation Research Board Annual Meeting.
Cooper, R. H. (1960). The problem of social cost. The Journal of Law and Economics, 3, 1–44.
Crocker, K. J., & Mastin, S. E. (1996). Regulation and administered contracts revisited: Lessons from transaction-cost economics for public utility regulation. Journal of Regulatory Economics, 9, 5–59.
Demsetz, H. (1968). Why regulate utilities? The Journal of Law and Economics, 11, 55–65.
Duflo, E. (2017). The economist as plumber. American Economic Review Papers and Proceedings, 107, 1–26.
Eckhardt, G. M., & Bardhi, F. (2015). The sharing economy isn’t about sharing at all. Harvard Business Review, January 28 https://hbr.org/2015/01/the-sharing-economy-its-about-sharing-at-all.
Edgeworth, F. Y. (1881). Mathematical physics. London: Kegan Paul.
Eyal, N. (2014). Nudging by shaming, shaming by nudging. International Journal of Health Policy and Management, 3, 53–56.
Fang, K., Agrawal, A., Steele, J., Hunter, J., & Hepper, A. M. (2018). Where do riders park dockless shared electric scooters? Findings from San Jose California. San Jose: Mineta Transportation Institute Publications, San Jose State University.
Fishman, E., Washington, S., & Haworth, N. (2013). Bike share: A synthesis of the literature. Transport Reviews, 33, 148–165.
Gosling, S. (2020). Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change (p. 79). Transportation Research D (in press).
Hamari, J., Sjöklint, M., & Ukkonen, A. (2016). The sharing economy: Why people participate in collaborative consumption. Journal of the Association for Information Science and Technology, 67, 2047–2059.
Hollingsworth, J., Copeland, B., & Johnson, J. X. (2019). Are e-scooters polluters? The environmental impacts of shared dockless electric scooters. Environmental Research Letters, 14, 084001.
Isafian, R. T. (2020). The dramatic impact of Coronavirus outbreak on air quality: Has it saved as much as it has killed so far? Global Journal of Environmental Science and Management, 6, 275–288.
Jevons, W. S. (1871). The theory of political economy. London: Macmillan.
Jiao, J., & Bai, S. (2020). Understanding the shared e-scooter travels in Austin, TX. International Journal of Geo-Information, 9, 135. https://doi.org/10.3390/ijgi9020035
Kahn, A. E. (1970a). The economics of regulation: Principles an institutions, volume I economic principles. New York: John Wiley and Sons.
Kostrzewska, M., & Macikowski, B. (2017). Towards hybrid urban mobility: Kick scooter as a means of individual transport in the City. IOP Conference Series: Materials Science and Engineering, 255, 1–9.
Lancaster, K. J. (1966). A new approach to consumer theory. Journal of Political Economy, 74, 132–157.

37 https://www.bbc.co.uk/news/uk-53219331.
League of American Bicyclists. (2019). *Bicycling & walking in the United States: 2018 benchmarking report*. Washington DC: League of American Bicyclists.

Leibenstein, H. (1979). A branch of economics is missing: Micro-micro theory. *Journal of Economic Literature, 17*, 477–502.

Leibenstein, H. (1987). *Inside the firm, the inefficiencies of hierarchy*. Cambridge Mass: Harvard University Press.

Manfredi, M. F. (2018). As electric scooters barrel their way into the sharing economy, manufacturers and their insurers should prepare for an influx of new claims. *The National Law Review*. November 27.

Mathew, J. K., Liu, M., Seeder, S., Li, H., & Bullock, D. M. (2019). Analysis of e-scooter trips and their temporal usage patterns, *Institute Transportation. Engineering Journal, 89*, 44–49.

McKenzie, G. (2019). Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C. *Journal of Transport Geography, 78*, 19–28.

Namiri, N. K., Lui, H., Tangney, T., Allen, I. E., Cohen, A. J., & Breyer, B. N. (2020). Electric scooter injuries and hospital admissions in the United States, 2014-2018. *Journal of the American Medical Association Surgery, January, 8*, 2020. https://doi.org/10.1001/jamasurg.2019.5423

Noland, R. B. (2019). *Trip patterns and revenue of shared e-Scooters in Louisville, Kentucky, Transport Findings*. https://doi.org/10.32866/7747. April.

Petersen, A. B. (2019). Scoot over smart devices: The invisible costs of rental scooters. *Surveillance and Society, 17*, 191–199.

Phillips, R. (2005). *Pricing and revenue optimization*. Stanford: Stanford University Press.

Pirrong, S. C. (1992). An application of core theory to the analysis of ocean shipping markets. *The Journal of Law and Economics, 35*, 89–131.

Porter, M. E. (1985). *Competitive advantage*. New York: Free Press.

Richter, F. (2018). *Majority of US city dwellers view e-scooters positively*. Statista. https://www.statista.com/chart/15786/public-perception-of-electric-scooters/.

Rochet, J.-C., & Tirole, J. (2006). Two-sided markets: A progress report. *The RAND Journal of Economics, 37*, 645–667.

Selcraig, B. (2019). At least 7 deaths connected to e-scooters in the United States (Vol. 19). San Antonio Express-New. March 2019.

Shiller, R. J. (2017). Narrative economics. *The American Economic Review, 107*, 967–1004.

Stigler, G. (1971). The theory of economic regulation. *Bell Journal of Economics and Management Science, 2*, 3–21.

Thaler, R. H. (2016). Behavioral economics: Past, present, and future. *The American Economic Review, 106*, 1577–1600.

Tirachini, A., & Cats, O. (2020). COVID-19 and public transportation: Current assessment, prospects, and research needs. *Journal of Public Transportation, 22*, https://doi.org/10.5038/2375-0901.22.1.1

Trefis Team. (2018). What drives value at electric scooter sharing startups like Bird? *Forbes*. May 1.

Trivedi, T. K., Liu, C., Antonio, A. L. M., Wheaton, N., Kreger, V., Yap, A., Schriger, D., & Elmore, J. D. (2019). Injuries associated with standing electric scooter use. *JAMA Network Open, 2*, Article e187381.

Weiss, M., Dekker, P., Moro, A., Scholz, H., & Patel, M. K. (2015). On the electrification of road transportation: A review of the environmental, economic, and social performance of electric two-wheelers. *Transportation Research D, 41*, 348–366.

Williamson, O. E. (1981). The economics of organizations: The transaction cost approach. *American Journal of Sociology, 87*, 548–577.