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Equity Research
20 March 2019

Sustainable & Thematic Investing

Micromobility: Fast, Cheap and Good Solution for 'Smart Cities'

City planners need to develop smarter cities that can transport an additional 2.7bn urban commuters by 2050. By the mid-2020s, 1.1tn passenger miles (4% of global total) could switch to micro, electric vehicles for urban trips below five miles, representing an $800bn revenue opportunity for micromobility operators.

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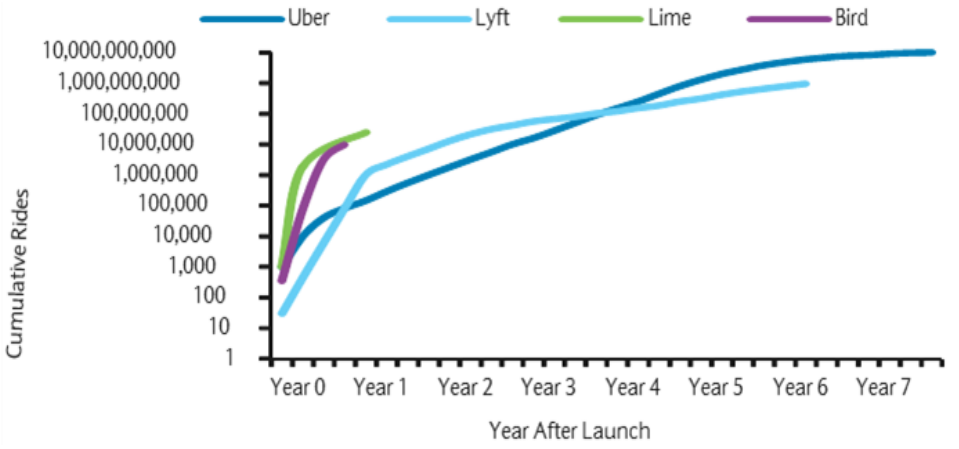
Micromobility: Fast, Cheap and Good Solution for 'Smart Cities'

Micromobility (transport using electric-powered personal-sized vehicles like e-scooters and e-bikes) could be an 'iPhone moment' for personal mobility. ~30tn passenger miles are travelled per year globally. 60% of current trips are below 5 miles. We expect 1.1tn of those miles to switch to micromobility (MM), which implies $800bn global revenue, with the change happening because compared to full-size autos, MM is:

- **Faster.** In high-traffic cities, micromobility can move people faster than the current average speed of <10 mph.
- **Cheaper.** In the densest cities, the cost per mile of an e-scooter is as little as a third the cost of conventional auto options (ride-hailing, driving a personal vehicle).
- **Good.** It's better for the environment, with a carbon footprint per mile of 28g vs 292g for a full-size vehicle. It's better for city planning, takes up less space than for roads and parking, and complements mass transit. The form factors can be more varied, and we expect a proliferation of choices. **It is a fun way to get around.**

Micromobility is already booming, with a growth curve even faster than ride-hailing (Figure 1). At this rate, we expect there to be investment implications for many sectors, with the most acute impact on Infrastructure, Property, Leisure and Autos.

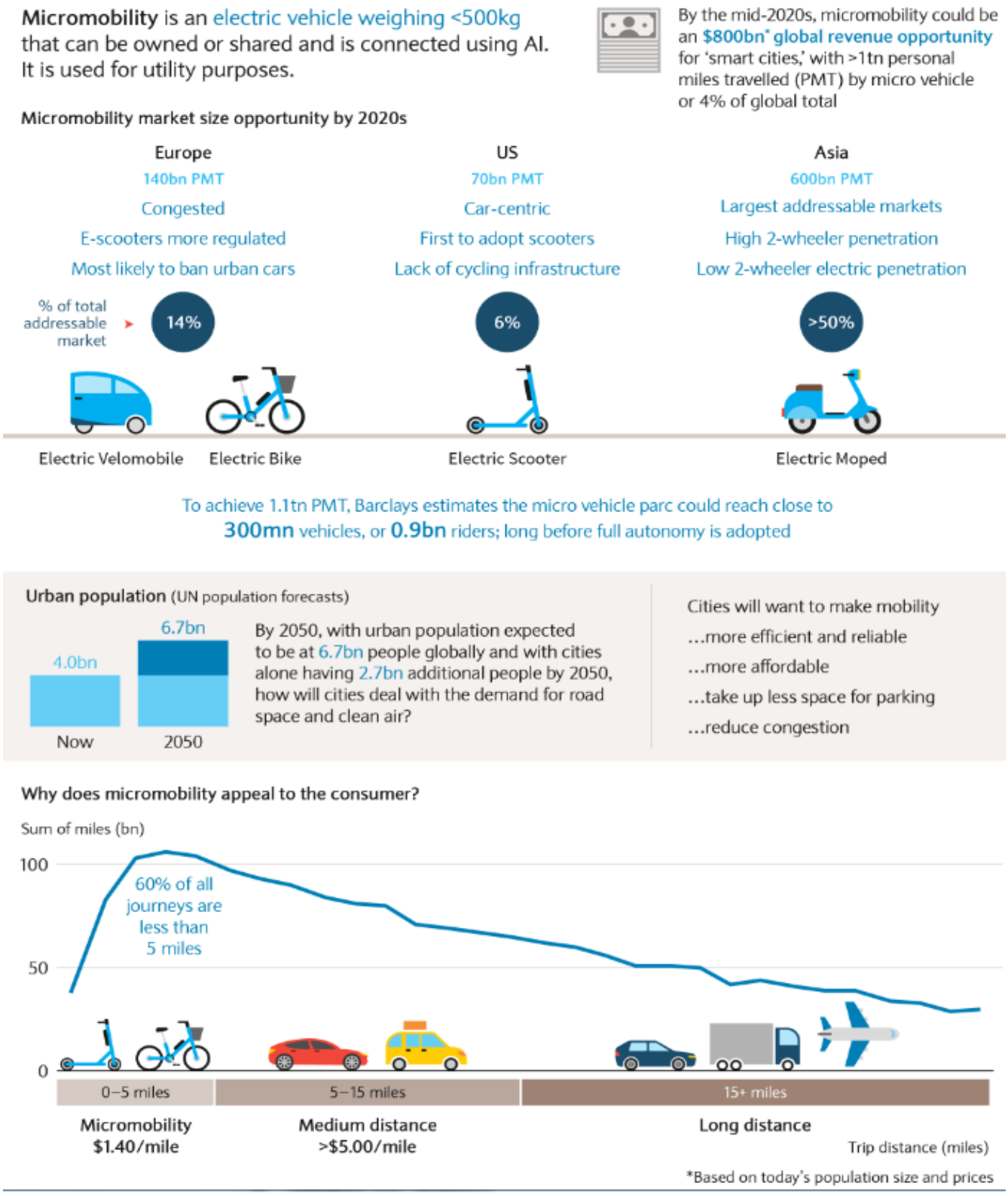
FIGURE 1
Micromobility has grown even faster than ride-hailing



Source: Barclays Research, company data

EXECUTIVE SUMMARY

FIGURE 2
What is micromobility?



Source: Barclays Research

FIGURE 3
Sector implications

Source: Barclays Research, *ICE = Internal Combustion Car, APM = Alternative Payment Methods

FIGURE 4

Barclays covered stocks potentially impacted by higher global micromobility uptake

	Stocks impacted	Commentary
Infrastructure	CRH, HeidelbergCement, LafargeHolcim, Buzzi Unicem, Vicat, Vinci, Eiffage	Integrated cement manufacturers could see boosted infrastructure spend initially, but potentially lower material intensity. Contractors key beneficiaries from new infrastructure design & building, especially those geared to 'smart cities'.
Property	Gecina, Icade	Gecina could see an increase in rental values given its large office catchment area. Icade looks set to benefit from improved mobility infrastructure in Greater Paris
Leisure	Merlin, GVC, Paddy Power, William Hill, SSP, Compass, Sodexo, Elior, Telepizza, Vapiano	Potentially increased footfall at Lego Discovery Centres/Sealife and at retail gaming companies. Concessions at stations could benefit from commuter's earlier arrival. Catering & restaurants could lose out to faster, cheaper food delivery apps
EU & US Autos	Ford, GM, VW, BMW, DAI, Conti, Valeo	e-scooter sharing: Ford, DAI-BMW MM hardware: GM, VW, Conti
EU & US Tech hardware - Semis	Infineon, ON Semi, Renesas, Toshiba, STMicro, Cypress, Dialog Semi, MediTek, Silicon Labs, Texas Instruments, Microchip, NXP	Increased chip and silicon content
Payments	Stripe, Wirecard, Klarna, Worldpay Global eCom, Adyen, PayPal, Square, Alipay, PagSeguro	Shift from bank-led to technology led should benefit alternative payment method (APM) providers
Internet & E-commerce	Delivery Hero, JustEat, Takeaway.com, ASOS, Boohoo, Zalando	Food delivery: increased utilisation and profitability Online pureplays could see advantages eroded if bricks-and-motor retailers start to provide same-day delivery but may benefit from an accelerated channel shift online. Zalando has a vision to become the tech backbone and top of the consumer funnel in this world.
Media	JCDecaux	Incumbent bikeshare operator. Existing relationship with city regulators. Needs to keep flexible to protect against new entrants
Business Services	the AA	Reduced car mileage could see reduced break-down utilisation for the AA. A longer-term shift to TaaS could decrease AA membership, unless AA pivots more to B2B and fleets (TaaS increased vehicle utilisation)

Source: Barclays Research

1 trillion (PMT) reasons we're so excited about micromobility (MM) – electric, connected and shared

We see micromobility (e-bikes, e-scooters, e-velomobiles and any other low-speed electric vehicles, LSEV) as the trigger for an 'iPhone moment' in urban personal and commercial transportation. It is a low-end disruption, so many of the incumbents may not see it coming, and even if they do, may not feel threatened by it. But they should. There were **3.3 trillion passenger miles travelled (PMT) in the US in 2017, ~30 trillion globally. ~60% of these trips were less than 5 miles in length** and yet in developed countries **more than 70% of those short-distance trips were taken by car** and only 2% by micro-vehicle (mainly bicycle). But **why use a 1,500kg vehicle to transport a passenger load of 100kg**? Urban areas are becoming denser and more congested, with average speed in many cities below 10mph. With the UN forecasting **7bn people will live in urban areas by 2050** (70% growth), how will cities deal with this additional demand for road space and additional pressure on clean air?

We see the potential for **1.1tn of the 18tn <5miles PMT globally to shift to micromobility** modes. We expect the micro mode to differ greatly by geography, dependent both on consumer appetite and government will. It could be that e-scooters proliferate in the sun-belt states in the US, e-bikes in Europe and e-mopeds and e-trikes in developing Asia & Africa, or a combination of all modes in all regions. Some will be owned but many more will be shared. We think micromobility suits consumer demand for greater affordability, accessibility and availability whilst also adding velocity and vivacity (the 'fun factor'). We expect speed to be a greater enabler of micromobility than cost and the lower 'hassle' of micro to allow operators to increase pricing to deal with customer demand. But even at current cost/mile (US$1.4/mile in US, $1.55 in EU and $0.5 in RoW), we estimate a **US$800bn revenue opportunity** for micromobility operators in the near term. The addressable market could rise substantially. **We forecast urban PMT to increase ~70% by 2050, based on the UN's population growth forecasts; revenue to $1.1tn**. MM operators are currently unprofitable, but this could change as vehicle utilisation rates improve and vehicle quality reduces vehicle churn. With a potential vehicle parc of 280m vehicles globally, based on our addressable market forecasts, we also see a revenue opportunity of €22.6bn for vehicle hardware manufacture.

City policymakers should embrace the adoption of micromobility too. With **congestion worsening** and spending on vehicle infrastructure rising substantially, we think city planners will move from disapproval to positive encouragement for a mode of mobility that requires significantly less infrastructure (**10 bikes or 20 scooters can fit into 1 car space and throughput is even better given faster speeds**), helps to **reduce greenhouse gas emissions** (GHGs) and can support existing public transport infrastructure by providing seamlessly integrated multi-modal mobility. Couldn't the space currently taken up by cars gradually be repurposed for greener spaces and to regenerate urban centres? City planners hold the power to adapt regulations and allocate mobility permits but will need to show a flexible approach to encourage innovation. Likewise, micromobility operators will have to work hand-in-hand with urban regulators, to ensure accurate data sharing and greater vehicle safety, to adapt supply to demand and to ensure greater integration of payment systems across the entire mobility ecosystem. **We expect micromobility then to follow the disruptive uptake trends of ride-hailing.** We see mobility **shifting from upfront purchase price and taxation to cost/mile usage**. We expect many cities to enforce **more zero emission (or even car-free) zones**, which may be imposed well ahead of the advent of level 5 (or 'everything, everywhere') autonomy. Indeed micromobility uptake could even be detrimental to urban autonomy[1]. In the race for micromobility scale, we do not see a 'winner taking all', but we do think there are some clear first-mover advantages and network scale effects.

Why read this report?

The objective of this report is to delve deeper into a new mode of mobility – micromobility – and define what it encompasses (any connected electric vehicle, used for utilitarian purposes, below 500kg in weight) and why we believe it addresses fundamental issues surrounding urban mobility. We explain why it ties into three global mobility trends: Electrified, Connected and Shared. We think anyone interested in urban landscapes (both developed and developing), mobility themes and sustainability should read this report. With $9.9bn invested globally in micromobility to date, investors should care. We explain why we think it will prove a truly disruptive technology and who and what will be driving the disruption.

By building a global addressable market for micromobility (using data from the NHTS to build a proprietary, theoretical model for the US which we scale to the global market), we analyse the impact micromobility could have on existing and potential new businesses models. We attempt to gauge the impact this mobility 'shift' could have on different sectors: changing Property, Construction & Infrastructure requirements, different demands on Tech, Oil and Auto demand, enabling factors for Retail, and Internet & Ecommerce, as well as opportunities within Media, Leisure and Business Services.

[1] 'Bikes put spanner on works of Dutch driverless car schemes', The Guardian, 13 February 2019

THE THESIS FOR MICROMOBLITY: FASTER, CHEAPER, GOOD

Micromobility – transport using electric-powered personal-sized vehicles like e-scooters and e-bikes, which can be owned or shared (and in shared mode are increasingly free-floating or dockless) – could be an 'iPhone moment' for personal mobility. 60% of current trips are below 5 miles, adding up to ~30tn passenger miles travelled per year globally. We expect 1.1tn of those miles to switch to micromobility, which implies $800bn of global revenue, with the change happening because, compared with full-size autos in dense urban areas, micromobility is a faster, cheaper and a fun, environmentally-friendly way to move around.

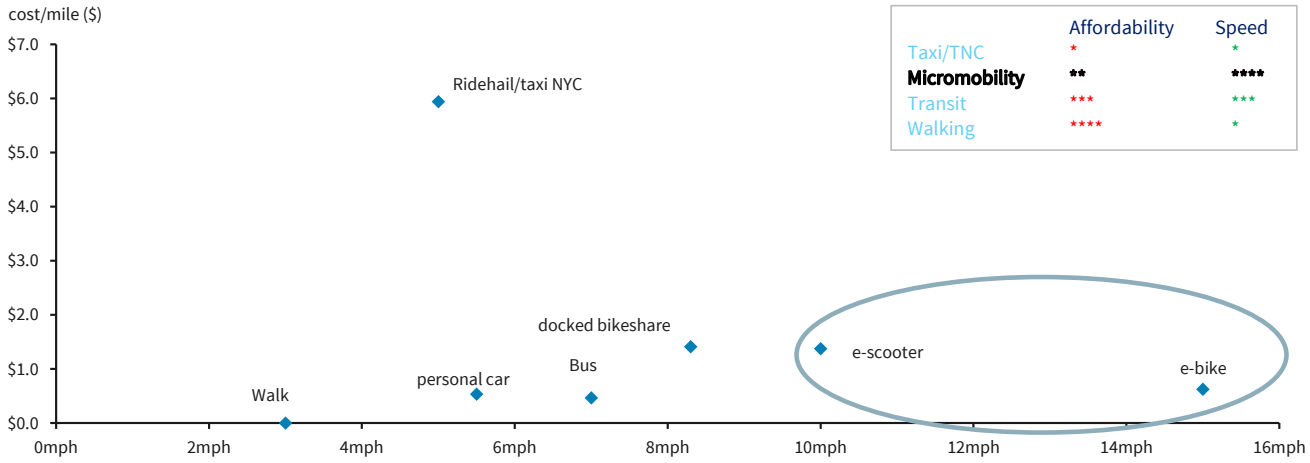
Micromobility is faster

Speed should be a key enabler of micromobility uptake for consumers, enhanced by the overall convenience. With cars averaging less than 10 miles per hour in many inner city areas globally, an electric-assisted micro-vehicle that can average more than 10 miles an hour (and in some cases >20mph) should appeal to many commuters. On a speed to average cost/mile basis, we think consumers will embrace micromobility as an enabler of faster commute times in congested urban areas.

A recent study[2] analysing New York's open sourced data for taxi and ride-hail trips, as well as docked bikesharing, found that, in NYC, a bike was faster than a taxi for more than 50% of peak time journeys. The same is likely to be true in many European cities too. For instance, in London the average speed in the centre of town is only 6 miles per hour, but e-scooter and e-bikes can reach speeds of 15mph and above.

FIGURE 5

We think speed is one of the greatest benefits of micromobility, especially if urban infrastructure is adapted to improve safety



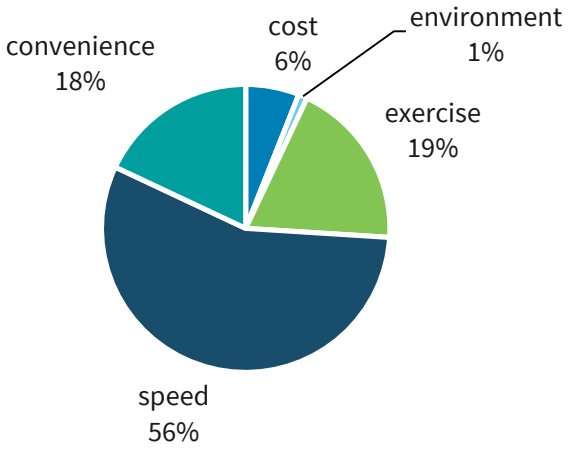
Source: Barclays Research, Uber, Lyft, Yellow taxi, Citi Bike, JUMP, Bird, NY Transit, AAA

This matters, because in cities that have the highest usage of bicycles (the traditional mode of transportation that has the most in common with micromobility), higher speed is often cited as a critical advantage for cycling. In polls of Copenhagen, for example, speed is the most cited reason to prefer bicycling, given almost three times more often than the next most popular answer (Figure 6)

[2] 'When are Citi Bikes Faster than Taxis in New York', Todd W Schneider, 26 Sept 2017

FIGURE 6

56% of inhabitants in Copenhagen stated speed as the main reason for using a bicycle (with cost cited by only 6%)



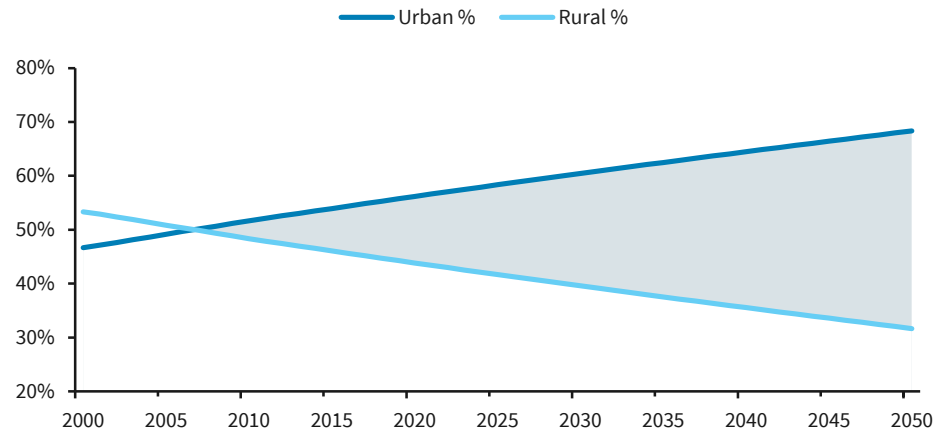
Source: www.cycling-embassy.dk

Urbanization is likely to continue increasing average population density

According to the UN Population division, by 2050 2.7bn additional people will dwell in urban areas (Figure 7).

FIGURE 7

Urbanisation is a global trend – by 2050 close to 70% of the global population are expected to live in urban areas

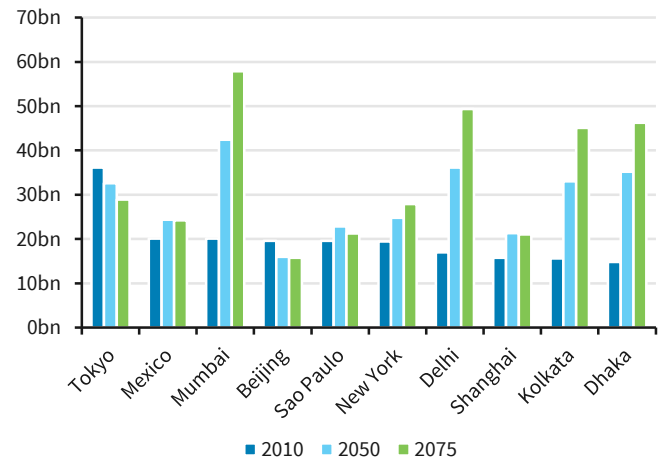


Source: United Nations Population Division, Barclays Research

There are already substantial demands on resources in cities. We expect the process of global urbanisation to put even greater strains on urban mobility demands. A report published in February entitled '*Upward and Outward Growth: Managing Urban Expansion for More Equitable Cities in the Global South*', by the World Resource Institute, argues that cities that try to tackle the growth in a regulated fashion to avoid the effects of sprawl, will fare better than those that allow private, developer-led growth. The report found that city dwellers' access to basic services, such as water, sewage and paved roads, drops sharply <3 miles outside city centres, leading to increased costs and less sustainability. But with greater access to mobility (via micromobility) for people living in areas of sprawl, could city planners re-think city centre environments?

FIGURE 8

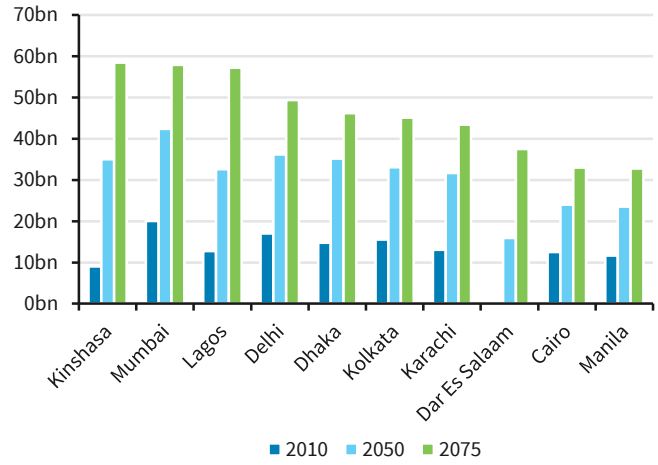
Only 4 of today's largest cities are expected to remain in the top 10 by 2075



Source: Socioeconomic Pathways and Regional Distribution of the World's 101 Largest Cities

FIGURE 9

By 2075 there could be no cities in Europe or North America in the top 10 and the largest city could be almost double the size of Tokyo today



Source: Socioeconomic Pathways and Regional Distribution of the World's 101 Largest Cities

If city policymakers decide to discourage car use further, via congestion charging, low emission zones, etc, light vehicle usage costs could rise considerably versus micro.

Less hassle for short distances

Propensity to travel mode may be strongly correlated not just to speed but also to a 'hassle' factor, which is hard to define. This consideration is likely to differ widely by geography, demographic and culture. It could also explain the surge in ride-hail uptake in certain areas but not in others. The transport mode choice of someone in a dense urban environment could differ markedly from that of a similar person living in an area of suburban sprawl.

Finding a parking space in a city may add significant hassle (and time) to a journey that in a less densely packed area would not be such a consideration to a motorist. Likewise, the pain of congestion in a large metropolis may drive more people to consider active mobility and transit, despite its inferior 'comfort', whereas outside a town, personal car ownership may trump all, even over short distances, because, even if the traveller wished to use ride-hail, wait times might be onerous.

FIGURE 10

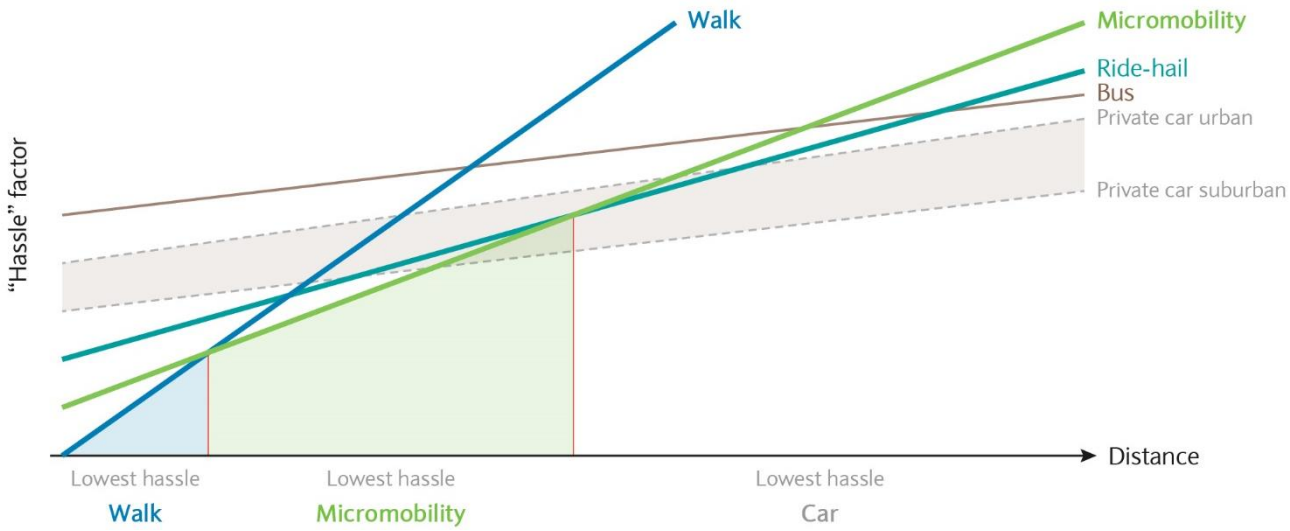
We attempt below to show a qualitative 'comfort index' of different modes of travel (but note that preferences are likely to differ widely by individual dependent on location, culture and demographic)

Travel Mode	Positive (comfort & fun)	Negative (hassle)
Walking	Health, price, availability, convenience	Exertion, speed, weather
Owned bike	Health, happiness, speed, availability	Upfront cost, storage, parking, helmet, weather, exertion, safety/lack of infrastructure
Owned car	Convenience, availability, privacy, control, speed (extra-urban), weather	Upfront cost, parking, congestion, maintenance, emissions, health
Dockless e-bike	Health, happiness, speed, convenience, availability, cost, environment	Hassle of first use, lack of skill, helmet, accessibility, weather, infrastructure
Dockless e-scooter	Happiness, speed, convenience, availability, cost, environment	Hassle of first use, safety, infrastructure, regulations, weather
Ride-hail/carshare	Accessibility, convenience, cost (after first miles), weather, speed (longer distance)	Cost (short distance), wait time, emissions, health, privacy, safety

Source: Barclays Research

FIGURE 11

Over short distances, micromobility may be perceived by some commuters as less 'hassle' than a car or public transport



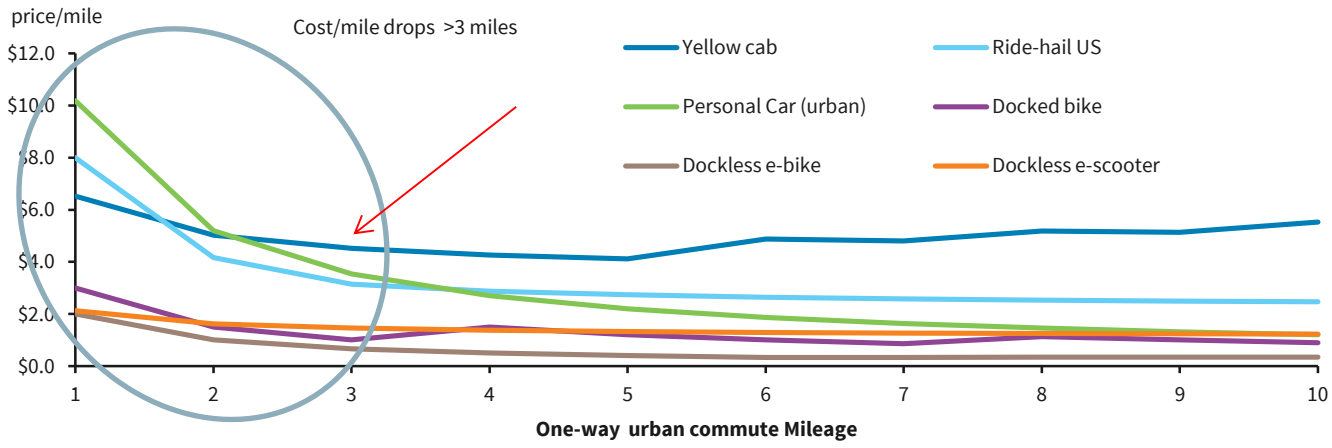
Source: Barclays Research

Micromobility is cheaper

In the densest cities, the cost per mile of an e-scooter is as little as a third the cost of conventional auto options (ride-hailing, driving a personal vehicle). Of course, cost/mile differs depending on the distance travelled, with the first couple of miles of a trip the most costly to the rider for any consumer mode of transit (Figure 12). But even so, on our analysis, average car usage (taxi, ride-hail or personal car) remains the most expensive means of transport for any one-way urban commute under 8 miles in length in the US.

FIGURE 12

Ride-hail costs drop significantly after the first three miles. As with all other transport means, the first few miles generate the most revenue for the operator



Source: Barclays Research, AAA, NY Transit, NY Taxi, Uber, Lyft, San Francisco yellow cab, Lime, Bird, Ford GoBike, JUMP, Taxify, Neuron, Citi

Micromobility is good

Micromobility is good for city planning, taking up less space for roads and parking, and complementing mass transit. The form factors can be more varied, and we expect a proliferation of vehicle offerings for different purposes. It is a fun way to get around.

It's good for the environment

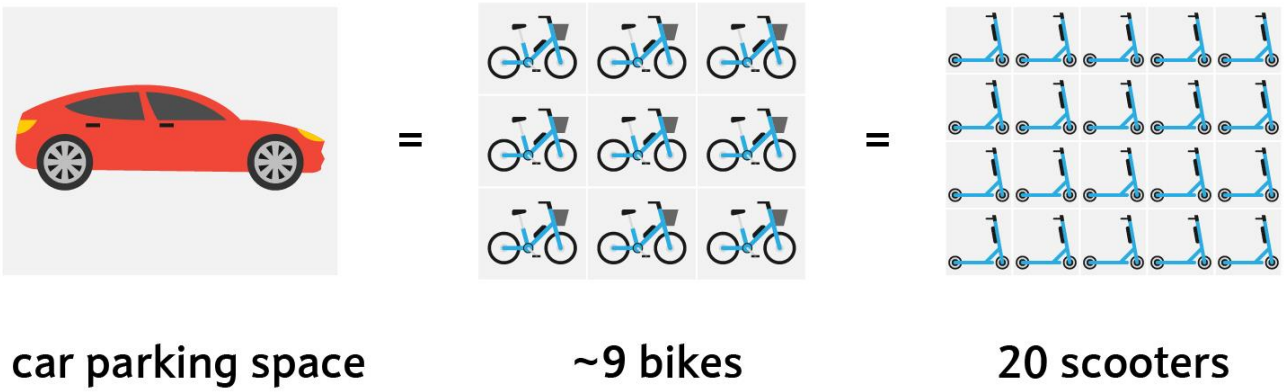
Micromobility has a carbon footprint per mile of 28g vs 292g for a full-size vehicle.[3]

It's good for urban planning

We expect that urban planners will increasingly see micromobility as an important part of the transportation mix in cities. We have already seen a lot of enthusiasm for bicycle sharing schemes, with a program now operating in most large cities (and many mid- and small-sized ones too). Although there are some challenges in adapting rules and infrastructure to micromobility, the big advantage is that it has a high speed and requires less total space (and less specialized infrastructure) than almost any other mode of transit.

FIGURE 13

With minimal infrastructure investment, cities could decide to repurpose car parking spaces to 'micromobility' spaces, to deal with the 'sidewalk clutter' issues of free-floating, dockless vehicles and at the same time deter car usage



Source: Barclays Research

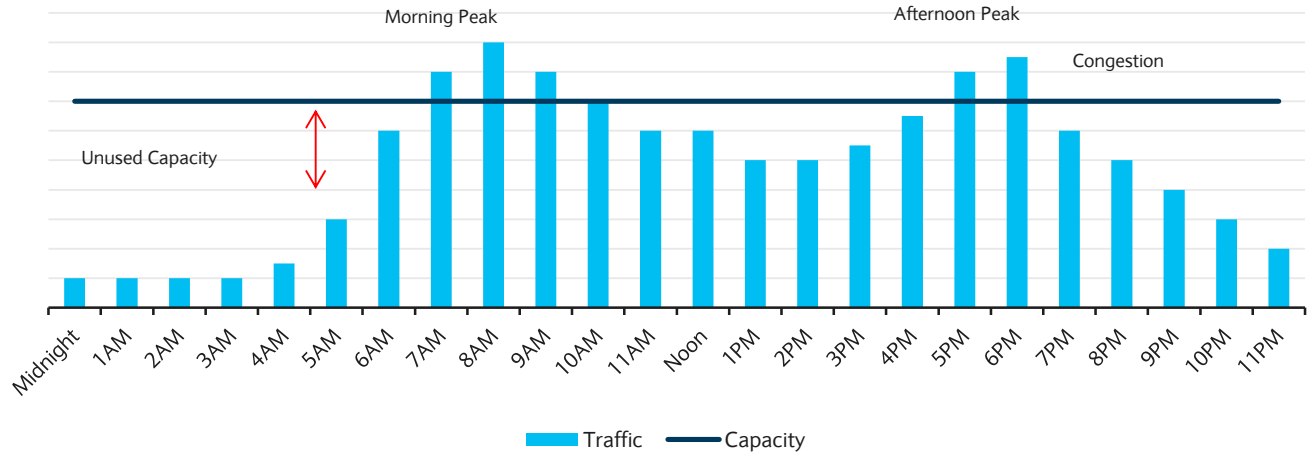
Micromobility can help cut congestion

The European Commission estimates that 1% of GDP in Europe is lost to congestion and the issue is becoming just as problematic globally. Cities are already grappling with how to deal with peak transportation demand, even before urban populations rise further. Limited capacity causes congestion but increases in capacity would be too expensive to provide and leave the additional capacity idle at non-peak times. One solution might be to encourage fewer commutes and more flexible working styles, but another might be to allow micromobility to support some of these peaks.

3 "Electric scooters battle to prove 'green' worth", FT, 12 March 2019

FIGURE 14

Recurring congestion follows a similar theme in many cities on weekdays, due to fixed working patterns



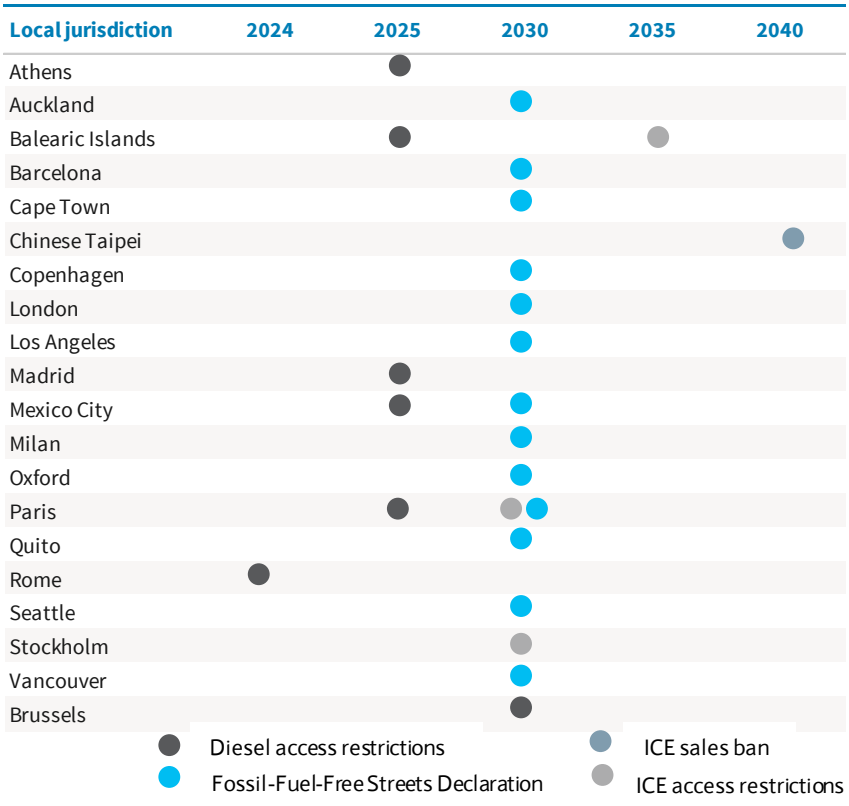
Source: Barclays Research, transportgeography.org

'Marchetti's Constant' argues that on average commuters are willing to travel for up to one hour/day (for further detail see the Property section of the report on pages 39f). If commuters could get to their workplace faster, via micromobility, they might be able to change their home location.

Another option cities are considering to ease congestion is whether to restrict access for cars.

FIGURE 15

Many local jurisdictions have already started to discuss access restrictions for cars



Source: Company data, IEA, Barclays Research

Micromobility could enable cities to reinvent inner city space

- In motorized cities in the US, 30% of the surface is devoted to roads while another 20% is used for off-street parking.
- In Western Europe, roads account for 15-20% of urban space.
- In developing countries this figure is about 10% (6% on average for Chinese cities but growing fast due to motorization).
- In many global cities, only 10-20% of urban space is reserved for pedestrians[4] and even less for green spaces.

FIGURE 16

Many global cities are looking to ban cars from the inner city area

Cities starting to ban cars	Brief summary
Oslo	Plans to permanently ban all cars from its city centre by 2019 and replace 35 miles of roads previously dominated by cars with bike lanes.
Madrid	Plans to ban cars from 500 acres of its city centre by 2020 with an aim to reduce daily car usage from 29% to 23%.
Hamburg	Plans to build a green network of connected spaces covering 40% of Hamburg by 2035. Also plans to make walking and biking its dominant mode of transport.
Copenhagen	Plans to become completely carbon-neutral by 2025. Currently has more than 200 miles of bike lanes with over half of the population biking to work every day.
Paris	Plans to double bike lanes and limit select streets to electric cars by 2020. Had instated a car-free Sundays rule in 2016.
London	From April 2019 the ultra low emission zone (ULEZ) replaces congestion charging and will stop old 'dirty' vehicles entering the centre. The zone will be expanded in 2021.
Brussels	Most streets that surround Brussels city square, stock exchange and Rue Neuve (a shopping centre) are pedestrian-only. The roads make up the second-largest car-free zone in Europe behind Copenhagen and looking for more options.
Berlin	Plans to build a dozen bike super-highways which will each stretch at least 13 feet wide and be blocked off from cars. The city began construction in 2017.
Helsinki	Plans to make cars obsolete by 2025, not by imposing bans but by developing and deploying mobility systems so effective that personal ownership will be seen as redundant.
Amsterdam	Has banned cars from city centres. Over 400 kilometers of cycle paths trails through the city with the European Cyclists' Federation estimating that half of all city journeys take place on 2 wheels.
San Francisco	Throughout the city, there are 125 miles of bike lanes. Had announced plan to ban cars and add bike lanes on 2.2 miles of Market Street, one of the busiest boulevards. Construction of first phase started early 2018.
New York City	Strips of lands in popular areas like Times Square, Herald Square and Madison Square Park are permanently pedestrian-only.
Mexico	In 2016, the government prohibited a portion of cars from driving into the city centre two days every work week and two Saturdays per month.
Bogota	The city has over 200 miles of bike-only lanes along with a program with certain bans from driving during peak traffic hour.
Chengdu	Plans to design a new residential area that makes it easier to walk than drive by 2020. Only half of the roads will allow vehicles. Zoning issues may delay the deadline.

Source: Company statistics, press reports, Barclays Research

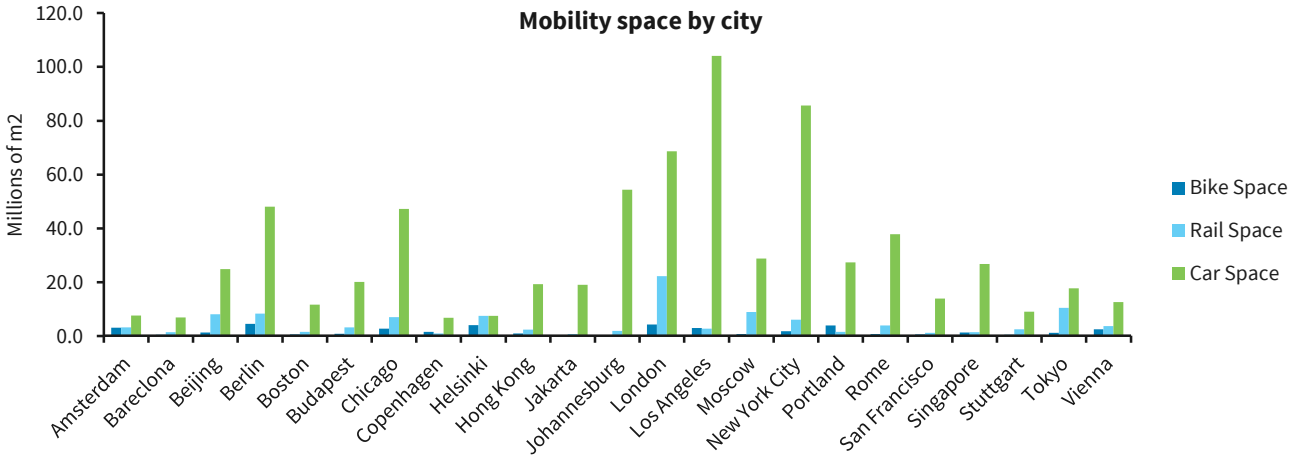
Why is so much space in cities given to the car?

- Public transit consumes on average **10 times less space** than individual transportation
- Most cities globally devote less than 10% the space to bicycles that they do to cars
- Citizens in Amsterdam have 12x the bike lanes of those in London or LA (and in Helsinki 23x) but the car still takes up 2.5x and 1.8x the space of the bike, respectively

[4] Transportation and the Urban Form, Dr Jean-Paul Rodrigue

FIGURE 17

Even in the most pro-bicycle cities, Amsterdam and Helsinki, the bike is given only 40% and 54%, respectively, of the space of the car. In some cities, particularly in the US, this percentage drops to <4%. In Jakarta it is less than 1%.

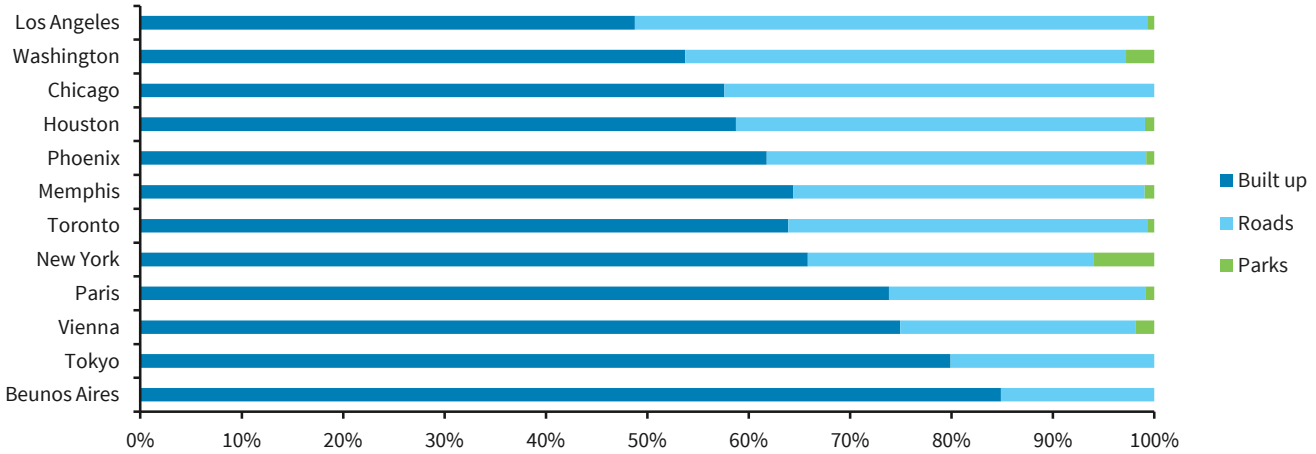


Source: Moovel Lab's 'What the street!?', McKinsey

- Could micromobility encourage lower car usage and therefore enable cities to devote less space to the car and more to parks and green spaces? We think so.
- A switch in urban space requirements could have wide-reaching implications for developers. Currently some sites are difficult/expensive to develop because the developer would be required to fund new roads. But if the road system were used more efficiently, by a larger number of smaller vehicles, infrastructure spending might reduce.

FIGURE 18

Cities currently devote the majority of their space to the car, and little to the pedestrian or green spaces



Source: transportgeography.org

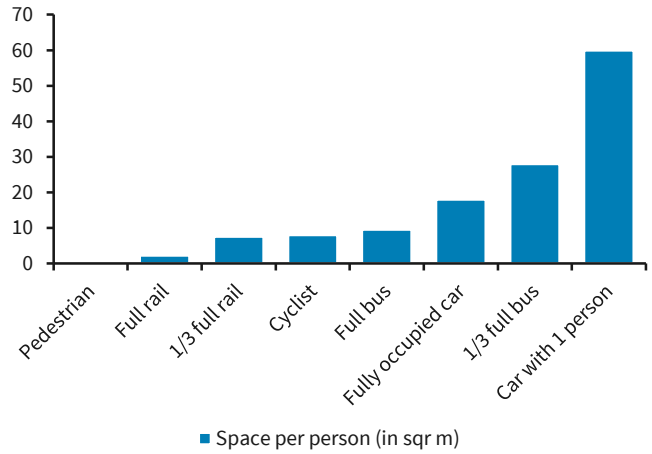
Micromobility can aid transit usage and provide first/last-mile solutions

In many cities globally transit usage is falling (as a result of both ride-hail uptake and increased vehicle miles travelled by personal car).

Given heavy investments in transit infrastructure and also its performance (when fully utilized) on both a space and speed basis, if micromobility operators can persuade cities that micro-vehicles are a viable first- and last-mile solution to enable more seamlessly integrated mobility, we think many cities are likely to embrace the mode.

FIGURE 19

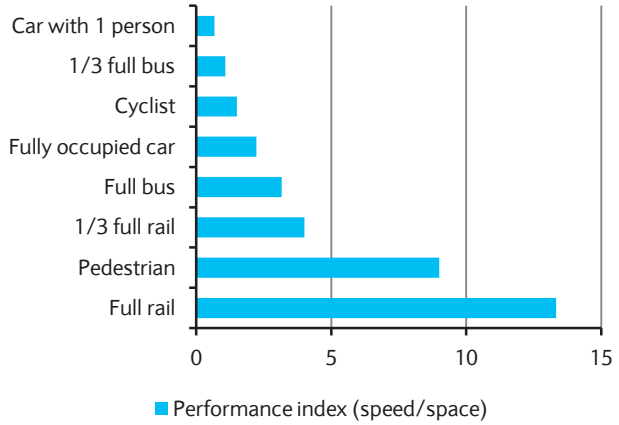
On a space/person basis, a single-occupancy car is the worst use of city space



Source: transportgeography.org, Tolley & Turton, 'Transport systems, policy and planning, NY'

FIGURE 20

Performance index (speed/space) shows transit remains the most efficient option, although utilization rates are important



Source: transportgeography.org, Tolley & Turton, 'Transport systems, policy and planning, NY'

Micromobility aids equitable access to public transport

As yet there is mainly only anecdotal evidence to show the impact of micromobility on public transit but a University of Kentucky report[5] found that bikeshare increases rail usage (although it can equally decrease bus ridership). A further report[6] in the US Sustainability Journal also found that transit usage has increased in the US where bikesharing is used.

JUMP CEO Ryan Rzepecki recently commented in a post on Medium[7] that the company had found that 55% of all JUMP trips in San Francisco started or ended in a community of concern (CoC), including many that had not been covered by the prior docked bikeshare system in the city. The company also found that riders on the income-eligible Boost plan were riding 2.5x more frequently than standard members. As part of JUMP's permit in San Francisco the operator has committed to keeping 20% of its fleet of e-bikes in CoCs.

Micromobility is already booming

Dockless e-bikes and e-scooters exploded onto the US scene in October 2017

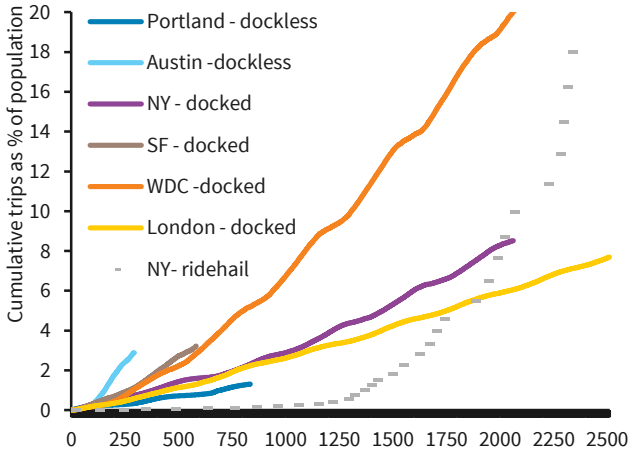
It was with **Bird's** e-scooter deployment in Santa Monica in October 2017 that dockless micromobility really captured the eyes of the press in the US (especially as it dropped the scooters in the city without prior approval). But dockless scooters secured such early success that they have since expanded to cover 130 US cities (154 globally). From a survey of 7,000 individuals across 10 major US regions from May to July 2018[8], conducted by Populus AI (a data platform to aid city and private operator mobility needs), the data shows that after less than 12 months of operating, c4% of the population had tried e-scooters in cities that have such schemes in operation (whereas docked bikeshare schemes took 8 years to reach their current 13% adoption rate).

[5] 'Understanding the Recent Transit Ridership Decline in Major US Cities: Service Cuts or Emerging Modes?' Michael Graehler, Richard Mucci, Gregory Erhardt, University of Kentucky, August 2018
[6] Yuanyuan Zhang and Yuming Zhang, 'Associations between public transit usage and bikesharing behaviors in the United States', *Sustainability*, June 2018, Volume 10, mdpi.com.
[7] *https://medium.com/@jumpbikes/celebrating-one-year-in-san-francisco-28469d5dccaa*, 8 February 2019
[8] https://www.populus.ai/micromobility-2018-july

Micromobility is already growing even faster than ride-hailing (Figure 1).

FIGURE 21

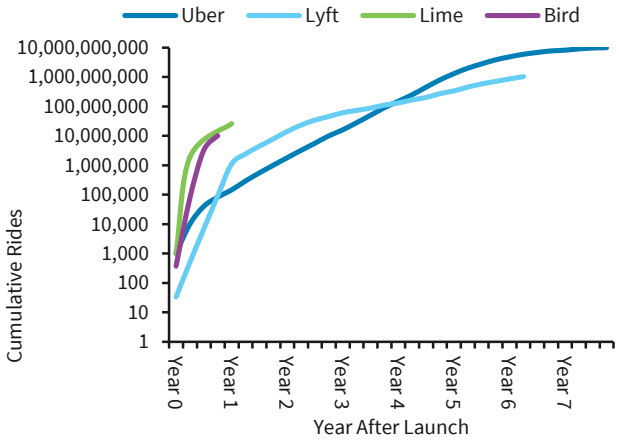
Docked & dockless bikes have shown strong uptake curves in cities where they are on offer



Source: NHTS, open source bike-share data from US and EU operators

FIGURE 22

Micromobility adoption in terms of cumulative rides has already overtaken ride-hailing in its infancy

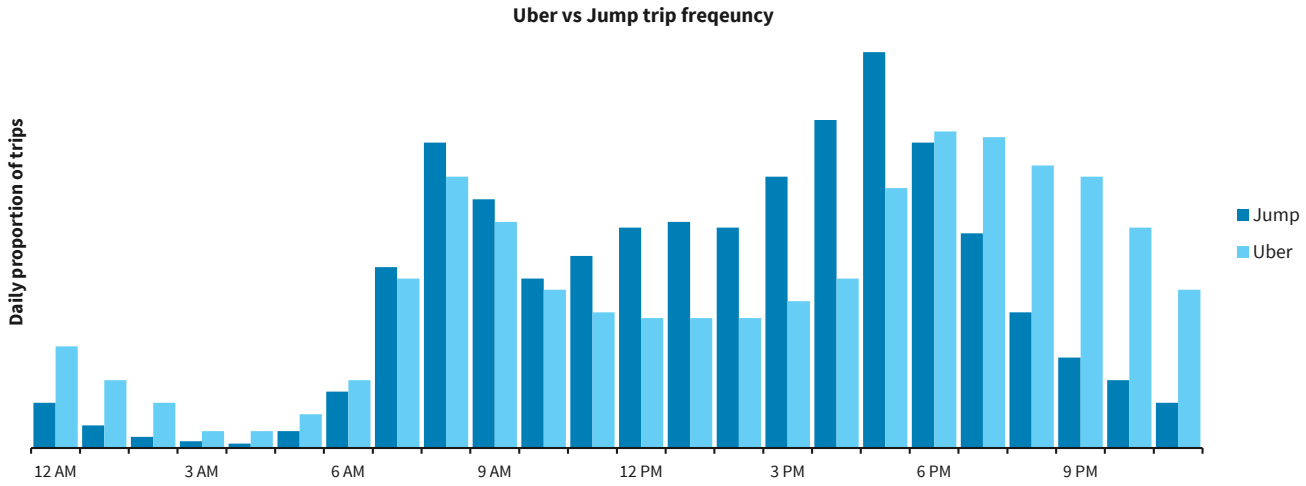


Source: Barclays Research, company data

At the Move 2019 conference in London last month, a representative from Uber explained the business had seen 10% loss of short trips (below 5km) since the advent of micromobility in San Francisco but that the growth in overall trips since its purchase of JUMP showed a 15% increase, which fully compensated for the shortfall[9]. Ride-hail operators can clearly see the opportunity for micromobility to complement the existing car-hailing business.

FIGURE 23

Ride-hail and micromobility (e-bike) usage is relatively complementary in its demand profile



Source: JUMP

[9] 'Celebrating One Year in San Francisco' Ryan Rzepecki CEO, JUMP Bikes, 8 February 2019 (via Medium)

Micromobility is happening now because…

In the meantime, micromobility is benefitting from large-scale trends in the transport sector and start-up companies can capitalise on those same trends without having to solve the 'toughest' problems of autonomy or range/cost of full EVs. In tech terms, it is the 'minimum viable product' that:

- Benefits from developments in vehicle **electrification**, and getting enough battery capacity to drive a scooter or bike is an easier to solve problem than hauling 2 tons of vehicle 300 miles,
- **Connects** via existing mobile infrastructure, without the need for 5G or V2x infrastructure,
- Harnesses **AI** (artificial intelligence) to analyse data on usage, without needing human-like intelligence to solve the edge cases for autonomous driving,
- Builds on business models pioneered in the **sharing economy**, without the need to disrupt personal auto ownership to achieve successful scale,
- Generates a lot of appetite in the VC ecosystem to fund (with to date €9.9bn invested in the micromobility space globally)

The opportunity is large

To attempt to estimate the potential addressable market for micromobility, we are extrapolating from historical personal transport trips in the US by distance and population density. We think 5 miles and below is a reasonable assumption for micromobility applications – Mobike in China found that 87% of riders use their platform for trips of less than 3 miles and 99.9% for trips of less than 5 miles[10]. This is a lot of trips, with c60% of the total 370bn annual trips in the US in 2017 below the 5-mile range.

Our approach to estimating the potential US market is to use cycling as a limited example of behaviour that we can scale up to estimate how people might use micromobility. We do this by:

1. Identifying current behaviour that has the most similar characteristics to future micromobility. **In our view, this is when known cyclists have a bike available to them**.
2. **Estimating the proportion of short trips that would switch to this solution if it were fully penetrated**, empirically adjusted for population density.
3. Estimating the scope for transformational uplift from changes in behaviour due to increased convenience and the last-mile problem. Here, we **use the transformation of taxi volumes due to ride-hailing as a multiplier**.
4. **Applying a dollar value to these total trip miles**.

How big could the micromobility market be based on current trip behaviour?

To create our baseline estimate for current cycling, we use the US National Household Transportation Survey (NHTS)[11] from 2017, which provides detailed data on about 130k households across the US and each household's use of every mode of transportation. Details of the NHTS are available in Appendix 1.

[10] 'The unofficial big data analysis of Mobike', Wo, 5 February 2017
[11] Federal Highway Administration. (2017). 2017 National Household Travel Survey, U.S. Department of Transportation, Washington, DC. Available online: https://nhts.ornl.gov.

Selecting current behaviour that looks like future micromobility – cyclists

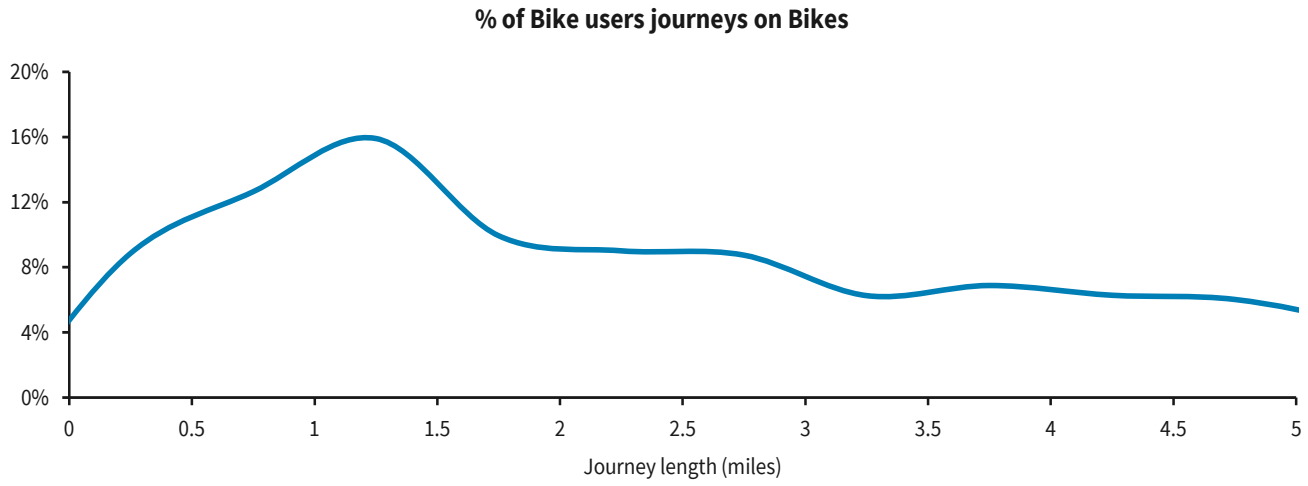
Micromobility's core current focus is for relatively short journeys, with the benefits including ready availability, ease of use, compact form factor and no need for parking as per autos. Some of these benefits are shared by existing bikesharing schemes, although the availability of such schemes has been narrow.

We believe that an analogous situation to future micromobility is bicycle usage to and from home, where a bike is owned. In our view, the decision faced (between a bike or another method of transport) in that moment is roughly analogous to the decision people will face when a micromobility option is available to them. Micromobility providers recognize the similarity in behaviour, along with the potential for expansion of it. For example, Lime highlighted in its annual report that more than 55% of its riders had not used a bike in the last month and 36% had not used one in the last six months (we account for these additional users who had not ridden a bike in the behaviour change multiplier).

We see from Figure 24 that the surveyed bike owners use their bikes for between 5% and 16% of short trips, depending on length. In more densely populated locations, where a bike is available, it is utilised more frequently.

FIGURE 24

Non-electric-bicycle journeys in the US peak between 1 and 1.5 miles in trip length

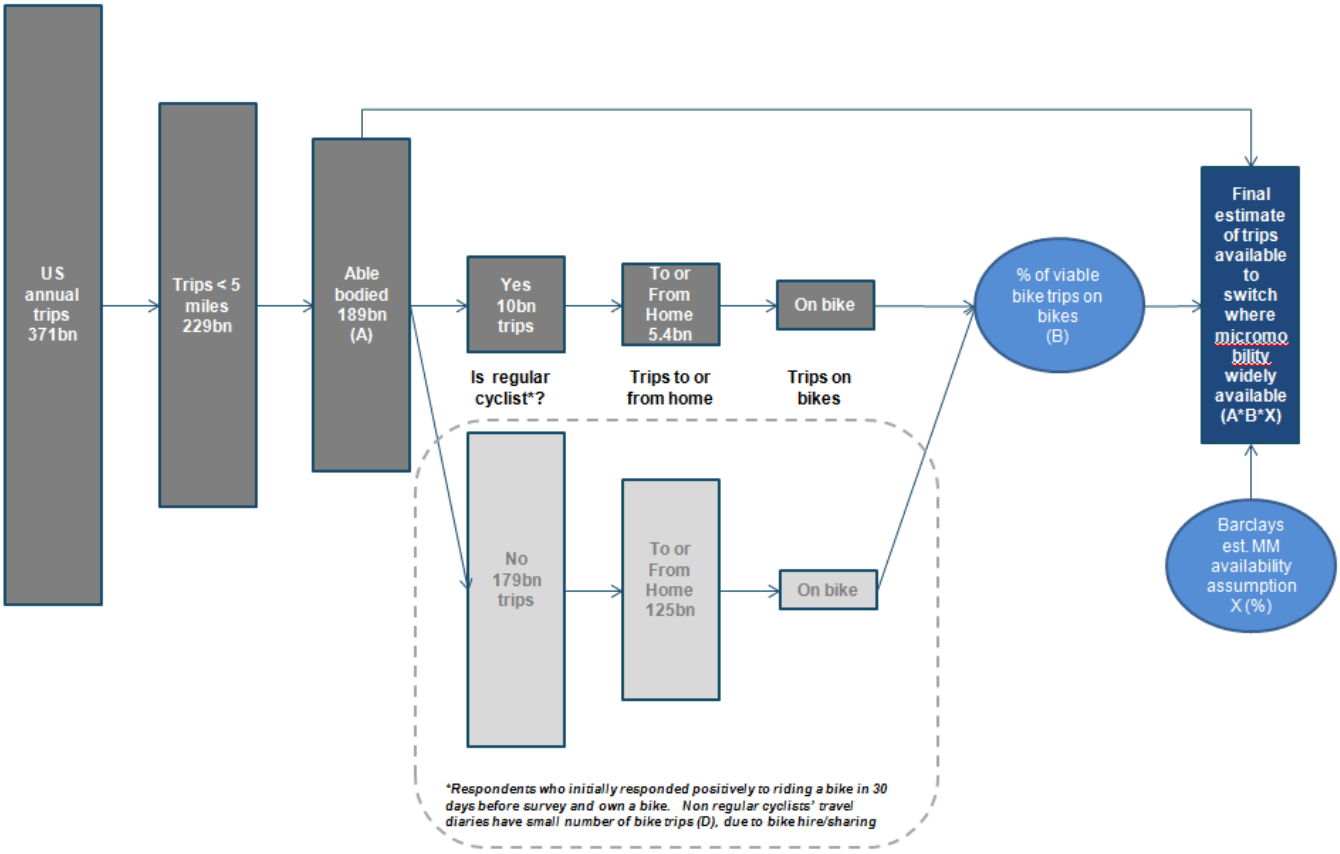


Source: NHTS, Barclays Research

The model

More details of the methodology of the model can be found in the Appendices, however, here we summarise the main four stages. Figure 25 also shows how we segment and filter the US population to achieve the first two stages.

FIGURE 25
Schema of US population for our estimation model, before segmenting by population density



Source: NHTS, Barclays Research

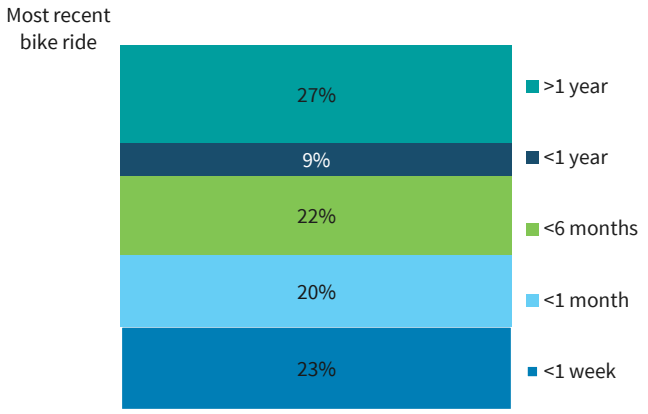
First, we estimate the rate of short trips that are on bikes, when a bike is available. We define our signal sample as 'cyclists at home'. There are 8047 individuals in the 2017 survey who are defined in this sample, representing proportionately 7.9 million members of the US population (with a standard error of 0.3m). We also refine this by making different estimates in different buckets of population density, because cycling behaviour varies depending how densely packed a place people live in. On average 12% of the relevant short trips were taken on bikes in 2017.

Second, we estimate the baseline number of micromobility trips by multiplying the rate of bike usage by Barclays' assumption of how available micromobility would be in each density bucket. In the densest urban areas of the US, such as San Francisco or New York City, where micromobility vehicles might be close to virtually the entire population, the assumption is 100%. For other areas, X is materially below 100% to represent the number of houses that are close enough to a micromobility vehicle to make use of it. Put another way, this is the number of bicycle trips we think would happen if bikes were as available as micromobility in a fully-penetrated MM world.

Third, we scale that baseline up by a multiplier for how behaviour might change because of micromobility. People are likely to use an electric-powered micromobility vehicle more than they would use a human-powered bike in the same situation. And there are clear advantages of dockless, shared vehicles versus personally-owned bikes (upfront cost, parking, storage, etc). Additionally, an electric scooter is in some cases easier to use (especially if a helmet is not mandatory) for many riders. A recent global survey by e-scooter operator Lime found that of more-than 11,000 responses, 30% of riders replaced a

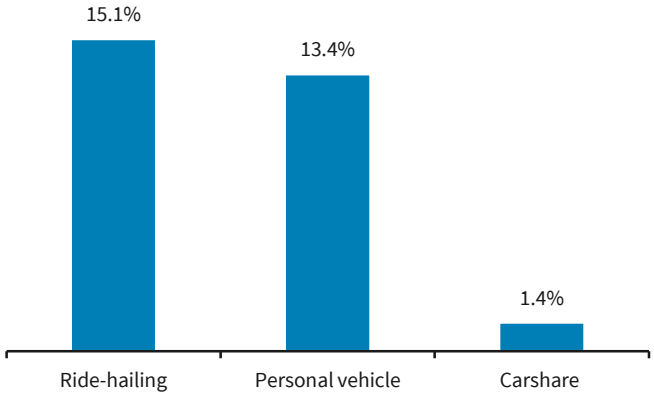
trip they would normally take by car with a bike or scooter and that many new or irregular bicyclists were enticed by the mode in a shared capacity.

FIGURE 26
Lime's 2018 year-end report found that 36% of its riders had not ridden an owned bike in more than 6 months



Source: Lime year-end report 2018

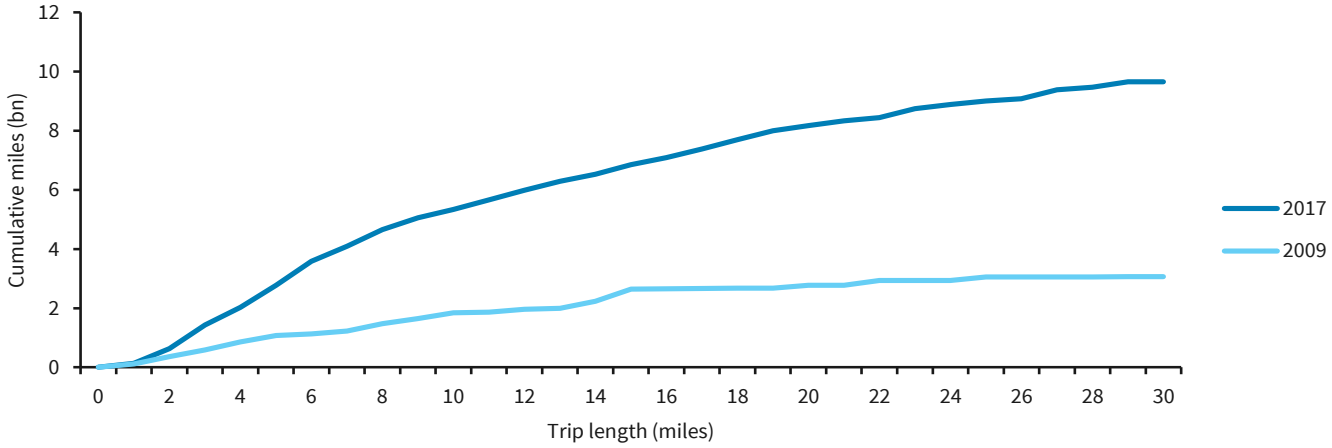
FIGURE 27
The Lime report also found 30% of its riders had switched from using a car to using their micromobility vehicles



Source: Lime year-end report 2018

The best estimate we have for assessing potential behavioural change from micromobility is the increase in taxi usage after the arrival of ride-hailing, which was an increase of about 3.7x across all situations (Figure 82). The advent of ride-hailing added 12.1bn taxi miles in the US.

FIGURE 28
Cumulative miles travelled for taxi/limo trips have increased substantially from the 2017 NHTS survey 2009[12] and 2017



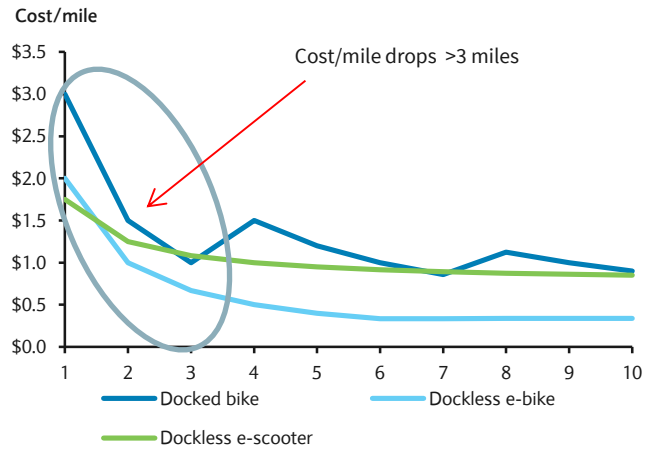
Source: NHTS, Barclays Research

Fourth, we multiply the number of miles by an average revenue per mile for micromobility companies.

[12] Federal Highway Administration. (2009). 2009 National Household Travel Survey, U.S. Department of Transportation, Washington, DC. Available online: https://nhts.ornl.gov.

FIGURE 29

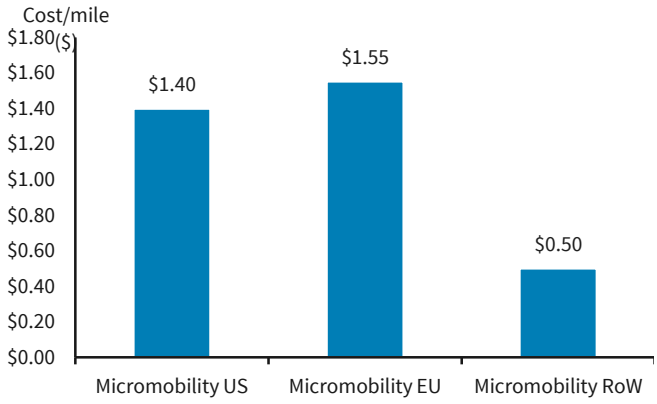
In the US, cost/mile of micromobility drops significantly over 3 miles but the average e-scooter journey is less than 2 miles



Source: Barclays Research, JUMP, Bird, Lime

FIGURE 30

Current cost/mile of e-scooters by region



Source: Barclays Research, Bird, Lime, Jump, Neuron Mobility, Scoot Global

The results

In Figure 31 below we show our estimates for trips of <5 miles that might become available to switch to micromobility. Overall, we estimate approximately 6% of our target demographic's trips might switch. However, in the densest areas of the US, this figure is as high as 18%, reflecting higher assumed availability of shared micro-vehicles.

Based on this 'bicycle behaviour' model, we estimate that 11bn trips/annum in the US could become available for micromobility, or 18bn miles.

We then look at those incremental trips that might switch to micromobility based on a 'behavioural change' model. We take the 3.7x increase that ride-hail brought to taxi trips between the 2009 and the 2017 NHTS surveys, and assume micromobility could also drive a similarly 'disruptive' increase in mileage. This leaves a model for the US of 42bn estimated trips or 66.5bn micromobility miles. To this addressable market we apply the current e-scooter price/mile of $1.4 in the US to reach a potential US revenue opportunity.

FIGURE 31

If micromobility uptake were to follow a similar model to ride-hail uptake, we estimate there could be 42bn trips available for micromobility modes

	a	b	c	d	e	d_2	f	g	h	i
Household population density	% of reference trips that currently use bike	Barclays' forecast availability of MM by pop density	Total US trips <5 miles (bn)	Of which able-bodied non-cyclists	Estimated 'bike behaviour' MM trips (bn) (a * b *d)	Ride-hail / taxi behaviour change multiplier	Barclays' estimated trips available for MM in a behavioural change scenario (bn) (e * d_2)	Barclays' estimated miles available for MM in a behavioural change scenario (bn) (f * 1.58)	Revenue / mile	Total US revenue opportunity (g * h)
0-99	5%	5%	18.9	16.3	0.04	3.7	0.1	0.2	1.40	0.33
100-499	8%	15%	26.1	21.9	0.22	3.7	0.8	1.8	1.40	2.54
500-999	8%	25%	19.6	16.6	0.23	3.7	0.8	0.9	1.40	1.20
1,000-1,999	6%	35%	29.1	24.3	0.53	3.7	2.0	4.1	1.40	5.76
2,000-3,999	12%	45%	46.8	38.7	1.73	3.7	6.5	9.4	1.40	13.22
4,000-9,999	17%	65%	58.3	47.7	4.62	3.7	17.2	26.5	1.40	37.15
10,000-24,999	18%	85%	19	15.2	2.11	3.7	7.9	11.7	1.40	16.42
25,000-999,999	18%	100%	11.2	9.2	1.75	3.7	6.5	11.7	1.40	16.44
Total	**12%**	**46%**	**228.9**	**189.8**	**11.2**	**3.7**	41.8	66.5		93.07

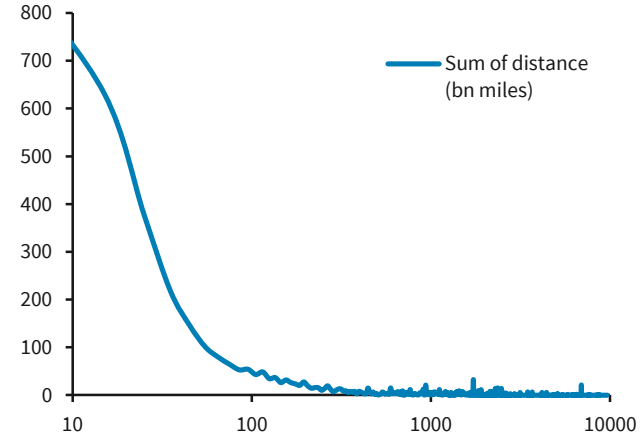
Source: Barclays Research

Scaling the model to global potential

We see from the NHTS that 48% of US miles travelled are for journeys under 30 miles (11% of PMT are <5 miles) and 95% of all trips are below 30 miles (60% <5 miles). This is illustrated in Figure 32 and Figure 33. This shows the size of the market in the US for short journeys is large in absolute terms, but also in terms of the % of overall travel.

FIGURE 32

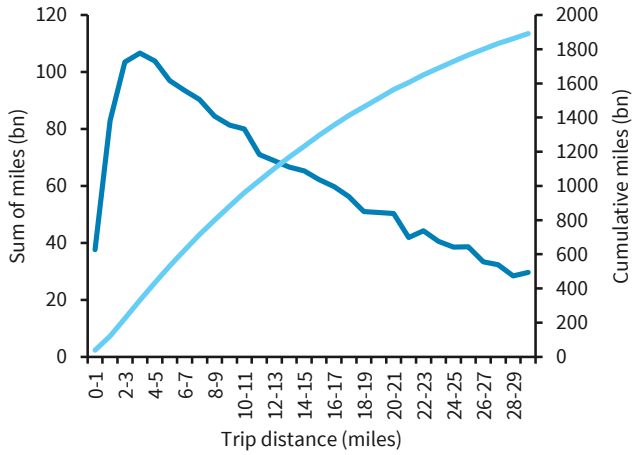
Trip miles in the US show the majority of trips fall in the 10 miles and below category



Source: NHTS, Barclays Research

FIGURE 33

Trip frequency clusters around short-distance journeys (peaking at 3-4 miles)



Source: NHTS, Barclays Research

We do not have the same granularity of data for travel modes and distances on a global basis but we believe our US model can be used to build a global addressable market forecast for micromobility, based on population density.

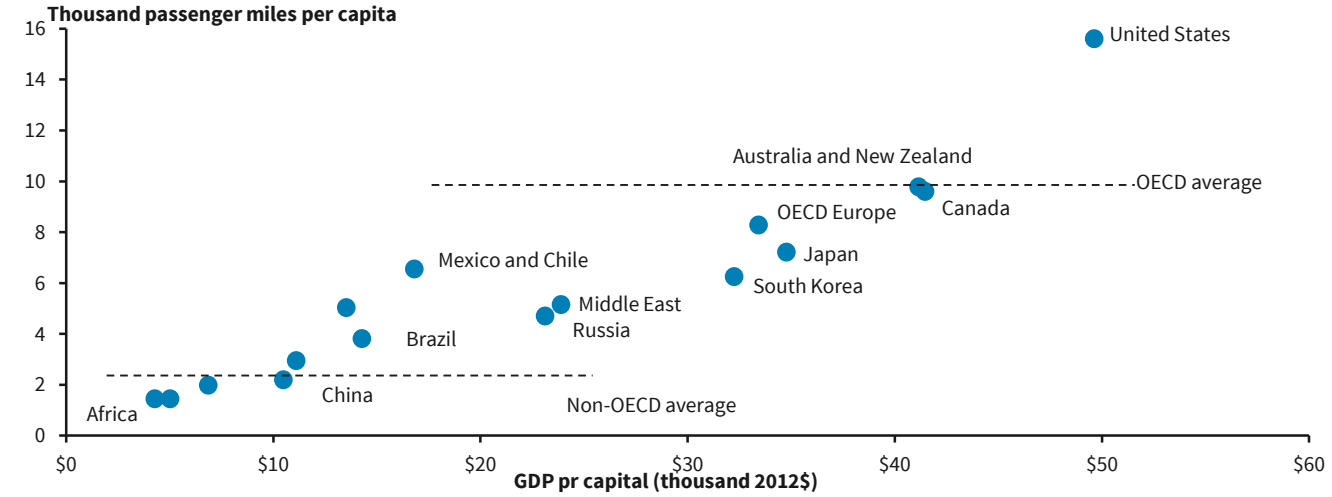
Every year there are currently 30tn PMT globally

We have used our US model, combined with EIA data on PMT and UN estimates for urban population density globally, to build an estimate for the global addressable market for micromobility.

As we can see from Figure 34 below, average distance travelled by passengers (PMT) annually is greatest in the more developed regions of the world and declines in regions with lower GDP/capita. This difference in distance, as well as differences in travel mode, are important to consider when thinking about the global propensity for micromobility uptake.

FIGURE 34

Passenger Miles Travelled (PMT) per capita per annum differs widely by geography



Source: EIA 2012

Based on our US micromobility model, 254miles/person/year (66bn incremental miles for a US urban population of 0.26bn, according to UN population statistics) could become accessible for micromobility in dense urban regions – 0.7 miles/day or 0.5 trips/day (assuming an average trip length of 1.5 miles, which is the average length of trips for current US dockless micromobility). Scaling this globally based on UN urban population statistics, we see an opportunity for 1.1 trillion PMT globally to come from micromobility (~75% from less developed regions of the world). This could potentially rise to over 1.5tn by 2050, based on UN urban population growth forecasts, with over 1tn of these micromobility miles coming from Asia and Africa alone:

FIGURE 35

Barclays' estimated global urban addressable market for micromobility (PMT/region/year) based on UN urban population growth estimates and population density statistics

Region, subregion, country or area	Today	mid-2020's	2050
WORLD	1,010	1,110	1,700
More developed regions	250	260	290
Less developed regions	760	860	1,410
AFRICA	130	150	380
ASIA	540	600	890
...of which China	200	220	280
...of which India	110	120	220
...of which Rest of Asia	230	260	390
EUROPE	140	140	150
LATIN AMERICA	130	140	170
NORTH AMERICA	74	78	98
...of which US	66	70	88

Source: Barclays Research, NHTS, UN Urban Population forecasts

There were 4tn personal miles travelled (PMT) in the US in 2017 (3.3tn on land). We estimate there are **currently ~30tn PMT globally** (based on national statistics and data from the EIA and Worldbank). Our model above assumes just 4% (1.1 trillion) of these global miles might switch to micromobility (although closer to 20% of all trips below 5 miles in length in urban locations).

At current e-scooter costs by region (which are currently 2-3x e-bikesharing prices), c80bn micromobility miles in North America could generate revenue of $130bn/annum. We believe the additional speed, fun and lower 'hassle' factor of micromobility over time, particularly if cities globally start to instigate aggressive anti-car strategies, could enable higher pricing strategies as time progresses.

On a global basis we see scope for 1.1 trillion PMT switching to micromobility and a $800bn global market in the next few years.

FIGURE 36

We estimate potential for the global addressable market for micromobility to provide a global revenue opportunity of $800bn at today's prices and population, $1.1tn by 2050

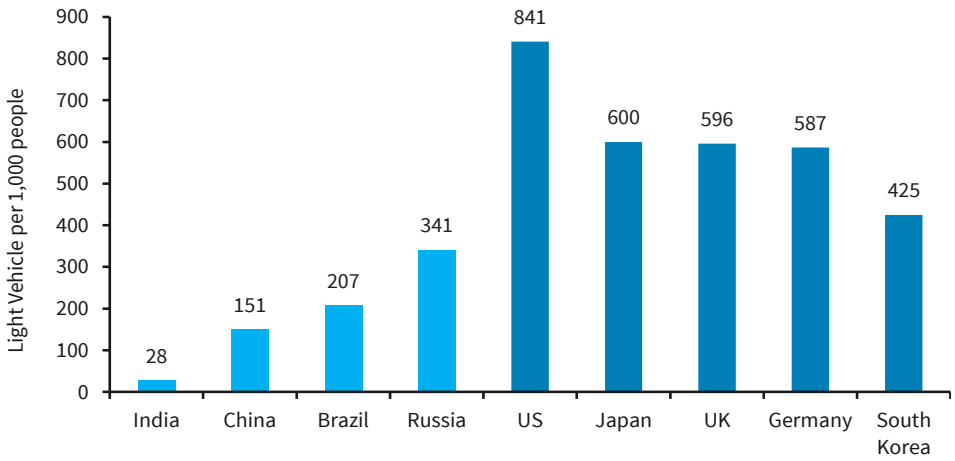
	Today	mid-2020's	2050
North America	$120	$130	$160
Europe	$220	$220	$230
RoW	$400	$450	$730
GLOBAL	$740	$800	$1,120

Source: Barclays Research

Transport methods vary widely by country and region. Car density is highest in developed markets and particularly high in a car-centric region like the US.

FIGURE 37

Car density (ownership/1000 inhabitants) in developing markets is significantly lower than in mature markets

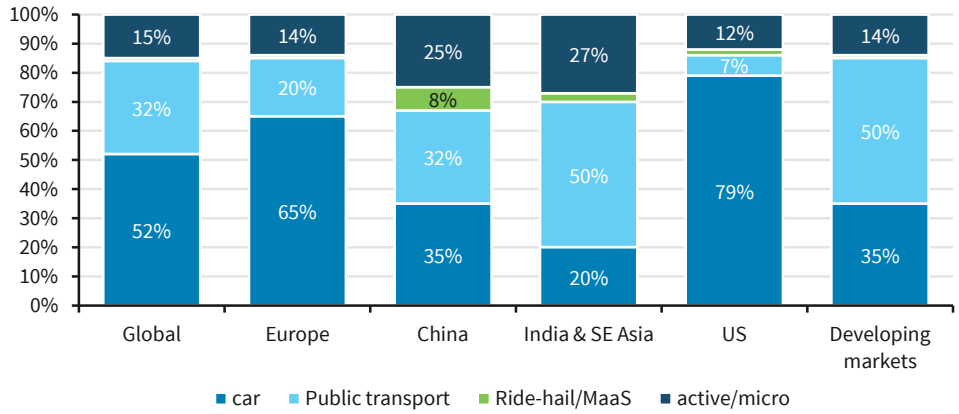


Source: IHS, Barclays Research

We present below our estimate of personal land transport journeys split by mode based on an overview of data from NHTS and other similar national statistics globally. Were we to present the same split by miles or PMT, car and public transport percentages would have an even greater weight, given the larger distances travelled on average via each mode. But what is clear is that there is already a skew towards greater active and micro transport in developing regions of the world. For convenience, we have included non-electric 2- and 3-wheeled vehicles in this bucket, which we do not classify as 'micromobility' for the purposes of this report but we do see as being part of the addressable market for micro-electric vehicles. We see a significant long-term opportunity in developing markets for this mode to electrify, just as has been seen already in China with the recent uptake of electric bikes.

FIGURE 38

Mode of transport globally differs by region (trips) but we estimate that electric-micromobility is currently a low-single-digit percentage in all regions

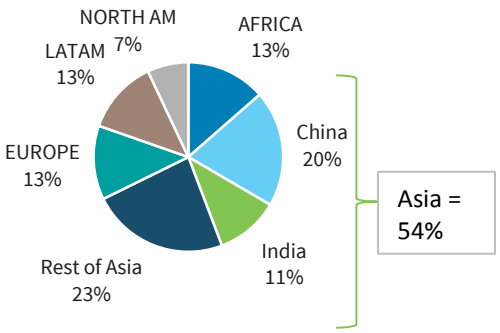


Source: Barclays Research, NHTS, national statistics * currently the majority of active/micro is 'walking' e.g. in the US 11% of trips are on foot versus 1% using bicycles or mopeds as per 2017 NHTS data

But with more and more trips available to potentially switch to micromobility, we could see a scenario in the mid-2020s where 9% of all trips (4% of PMT) switch to the mode. However, given our forecasts for overall global PMT and trip growth (based on UN population forecasts), the absolute number of car trips would not decline, despite this rapid growth in micromobility and also ride-hail (Figure 40).

FIGURE 39

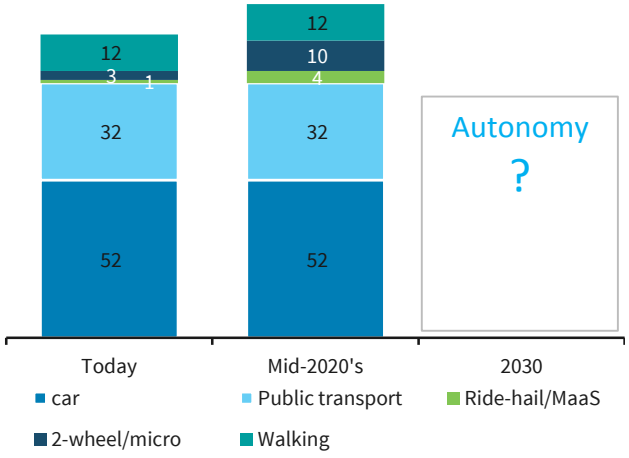
Based on our addressable market model, we show below our forecast breakdown of PMT by region in the mid-2020s



Source: Barclays Research, NHTS

FIGURE 40

Indexed to 100 today, we expect the growth in total global PMT by the mid-2020s to see no absolute decline in car usage, but growth in micro from 3/100 trips (3%) today to 10/110 trips (9%) by the mid-2020s



Source: Barclays Research, national statistics

Limitations of our model

Our model uses real US mobility data and the rapid changes due to ride-hailing to derive indicative estimates of the potential market size for micromobility. The model's output is best considered as a guide to orders of magnitude and to identify the important factors that could determine potential market size. A major constraint we have imposed is to not consider any journeys over 5 miles.

We believe the behaviour isolated could be similar in nature to future micromobility potential, but nevertheless acknowledge this is an analogy, not a direct observation. Whilst the relationships between a number of factors could feasibly be different for cycling and micromobility, we believe assuming similarity is a useful approach. Of course, uptake largely depends on the successful launch of attractive and well-priced micromobility solutions, and on buy-in from local authorities. Our model does not explicitly use these factors as inputs.

We use bicycle trips as an inputs. Bicycles carry capital cost and storage needs that are lower than personal vehicles but higher than micromobility pay-as-you-go schemes, giving us reason to believe our estimate could be conservative. Additionally, it is obvious that micromobility requires less physical exertion than cycling and the impact of this advantage is hard to quantify, particularly for longer journeys and across age groups. It is worth noting that the US is currently proposing *(US Bicycle Commuter Act 2019)* a new tax break for bicycle commuters, which would include a tax break off the cost of bikeshare usage or riding an electric bicycle. If this were to come into effect, it could potentially drive higher adoption of cycling (or of micromobility) in the US, which is not factored into the above model.

The impact of weather, durability and non-able-bodied accessibility is also hard to incorporate as these features will emerge and develop over time. On the latter, our able-bodied-only assumption is conservative, implying a lack of focus on this area in the short to medium term. We also assume the switching potential to micromobility will follow similar trends to ride-hail, when in reality the convenience of a weather-proof car with a driver and baggage space may heavily outweigh that of an electric-bike or scooter.

Finally, when extrapolating to non-US territories, the distinct differences in demographic factors such as population density, age, personal vehicle ownership and infrastructure create uncertainty. We choose to extrapolate to 'dense' areas in UN figures as we believe the comparability of these areas outside of the US is greater.

Can micromobility operators make money?

On our forecast of 1.1 trillion miles/annum (or 3bn/day) as the potential addressable market for micromobility by the mid-2020s and 681bn trips/year, we have attempted to forecast the addressable market for the micro-vehicle parc. We have split the parc into those vehicles that are personally owned (we assume 20% of the overall fleet, based on current bicycle statistics and our assumptions for accessibility of shared micro-vehicle fleets in urban areas) and those in shared use. We assume higher mileage on personally owned vehicles (2.5miles/trip), than shared (1.5/trip) based on current average urban distances travelled in the US on bicycles and shared dockless scooters (although we note that with an electric bicycle it is easier to travel longer distances than on a push-bike). We also make an assumption of utilization rates – 2x/day for an owned vehicle, to equate to a 2-way commute and 10x for a shared vehicle (in the US, Jump reports utilization of 7/day on its shared bikes and Bird reports 6x utilization rates on e-scooters – we assume this utilization improves as micromobility matures and more vehicles are made available). This leads us to forecast a micromobility vehicle parc of 280m vehicles by the mid-2020s (120m owned and 160m shared).

FIGURE 41

We have built a forecast for global micro-vehicle parc by the mid-2020s, based on our global addressable market assumptions

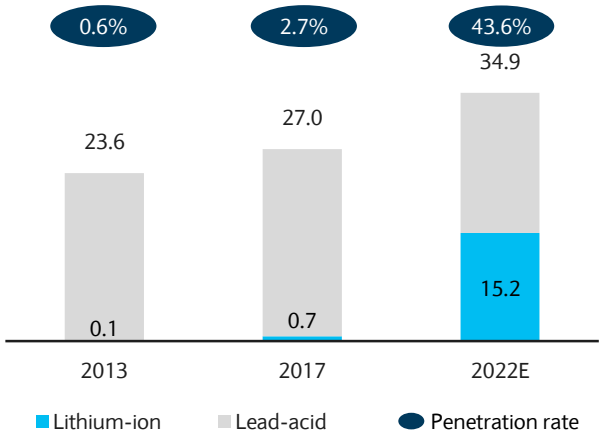
	Per year	Per day		
		Total	Owned	Shared
Global PMT (billions)	1,110	3.0	0.6	2.4
Global Trips (billions)*	681	1.8	0.2	1.6
Barclays est. utilisation/day			2x	10x
Micro vehicle parc (millions)	280	280	120	160

Source: Barclays Research *assuming 1.5miles/trip for shared vehicle and 2.5miles/trip for owned

Assuming improvements in current vehicle quality and more industrial-grade products for the shared market, we have assumed a turnover of 10 years for owned vehicles (assuming the ability to swap and upgrade batteries) and 4 years for shared, implying annual vehicle sales of 56m. This compares to the CIC forecast highlighted by NIU with its Q4 results earlier this week for an addressable market of 35m 2-wheel, electric-powered vehicles in China alone by 2022 (of which it forecasts 44% to be lithium-ion powered) – see Figure 43. Of course, should our assumptions for vehicle longevity prove too optimistic, the annual sales volume would need to increase to sustain a parc of 280m vehicles. Conversely, should vehicle utilization rates prove higher than our 10x assumption for shared vehicles, the number of vehicles in the parc required to reach our global trip forecasts would fall.

FIGURE 42

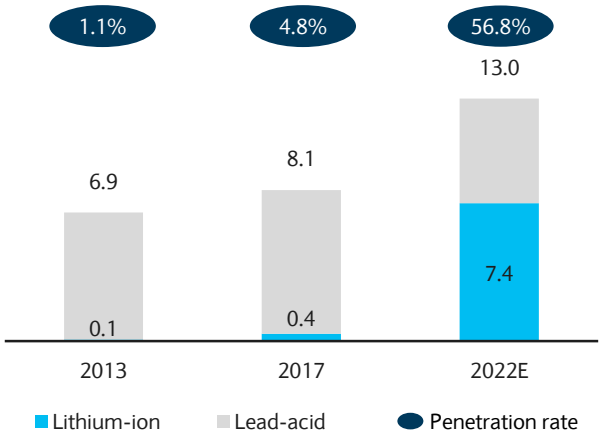
In NIU's Q4 results presentation, it showed forecasts for electric 2-wheeler volume growth in China (mn)…



Source: CIC, NIU

FIGURE 43

…and forecast $7.4bn of revenue from lithium-ion 2-wheelers by 2022 (US$ bn)



Source: CIC, NIU

Micro-vehicle OEMs could see revenues rising to >$22bn from micro-vehicle sales and Semis manufacturers could see chip revenue of >$200m

At $400/vehicle (assuming prices come down in the next few years – CIC currently uses $500/vehicle, which compares with consumer-grade e-scooters currently available to the consumer on Amazon), this equates to a $22.4bn annual revenue opportunity for micro-vehicle manufacturers. The number could be higher for e-mopeds and e-bikes/pedelecs, given prices are currently higher for these products than for electric kick scooters. Semi

manufacturers could also see >$200m of annual revenue content from increased power and semi chip content of c$4/vehicle.

FIGURE 44

We forecast 56m annual sales volume of micro-vehicles, or $22.4bn revenue opportunity for OEM manufacturers and $220m for semi manufacturers

	Total	Owned	Shared
Est. Annual MM sales volumes***	56	12	44
Riders/day (billions)**	0.9	0.1	0.8
Est revenue to OEM manufacturer (millions)****	$22,400	$4,800	$17,600
Est. Total revenue to Semi manufacturers (millions)	$220	$50	$180

Source: Barclays Research ** assume 2 rides/day/rider; ***assumes average life of 10yrs/personally owned, <4yrs for shared vehicle; ****assumes cost of $400/vehicle

Can micro-operators make money?

What does this mean for micro-vehicle operators? From our discussions with some of the start-up operators and interested venture capital funds that presented at the Micromobility conference in January in San Francisco, as well as recent press reports[13], we conclude that, while micromobility operators are currently attracting large funds of money, and many are generating positive gross profit margins, the industry is as yet unlikely to be profitable at the bottom line. Costs of expansion, marketing and competition to gain network have led many operators to try to undercut their competitors and give attractive offers to entice new riders. Additionally, city planners are increasingly restricting numbers of vehicles allowed on the streets and requesting up-front fees for licences or, in some cases, an additional fee/ride.

We estimate the average revenue/ride in the US for e-scooters is $3.3/ride (assuming an average journey of 2 miles and trip length of 15 mins at average San Francisco scooter prices as at March 2019). However, the revenue is dependent on trip length (mins) or distance (miles), which can differ widely by city. In Europe, we estimate average revenue is lower and currently closer to €1/ride (based on our discussions with operators and statistics from cities that report ride data).

We understand operating costs include charging & relocating, regulatory costs (city-permits/licensing fees), repair, credit-card fees, insurance and customer support. Vehicle-acquisition and churn costs are also important. Fixed costs for head office and salaries will come on top of these operating costs. We understand from our discussions with operators that charging and reallocation costs average around $10/scooter/day and city permits in some instances are $1/vehicle (per ride these costs drop depending on vehicle utilisation stats). Below we show our low and high estimates for operating costs for e-scooter operators, based on current prices in the US and different assumptions for trip length and utilisation. It is clear that, to be profitable at an operating level today, micromobility operators need to ensure the highest utilisation rates and reduce variable costs as well as vehicle churn.

[13] 'This Scooter-Sharing Company wants to Fill the Streets with 'Transit Pods'', Bloomberg, 10 May 2018 and 'The revenue, costs, and margins behind Bird Scooters', Crunchbase, 24 Octobers 2018

FIGURE 45

Barclays' scenarios for micromobility operating profitability in the US (at current prices and costs), depending on vehicle utilization rates and trip distance, as well as variable costs and vehicle depreciation

e-scooter (cost/ride)	Current estimate	Mid-2020's potential estimate
Rides/day	6	10
Trip length (mins)	15	18
Trip length (miles)	2.0	2.5
Avg revenue/ride (US$)	3.3	3.8
Revenue/day (US$)	19.50	38.13
Op cost/ride:		
Charging & rebalancing	1.67	1.00
City permit	0.17	0.10
Customer support	0.06	0.06
Repair & churn	1.00	1.20
Insurance	0.05	0.05
Credit card fees	0.41	0.35
Op cost/ride (US$)	3.35	2.76
operating Profit/scooter	-0.10	1.05
operating Profit/day	-0.62	10.53
Scooter cost + connectivity (US$/vehicle)	450	250
Scooter useful life (days)	100	250

Source: Barclays Research, McKinsey, Axiom, Bird, Jump

The economics clearly differ for e-bikes and e-mopeds as upfront vehicle costs are higher and utilisation differs – dockless e-bikes to date are used for longer distances but utilisation rates/vehicle are lower than for e-scooters. Vehicle churn is reduced the higher quality the vehicle.

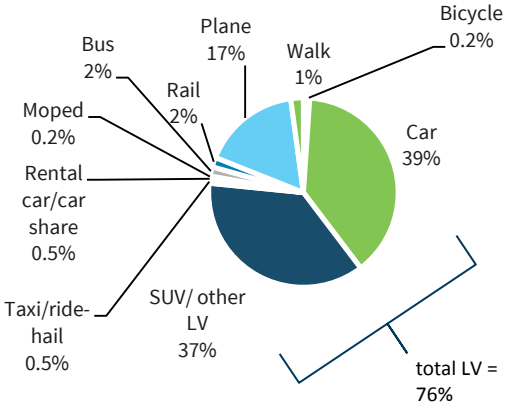
Risks remain that micromobility will be only a niche

Affordability does not explain the consumer's love for the car

It seems that cost does not explain why light vehicles comprised 76% of all personal miles travelled in the US in 2017 (albeit down from 86% at the last survey in 2009). Even looking only at urban environments and trips of <3 miles, 73% of PMT were taken in a light vehicle and only 3% by bicycle.

FIGURE 46

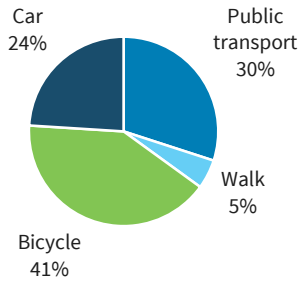
In 2017, 76% of all US passenger miles travelled were by personally owned Light Vehicle…



Source: NHTS 2017

FIGURE 47

…even in a bike-centric city like Copenhagen, 24% of commuter journeys are taken by car



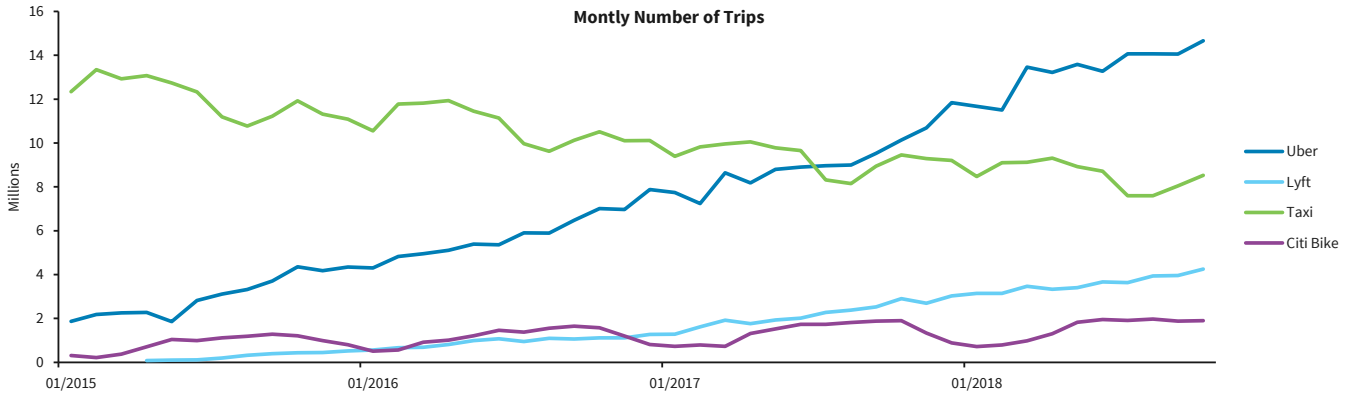
Source: www.cycling-embassy.dk

Weather may be an insurmountable obstacle, even in the densest cities

There is certainly a risk that climate and weather limit the adoption of micromobility in urban areas where it would otherwise be a good option. For example, in New York City, the Citi Bike program shows a clear seasonality pattern, with much lower usage in the winter (Figure 94). At the same time, ride-hailing has grown much more quickly overall, and without any pronounced seasonal pattern.

FIGURE 48

Ride-hailing monthly trips surpassed taxi trips in NYC since June 2017. Bikeshare trip growth has remained flatter and more seasonal.



Source: Uber, Lyft, Citi Bike, NYC government statistics

Does the micro 'form-factor' suit all scenarios?

Our addressable market assumes only 4% of all global PMT switches to micro-vehicle modes by the mid-2020s (and our model assumes only able-bodied people make the switch), but it is of course worth mentioning that many urban trip scenarios depend on a car for transporting more than one passenger and for transporting goods. There will naturally be many scenarios whereby using a ride-hail multiple, even to current bicycle trips, is not relevant because the purpose of the trip (e.g. a visit to a shopping centre or supermarket, which could require transporting multiple bags) does not fit with micro-vehicle use. As vehicles evolve and velomobiles, e-cargo bikes and LSEVs (low-speed electric vehicles) start to grow in popularity, this may overcome some of these challenges but we still assume that 96% of all PMT are via modes other than micro by the mid-2020s.

Do cities want micromobility?

We can see why consumers want to embrace micromobility as a fast, easy, fun and cheap way to get around urban and suburban areas and the latest utilisation statistics bear this out. But do cities want to embrace micromobility in the same way?

To date, cities have proved sceptical. In Europe many operators have yet to make any inroads due to tougher vehicle regulations and elsewhere cities are nervous about excess supply, sidewalk clutter and safety[14]. And cities have also become wary that micromobility might follow similar trends to the last mobility disruption – ride-hailing – and serve to:

- increase congestion and
- decrease transit ridership

Dockless micromobility is controversial in the US for sidewalk clutter and safety

The launch of dockless bikes hasn't been an entirely smooth progression, with many cities pushing back, including San Francisco, which gave only three operators permits to use dockless micromobility in the city. Sidewalk clutter and safety are two of the key complaints against the mobility mode. But that did not stop both Lime and Bird reaching 'unicorn' status and surpassing 10m cumulative rides in record time.

Many US cities are exercising caution on micromobility…

Many city planners are starting to clamp down on unregulated micromobility usage. Bird's and Lime's unauthorized entry into San Francisco, and unlicensed operating in other US cities, did not help with micro's PR and saw the operators receive 'cease-and desist' letters from numerous cities. Bird's 'Save the Sidewalk' campaign was an attempt to win back favour and other operators have been similarly collaborative and keen to work with cities. And consumers have clearly shown their appetite for the mobility form with strong ridership statistics.

…and conflicting regulations in Europe are making expansion choppy

While e-scooter companies do operate across Europe (e.g. in Berlin, Bremen, Frankfurt, Zurich Vienna and Paris), in the UK the vehicles are classified as 'powered transporters' and can only be legally used on private property. Unless the Department of Transport changes its definition, e-scooters operators are not coming to the UK. Similarly, in September 2018, Madrid temporarily banned three e-scooter operators, claiming the apps did not abide by rules that restrict the vehicles to bicycle lanes and single-lane streets with a speed limit below 30 km/h[15]. But if the operators comply with local licensing laws and adjust their apps

[14] 'Dallas family seeks answers after man riding electric scooter dies' and 'A Lime scooter accident left Ashanti Jordan in a vegetative state. Now her mother is suing on her behalf', The Washington Post, February 2019, 'Lime e-scooters pulled from Zurich and Basel after accidents', The Local, 9 January 2019

[15] 'Madrid orders removal of electric scooters within 72 hours' – *The Telegraph*, 5 September 2018

to comply, e-scooters should be allowed back on the streets. Regulators are battling to update regulation on micromobility to keep up with consumer demand.

Given the lack of consistency globally in regulations, we think scooter operators will either have to push hard for regulatory change, or be flexible in their approach to which vehicle is best suited to which environment.

Bike recycling & charging need to be ecofriendly too

Micromobility will only be environmentally friendly if the charging system is also as CO_2 neutral as possible. We also think policymakers need to be aware of the necessity to stipulate regulations on vehicle and battery afterlife. Advances in battery design and chemistry have brought down costs significantly but battery durability still remains an issue for most operators. Additionally, while our model may show a strong propensity for micromobility, in many regions globally, the charging infrastructure and supply chain for lithium-ion batteries is currently not developed enough to cope with the high numbers of electric vehicles we forecast.

Safety may also prove an impediment to micromobility

According to WHO, 1.25 million people/year are killed in automobile accidents globally. Currently city regulators are nervous about safety statistics from e-scooters, given many riders are new to the mode, or not abiding by the rules of the road, but we would expect these statistics to improve as the micromobility mode matures and vehicle iterations improve on safety features.

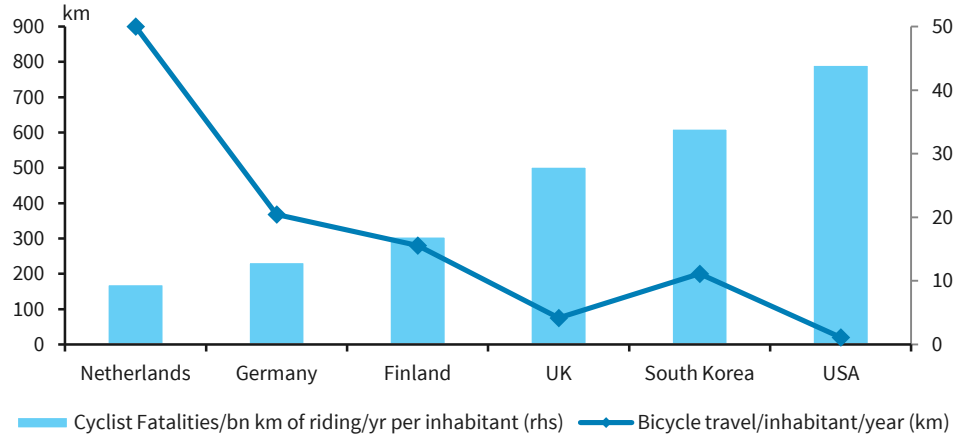
Safety issues with e-scooters

- Small wheels can get caught on uneven sidewalks/roads
- Damp weather can weaken tyre grip
- Many riders are inexperienced and unused to the speed of acceleration or more used to bicycle usage and therefore not as adept at stopping/balancing/turning a scooter
- Speed differential with pedestrians on sidewalks
- Speed differential with larger vehicles on roads
- Visibility of e-scooter for car drivers/truck drivers on roads
- Speed differential with non-electric bicycles in cycle lanes

But, as the graph below shows, safety can improve by sheer number of vehicles on the road.

FIGURE 49

Cycling fatalities fall substantially when more people cycle regularly and car drivers are more aware of cyclists on the roads



Source: National statistics

Will regulation hold back the advance of micromobility?

With sufficient data, we expect cities to understand the benefits of micromobility and start adjusting regulations accordingly. We expect the nervousness on the part of cities to change drastically when they see the multiple benefits of micromobility in terms of:

1. dealing with increasing levels of urbanisation,
2. reducing congestion,
3. encouraging sustainable mobility,
4. aiding equitable access to transport, and
5. making more transportation options available and affordable

Why now, when Segways failed and C5 before that?

We believe there will be failures in form factor along the way as the Segway and Sinclair C5[16] proved historically. These vehicles were ahead of their time when vehicle technology and battery technology had not advanced far enough to serve the 'job-to-be-done' purpose.

[16] https://en.wikipedia.org/wiki/Sinclair_C5

FIGURE 50

Why could new modes of micromobility survive today when the Segway failed?

Source: Barclays Research

But nowadays with battery costs much lower, equipment improved drastically and technology advancing so quickly that innovations in safety, design and IoT (Internet of Things) make each vehicle iteration better, we think there are a large number of use cases when a micro-vehicle will serve the tasks much better than a larger car. We think consumers will choose the mode more rapidly because of this fast iteration of form factor, which better suits consumers used to tech-speeds of adaptation (such as iPhone upgrades) than the car industry which is still working off 5-7-year product cycles. We think micro-vehicles can deliver a yearly cadence of new product introductions, more in tune with smartphone lead times.

Case study: Veemo, Elf and velomobiles/3-wheel bicycles

At the Micromobility Conference in California in January 2019, we witnessed two velomobiles in action: the Veemo (Figure 70), an enclosed electric-assisted three-wheel bicycle, and the Elf (Figure 71), a solar and electric powered vehicle from Organic Transit. The Veemo combines a battery with human and solar power. It is pitched as a clean and sustainable transportation alternative that can ride in bike-lanes, because of its bicycle classification. It launched in pilot mode at the University of British Columbia in 2018, with plans to expand into urban Vancouver later this year. It may not be fully weather-proof (it offers no heating) but it does offer weather protection and no driving licence is needed in any countries where no licence is required for an e-bike.

Similarly, the Elf is a pedal hybrid vehicle, also powered by solar, which under US federal consumer safety law is classified as a bicycle and requires no driving licence in the US. It is designed to go at 20 mph on the flat (the top allowable speed under US Federal guidelines) but can reach speeds of 30mph with a combination of electric assist and pedalling. It has a range of 48 miles in electric mode and at just 73kg the Elf can carry up to 250kg in passenger weight (with room for 2 adult riders).

Will the Veemo and Elf be the next big thing for city commuting or follow in the footsteps of BMW's C1 (a cabin motorcycle which was discontinued in 2002 due to low sales)? We don't know, but we think that, in general terms, the climate today is much more ready for MM offerings than has been the case historically.

Lit C1, Lingyun Intelligent Technology and gyro-vehicles

The Lit C1 is a concept vehicle developed by Lit Motors as a self-balancing, two-wheeled electric vehicle, or AEV (auto-balancing electric vehicle). The vehicle is yet to be launched, despite Lit Motors taking deposits since 2011. But more recently, a Beijing-based company Beijing Lingyun Intelligent Technology Company, backed by Sequoia (which has also invested in Ninebot, Segway and Bird[17]) is looking to produce a similar gyro-vehicle called the 1703.

Might a self-balancing, gyro-vehicle provide the 'iPhone moment' for mobility or will Lit Motors and Lingyun Intelligent Technology's offering follow the doomed path of the Razr, Segway or Sinclair C5?

Vehicle iterations are already happening fast in terms of both hardware and software

E-scooter companies started off predominantly using Xiaomi's (a parent company of Ninebot's which in turn owns Segway) Mi Bluetooth-connected electric scooter, with a range of 18 miles and top speed of 15mph. But even in the 18 months since operations started, vehicles have become smarter and are now largely app-connected, can be unlocked by a combination of Bluetooth, cellular data and GPS and often have additional safety and security software. Wheels are getting bigger and vehicles safer and many operators already offer multi-modal vehicle forms: such as Scoot Global, which started life as a moped-sharing operator but now offers e-bikes in Barcelona, electric kick-scooters in Chile and electric mopeds in San Francisco, as well as being one of only two scooter operators with a permit to operate in San Francisco.

We expect vehicle ranges to improve, charging capabilities to mature (with swappable batteries already commonplace) and micromobility operators to adapt fast. Some companies have even persuaded local businesses of the benefits of subsidising charging points, because the businesses saw increased foot traffic as a result of the popularity of the vehicles.

Will next generation vehicles all be produced in China?

Cost base and access to the largest market for electric vehicle batteries explains why almost all of the current commercially available e-scooter models are manufactured in China. However, to date, the quality of the vehicles being used has been called into question by high 'churn' factor, with many vehicles lasting less than the three months required to reach

[17] Bird Rides raises $300m as scooter group race for scale, FT 28 June 2018

profitability for many operators. This is because using consumer-grade vehicles in a commercial, shared operation is not the best form factor for the job-to-be-done.

Case study: Superpedestrian (an MIT start-up)

Superpedestrian is hoping to design electric bikes and scooters that will better suit shared micromobility. Its e-scooter model is sturdier (with 12 inch wheels), safer and more adaptable than the designs currently on the market. All of its specs are adjustable real-time, such that it can adapt to local regulations, even if those regulations change. It has a more efficient battery than most consumer-grade electric scooters, such that it has almost double the range, with full in-house development of software, rather than relying on off-the-shelf solutions found en masse in Asia. The company is also designing industrial-grade electric bicycles. All the components are designed to self-monitor and attempt to repair themselves, or at least to be suitable for remote-maintenance, to save micromobility operators costly technician visits.

HOW TO INVEST IN MICROMOBILITY

In collaboration with our sector analysts, we aim to assess the implications that our discussion on micromobility could have on individual companies and their respective industry outlooks. We focus our analysis by region and by sub-sector based on companies currently under Barclays' coverage.
For a broader view on the micromobility opportunity, both public and private and globally, we recommend that readers view our Mobility Landscape (Figure 64).

FIGURE 51
Barclays coverage – Analyst collaboration

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Source: Barclays Research

Infrastructure

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A shift in the type of infrastructure spending (away from traditional roads maintenance towards investment for micromobility and greener infrastructure) would certainly have profound implications for contractors, infrastructure operators and also material manufacturers (roads and highways typically account for c.35-40% of cement/aggregates consumption in developed economies).

At first, a spike in infra spending would benefit heavy material producers; the need for changing infrastructure and the related urban regeneration projects would probably generate incremental business opportunities, above and beyond usual maintenance works. Nevertheless, it remains to be seen whether the new type of infra investment would carry similar materials intensity than roads and highways. We believe this will increasingly be a key topic for integrated cement manufacturers, particularly **CRH, HeidelbergCement, LafargeHolcim, Buzzi Unicem** and **Vicat** among the stocks we cover.

For infrastructure owners, changing mobility habits might have infrastructure availability benefits (less congestion), but the implications for traffic remain relatively unclear; to date, multi-model transportation, car sharing, etc... have benefited traffic and there has been little evidence of the opposite globally. We see the infrastructure operators (**Vinci** and **Eiffage** for their motorway concessions, **Getlink** managing the Channel tunnel) as largely immune to micromobility changes (with a few minor exceptions), given the focus of their asset on long journey traffic (no inner city road management).

Ultimately, we see the contractors as the key beneficiaries of a switch towards more public money into 'greener' infrastructure. In a way, they benefit irrespective of the type of infrastructure being built, but will be involved in the design and building (and sometimes also in financing and operation) of the infrastructure. Some of our contractors (Vinci, Eiffage) are actually leading the way, having developed new offers (smart cities, smart roads, sustainable districts...) to provide energy-neutral and more connected turnkey solutions to local authorities. Such new higher-value-added offers, if they keep on expanding fast, would mostly benefit the large integrated players, as barriers to entry are typically higher (more technological content, specific know-how), resulting in better profitability than traditional construction services.

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Mobility is an important factor for real estate attractiveness

Mobility is incontestably an important factor for the real estate sector, as it has an impact on property valuation and rental values. The most obvious impact is for shopping centres for which the size catchment area is vital as it defines the area where the shopping centre has enough influence to draw customers. But we also think that, just like shopping centres, offices have a catchment area (representing the limited number of workers within an hour's commute a company can likely hire) which can expand based on an increase in mobility. Based on our analysis on Paris offices (see *French Offices: It's all about connectivity and developments*), we concluded **Gecina** has the largest office catchment area and is therefore in a good position to drive rental values up. The improvement in infrastructure in Greater Paris, linked to the Grand Paris Express project (GPE), is a long-term positive catalyst for **Icade** which has positioned its office portfolio over the years to benefit the most from the GPE in the future.

Our long-term view on real estate and mobility is as follows: 1) central locations combined with good infrastructure (tube stations) will continue to win in the future and 2) obsolete parking spaces may see greater demand for logistics purposes than alternative vehicles.

Central locations for offices will continue to thrive

We believe offices in high-quality locations, mainly driven by good connectivity to other parts of the city or from a commute perspective, will continue to thrive. Companies struggle to attract talent, and one of the ways to attract talent is to offer a workplace that can offer a good work/life balance (which includes connectivity).

Therefore, the pressure on the current infrastructure is rising. Large infrastructure projects in London (*CrossRail)*, Paris (*Grand Paris Express*) and Amsterdam (*Noord Zuidlijn*) are all being built or have been completed in order to ease this pressure. Property prices and rents – both residential and commercial – have spiked in locations where stations have opened or will open in the near future.

Many workers use public transport in large cities, but despite the number of parking spaces being only 1 per 600-1,000sqm of office space, or 1 per 60-100 employees (*source*) and high urban congestion, a surprisingly large number of commuters still use a car for their journey to work. We do see developers offering more space for smaller vehicles, such as bicycles, as more and more people are cycling to work, but so far the impact on the overall building has been negligible.

Spain: the exception to the rule

While we have seen some cities temporarily or permanently banning the use of cars and encouraging workers to commute by public transport, enhanced by ecological concerns and just the need for a more walkable urban environment, Spain is a separate case. Driving to work is popular in Spain, hence the large amount of parking space in real estate companies' portfolios and even buildings under development. This also means poor road traffic in the mornings, especially in the North of Madrid. We note that this is a big drawback for the offices located there, and it is therefore more difficult for companies to increase rents, notably **Merlin Properties**.

A new major infrastructure project in the North of Madrid, *Madrid Nuevo Norte*, has been designed based on a mobility strategy. It will address the issue of heavy car traffic by improving the connectivity of the Chamartin train station. The question remains as to whether this will help change car habits when it is complete (~2030).

Mobility analysis on Paris offices

Companies looking for large office space will have to switch outside Paris to meet their needs.

Mobility is an important factor for office attractiveness. In Paris, given portfolios are reaching almost full occupancy (vacancy rate below 2.4%, *BNPRE*), we argue that even if the city remains the most attractive area, notably the CBD, companies won't have a choice but look for office space outside the city. But it doesn't mean all areas outside Paris are equally attractive, in our view: in fact, we find accessibility to be the number one factor in attractiveness.

Why is public transport important in Paris?

Parisians mostly use public transport to commute to work.

On average, c.60% of Parisians used public transport to commute to work in 2017 versus just 24% who commuted by car (Insee).

France is not the only country where one can see the decline in car use. We find several reasons for this decline: costs, good transport infrastructure, rise of car sharing (Uber, Blablacar), cycling (Velib' in Paris).

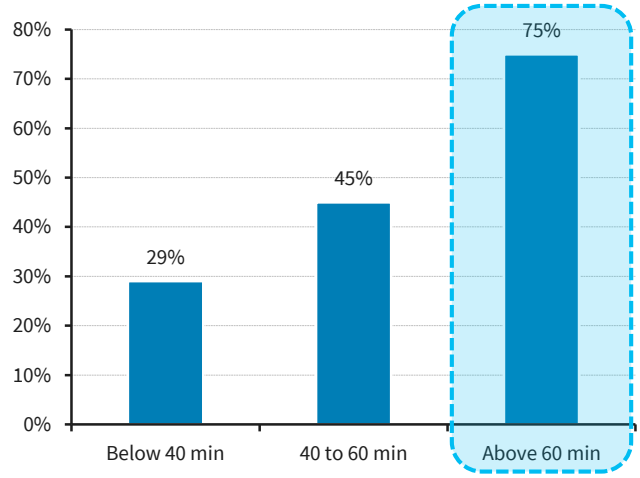
Employee satisfaction correlated to the length of commute

The level of dissatisfaction is directly linked to the length of commute.

Commuting is part of life for many, but the shorter the better. According to a study '*Paris Workspaces 2018*' published by the independent French survey institute Ifop and SFL in June 2018, Parisian workers (who include people living in Paris and the first ring) spend 47 minutes on average commuting to work. It seems like a critical tolerance level is below one

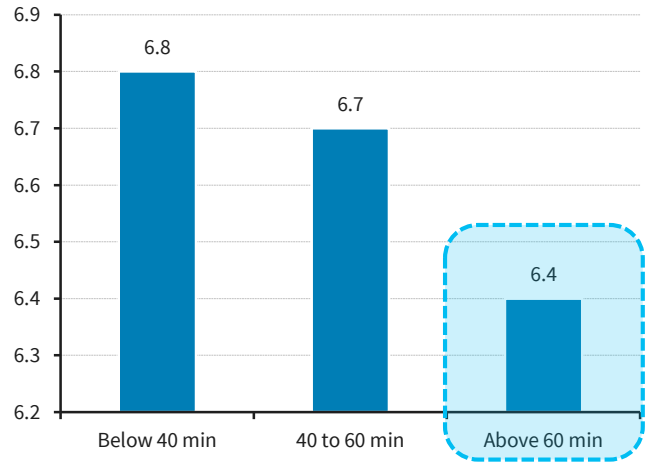
hour, as thereafter the degree of dissatisfaction increases dramatically from 45% to 75% (Figure 52). Workers commuting for more than 60min are also the less likely to feel well at work, as their well-being rating is the lowest (Figure 53).

FIGURE 52
Degree of dissatisfaction per commute time (%), 2018



Source: Paris Workspaces, Barclays Research

FIGURE 53
Well-being at work rating (from 1 to 10, 10 = the best)

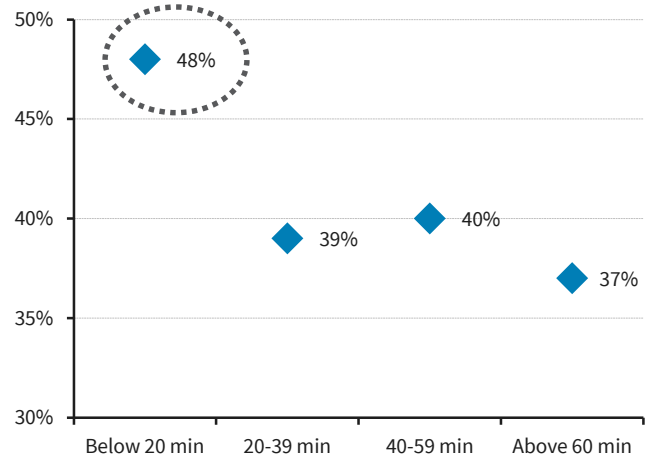


Source: Paris Workspaces, Barclays Research

Arbitrage between HR and real estate costs

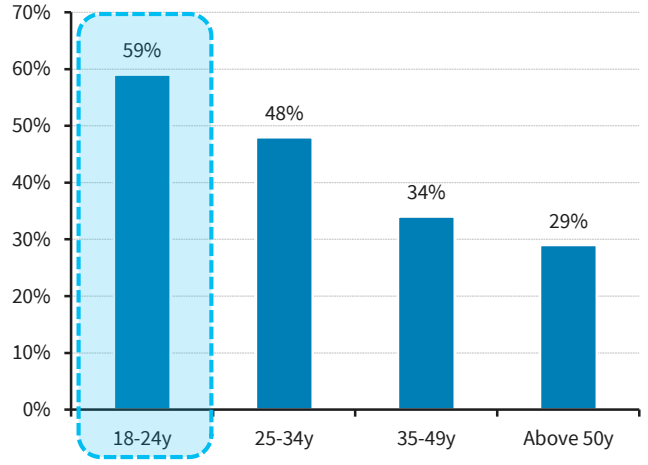
We think that companies will have to increasingly consider the balance between real estate and HR costs. Having employees with shorter commute time benefits a company in two ways – retention and attraction.

FIGURE 54
Workers planning to stay 5+y in the company



Source: Paris Workspaces, Barclays Research

FIGURE 55
Importance of office (location and quality) when considering a job (%)



Source: Paris Workspaces, Barclays Research

There are financial consequences for the companies as well: workers with a commute above 40min work 8.20h per day on average, versus 8.36h for workers with a commute below 40min.

Grand Paris Express, the long-term public transport catalyst

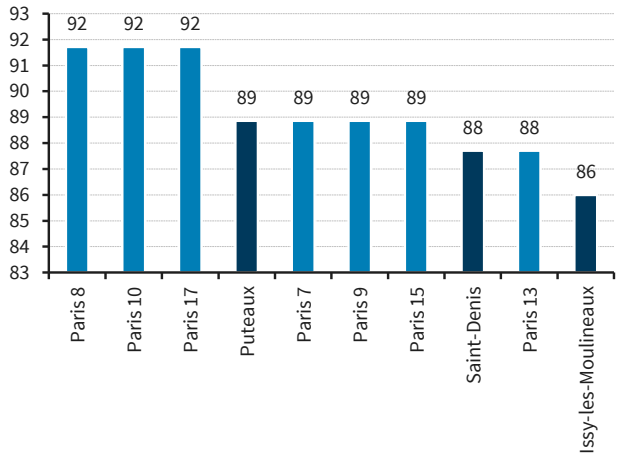
The Grand Paris Project was announced in 2007 with the objective to enable an underground outskirts-to-outskirts commute. We think the Grand Paris Express will be a major catalyst for Greater Paris offices, especially for Icade, but also for Parisian offices. All

the office hubs will be able to extend their catchment areas. **According to the real estate broker *C&W*, if an office has at least two public transport options, rents are on average c.20% higher.** If better public transport is combined with multi-modal mobility (including micromobility), rents could also rise.

Gecina has the most accessible office portfolio

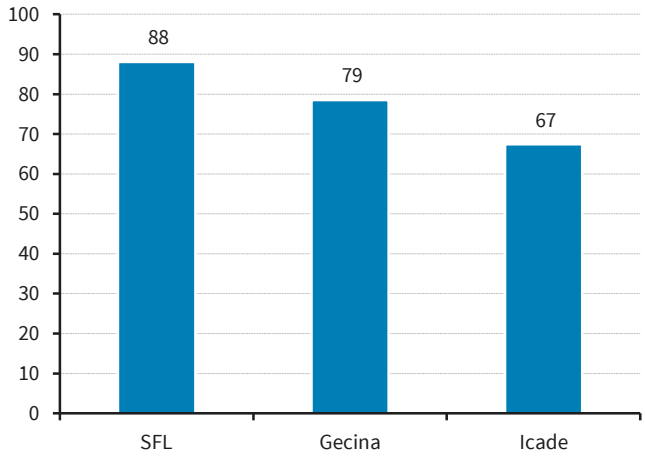
We find that Gecina has a more accessible office portfolio than Icade, as its accessibility score weighted by its portfolio exposure as of December 2017 is higher, at 79/100 versus just 67/100 for Icade. SFL, the French subsidiary of **Colonial** has by far the highest accessibility score, at 88/100 due to its 98% exposure to inner Paris as of December 2017.

FIGURE 56
Top 10 accessibility score (out of 100), 2017



*100 being the best. Source: Le Parisien, Barclays Research

FIGURE 57
Office portfolio accessibility score (out of 100), FY 2017



*100 being the best. Final score is weighted by portfolio exposure (space).
Source: Le Parisien, Gecina, Icade, Barclays Research

Retail: cars still relevant

Cars still relevant for grocery shopping

There are few shopping centres in very central locations, but we have seen those with good connectivity do better than others – the Westfield shopping centres, for example. If more mobility options were made available, such as micromobility, this could help the connectivity of some centres. But we believe people will continue to use cars to travel to shopping centres, particularly when this involves grocery shopping as they will buy in bulk.

Finding an alternative use of parking space?

In theory, if cars become obsolete, parking spaces could be converted into something else (for example, alternative vehicles). But we believe logistics players will also be keen to get their hands on such spaces for last-mile delivery. While current values of parking spaces are still too high to make this a viable alternative, we do not rule out the possibility at some point in the future.

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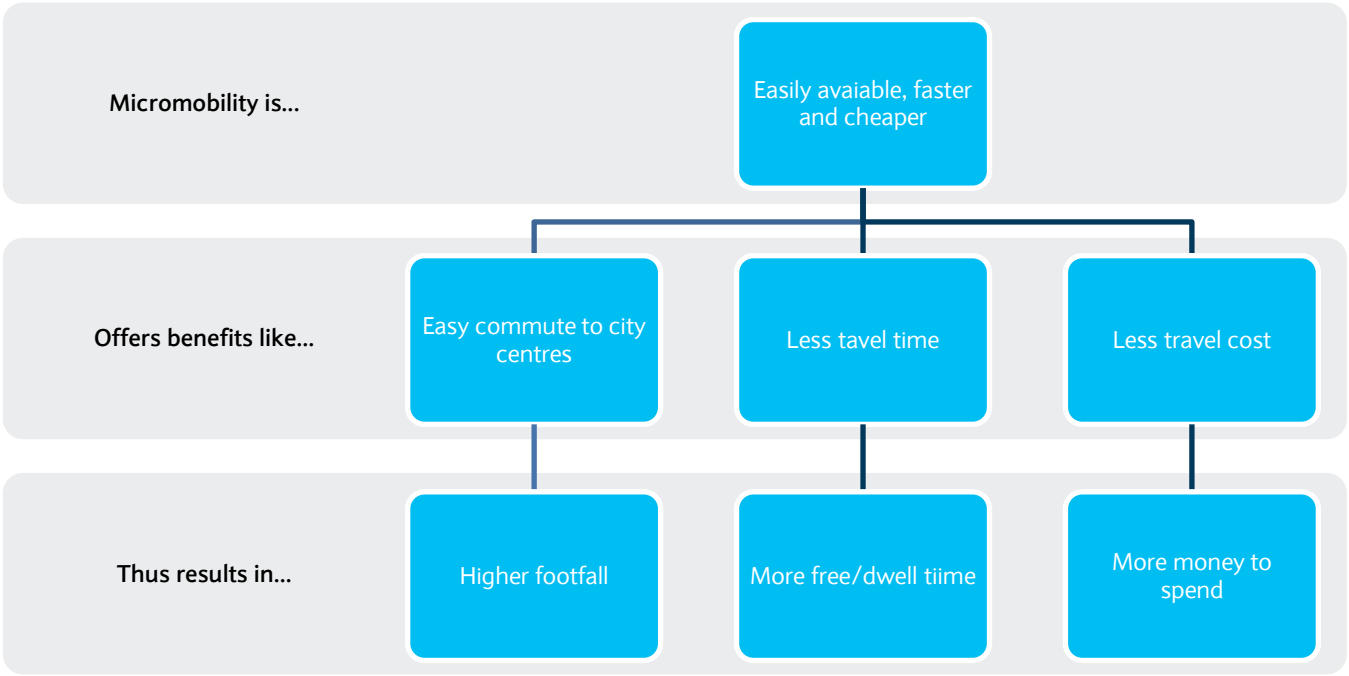
We expect increased micromobility adoption will result in higher footfall on high streets and shopping malls as access to city centres becomes easier and cheaper. This could lead to a boost for attractions located in city centres or shopping malls such as Lego Discovery Centres/Sealifes (owned by **Merlin)** and retail gaming companies (**GVC, Paddy Power** and **William Hill**). Similarly, concessions companies like **SSP and Elior** could benefit as faster commutes may initially mean earlier arrival at airports or railway stations, though if this mode of transport replaces rail/car, this might also have a negative effect on performance at some rail locations. We could also see a negative impact on catering companies (e.g. **Compass, Sodexo and Elior**) and restaurants (**Telepizza, Vapiano**) as faster and cheaper food delivery apps may encourage business employees, visitors to hospitals, university students etc. to 'order' food at the expense of in-premise catering services and restaurants. However, we do expect catering companies to adapt to modern technologies and enhance last-mile delivery mechanisms to reduce time and cost of deliveries (e.g. Sodexo's robot food delivery services at George Mason University's Fairfax, VA campus).

FIGURE 58
Micromobility helps to attract more customers with more free time and money to spend at attractions and gambling shops



Source: Barclays Research

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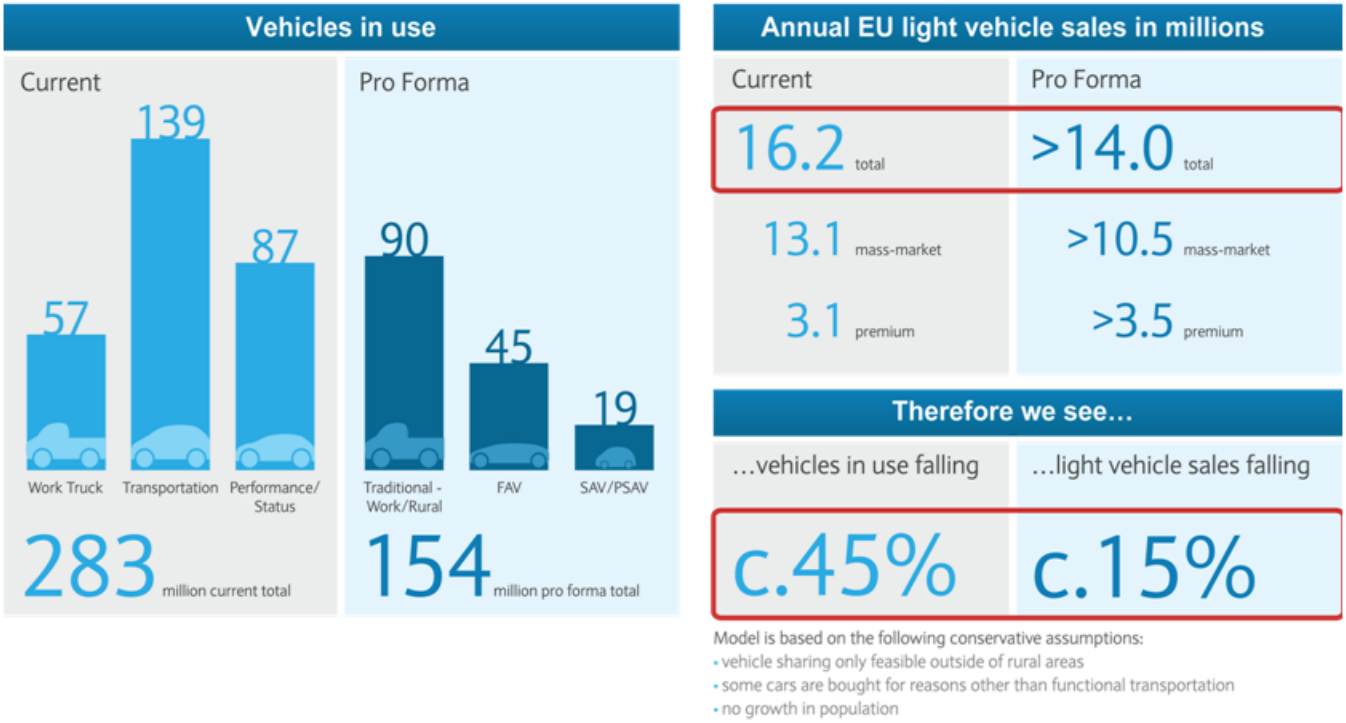
If micromobility uptake is as drastic as we forecast, it could have clear implications for car demand and ownership globally. We discussed many of these trends from the point of view of autonomous driving in our reports *The transition to a world of #DM – the rise of multi-modal transport* (06 September 2017) and *#DisruptiveMobility in Israel. Legacy Auto closing the gap on Tesla* (29 May 2018).

While the advent of Level 4 autonomous driving (i.e. vehicles that can handle some, but not all, driving routes in urban areas in full driverless mode) has come closer, Level 5 autonomy (i.e. 'everything, everywhere') is being pushed further back. We expect Level 5 autonomy to flip household economics from an ownership to a TaaS/ridesharing model. Under our most aggressive scenario of autonomy car sales in the US would fall 12% by 2025E and 39% by 2030E. The comparable figures for Europe are 15% and 45%, respectively.

FIGURE 59
Under our most aggressive Level 5 autonomous model, we could see 'peak car' globally, with cars in use falling 45% in Europe. However, in the near term we expect that an acceleration of Level 4 autonomy, combined with an increase in other shared-ownership modes and overall growth in urban miles travelled, will mitigate any car usage declines



Source: Barclays Research

But for the interim period in the 2020s when Level 4 autonomy (i.e. where cars operate autonomously in high-volume/easier-to-handle routes but 'human driven' rideshare is still necessary for the more difficult routes and driving conditions) starts to accelerate, we predicted a sharp rise in multi-modal transport and a steady shift from ownership to 'TaaS' (transportation as a service). Micromobility fits firmly into the TaaS remit, and, while increased autonomy could aid the operating cost base, it is by no means necessary for strong micromobility uptake globally.

But how micromobility interacts with this multi-modal transition is harder to anticipate. The advent of ride-hailing has to date had limited impact on car-ownership levels, albeit with some evidence from the NHTS survey in the US showing a downsizing in urban households

from multi-car ownership to single household ownership. But it is unclear whether a sharp uptake in miles ridden on shared scooter, e-bike or e-moped will have a more dramatic impact. We believe that, while micromobility is in its infancy, commuters will enjoy the freedom and speed of the new mode of transport, but maintain ownership of a personal vehicle for longer journeys, or where public transport and TaaS do not serve the 'job-to-be-done'. But as time unfolds, and if, as we believe, many cities across Europe start to deter car usage, we might see the transition to 'peak car' occurring earlier than our above forecasts suggest.

We do not think the incumbent auto names are naive to the level of disruption coming to existing business models. Many of the companies are seeking to position themselves as Mobility Service Providers rather than car manufacturers, or as electric drivetrain suppliers rather than combustion engine suppliers. **GM** is arguably ahead of the curve on autonomy with its purchase of Cruise and, with the 2019 launch of its electric bike brand ARIV, is positioning itself as a micromobility hardware manufacturer. By contrast **Ford** is investing in micromobility operators with its purchase of e-scooter sharing business Spin, and sponsorship of GoBike in the Bay Area.

In Europe, **BMW** is focused heavily on electric vehicles and sustainability across the entire group and its 2-wheel business division, BMW Mottorrad, already offers the BMW C Evolution, an electric moped, which at 275kg classifies as a micro-vehicle under our definition. In 2018 it launched the X2City, an electric kick-scooter to address 'last-mile' mobility. However, despite plans for a folding pedelec announced in 2012, the e-bike failed to reach commercial production. As yet, BMW has made no solo attempt to move into the micromobility operating space, albeit the recent merger of its Mobility Services unit with its competitor **Daimler** gives it access to Daimler's TaaS offerings. Daimler has already invested heavily in TaaS, via Hailo, MyTaxi, Flixbus, Careem, Turo and many other ventures (for a full list see figure 1 *#DisruptiveMobility in Israel. Legacy Auto closing the gap on Tesla*, 29 May 2018). And in the micromobility space, Daimler has announced plans to launch a pilot of shared kick-scooters in Lisbon branded Hive, via its MyTaxi investment.

On the supplier side, both **Bosch** and **Conti** offer electric bike drivetrains. Bosch currently supplies parts to recently listed Chinese scooter company, NIU. **Valeo** also offers electric drivetrains for low-speed electric vehicles (LSEVs) to try to capitalise on the mode's popularity in China.

While micromobility is just one of many disruptive forces facing the car industry (usually summarised into the acronym ACES or Autonomous, Connected, Electric and Shared), it may be that this low-end disruption will creep up stealthily and, while more focus is being diverted to investment on autonomous driving, the nearer-term threat to revenues could come from micro-vehicle usage.

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Escooters and ebikes contain a wide range of semiconductor content including general purpose MCUs, connectivity (Wi-Fi/BT/GPS), cellular, and power. Starting with the latter, such vehicles naturally require a battery and a motor, which in turn require power semiconductors to charge the battery and to transfer/convert that energy to the motor. We see motors for these vehicles currently ranging in power from .25kW for entry level e-bikes and e-scooters to 2-3kW for an e-moped (e.g. Revel) and up to 8kW for an e-trike/velomobile (e.g. Torrot's Velocipedo). We expect most of the unit volume to be in the lower categories in the near future, with roughly $2 in power content per kW equating to around $1-2 per vehicle. This is obviously a tiny fraction of a full xEV car at c$450 of power semi content per vehicle, but could be greater in unit volume in the near term. Over time, we estimate our 280m vehicle global mobility park could drive high-double-digit million unit volumes on an annual basis (these vehicles, particularly the shared fleet ones, will have a shorter lifespan than an xEV car for personal use), implying scope forc$250m of annual revenue. While $220m of annual revenue is less than 5% of the c$6bn power MOSFET market, it is incremental growth nonetheless. **Infineon** leads globally with 26% market share of the power MOSFET market, followed by **ON Semi** with 14%, **Renesas** with 9%, **Toshiba** with 8% and **STMicro** with 7%. In addition, these names plus **Analog Devices, Cypress, Maxim, Monolithic Power** and **Texas Instruments** play in battery management.

In addition to power content, devices that are shared and therefore connected will also require narrowband connectivity and processing capabilities on board. This could add a further silicon content on the order of $2 per unit. From a connectivity perspective, companies such as **Cypress, Dialog Semi, MediaTek, Silicon Labs** and **Texas Instruments** can provide connectivity either as a standalone solution or as part of a connected MCU. Each scooter/ebike will also need multiple micro controllers (MCUs) from companies such as **Cypress, Microchip, NXP, STMicro** or **Texas Instruments** to manage operations ranging from throttle and electronic display to connectivity and battery management. Many companies in our space bundle WLAN/BT with an MCU (Microprocessor Control Unit) or even as a SoC (System-on-Chip) with specialized software packages so that customers can easily integrate functionality into their new devices and can get to market quickly. Lastly, as we've seen with vehicles and smart devices, cellular connectivity likely comes into play longer term and both modems (**Qualcomm, MediaTek**) and front-end RF (**Skyworks, Qorvo**) could find content opportunities as well.

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Payments

Payment is on a transition from a physical exchange of payment means to becoming invisible and integrated within a business process. Uber is an example of this transition as payment for its service has become 'invisible' (as Uber has your payment method on file) and is completely integrated in the business process, which is reducing payment friction and improves user experience.

Most micromobility business models will emulate such payment models as payment friction needs to be kept to a minimum for their success.

We expect this to have broad ramifications across the payment ecosystem, with entry barriers being eroded, resulting in an increasing number of new entrants and pricing pressure on the commodity parts of the value chain. All participants will be affected; with the payment user experience becoming digital, infrastructure will lose its differentiation and be de-bundled and the merchant relationship will be software-led, in our view. Hardware vendors will see dedicated payment form-factors, such as the payment card or terminal, become redundant.

For issuers and schemes, the road to invisible payments will result in the disappearance of a dedicated payment interaction, which is eroding entry barriers and brand recognition. The online transition resulted in an explosion of alternative payment methods (APM), but, with the possible exception of PayPal, none of these local methods posed a threat to the universal model of the card scheme. Mobile, a key channel for micromobility, is challenging this and large-tech is taking interest, given the stickiness, frequent interaction and rich payment data – Apple, Google, Facebook, Alibaba, Tencent have all declared interest in the space. Issuers and schemes are therefore facing increased competition and are set to see an erosion of their payment brands.

For acquirers, we think the move to invisible payments will result in pricing pressure on the commodity elements of the value chain and the requirement to integrate payments into underlying business processes. The value is therefore shifting from the underwriting of risk to seamless software integration and this is driving a transition from banking-led to technology-led acquiring.

We expect the move to invisible payments to generally result in a share shift from bank-led payments to technology-led payments, benefitting companies such as Stripe, Wirecard, Klarna, Worldpay Global eCom, Adyen, PayPal, Square, Alipay and PagSeguro – whilst these should not be seen as investment recommendations, these vendors all appear well placed to significantly outgrow the industry.

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Internet & E-Commerce

From an e-commerce perspective, micromobility will likely have a limited direct impact on the names we cover – as the size and number of parcels being delivered is better suited to larger vehicles. However, the *indirect* impact may be sizeable, as bricks-and-mortar peers might be able to leverage micro-vehicles to improve connectivity with their store networks. This could lead to more efficient last-mile operations within cities – and could conceivably enable more traditional general retailers (especially those with dense urban store networks) to offer services such as same-day delivery or even on-demand delivery. Currently, the online pureplays under our coverage (ASOS, Boohoo, Zalando) benefit from meaningfully superior delivery propositions compared to their traditional bricks-and-mortar peers; the rise of micromobility could gradually erode this advantage, as their distribution networks (i.e. lack of stores) are not suited to harnessing the power of micromobility. However, this will not necessarily be the case, as online pureplays can actually be part of the solution. For example, Zalando is building technology to help retailers to connect their store-based and online inventory – which can then also be offered on the Zalando platform. In addition, we believe the improvement of delivery propositions among bricks-and-mortar players could help accelerate the channel shift online as the overall experience would be enhanced.

Elsewhere in our coverage universe, we believe micromobility could have a meaningful impact on the food delivery names we cover (Delivery Hero, JustEat and Takeaway.com). Specifically, faster, cheaper, or 'greener' vehicles compared to the scooters or bicycles currently in use could have a positive impact on the underlying unit economics of the category. As discussed in our note, *Delivered food: disruption is just beginning* (16 February 2018), one of the key factors in the economics of the category is delivery utilization – and we estimate 2 deliveries per hour is the industry average. An increase in this drop rate – even to just 2.5-3 drops per hour – could have a meaningful positive impact on margins. The other major cost saving would arise if these deliveries could be automated without a human – this is likely further down the line, but it could plausibly be the next leg of the micromobility story.

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Food Retail

In the food retail sector, Sainsbury trialled the UK's first electric cargo bike grocery delivery service in April 2018. The trial was designed to examine whether the greener grocery delivery method could offer a more efficient way of delivering groceries to customers in busy cities. The findings from the trial were praised by the Department of Transport [1] [18]as having "*exceeded expectations in its potential commercial viability and efficiency*". The report published by the Department of Transport confirmed "*96.7% of orders could be fulfilled in a single e-cargo bike drop*" and highlighted that the bikes were able to make the most of cycle lanes to avoid traffic and to park closer to customers' homes. The zero-emission delivery method is not only environmental friendly but it also shortens journey times and doorstep times. With the support of the Department of Transport, we expect the initiative will be rolled out by more supermarkets across the UK.

In Continental Europe, Ahold Delhaize launched a similar scheme in December 2018 to trial free deliveries of 'AH to go' meal items by e-bikes from two Albert Heijn stores in Amsterdam. Results of the trial will be reviewed in early 2019, with Albert Heijn expected to roll out more delivery initiatives in 2019. Similarly, French supermarket giant Carrefour reportedly launched a new home delivery service by e-bikes in Marseille in December 2018. The bikes are able to carry up to 300kg of merchandise and allow for the installation of various types of boxes to accommodate chilled and frozen goods. As delivery time and the associated costs have become increasingly important factors for food retailers to gain competitive advantage in a market that is moving towards online and convenience, we would not be surprised to see more innovative delivery solutions emerge in the sector in the foreseeable future.

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Media

Within the Media sector, **JCDecaux** is the most involved in micromobility. As well as providing outdoor advertising billboards and formats across cities and transport hubs, JCDecaux runs self-service bike rental schemes in 57 cities and 13 countries across the world. In its 2017 annual report, JCDecaux describes the schemes as "*A genuine supplement to public transport, self-service bicycles are a means of improving city life and optimizing moving around while keeping with current environmental and public health concerns. They are also part of a shift in consumption patterns towards the sharing of goods and services*". Having installed its first 'City Bike' scheme in Vienna in 2003, JCDecaux now supports 700,000 long-term subscribers and 3.2 million occasional users each year globally.

An increase in micromobility could have a large impact on JCDecaux. Many cities have existing bike schemes that could be replaced by e-bikes and e-scooters meaning there could be a large number of contracts up for tender – presenting an opportunity or threat for JCDecaux depending on whether it is the incumbent. Compared to traditional bicycle schemes, e-bikes and e-scooters may require higher opex and/or capex for the installation and maintenance of such a scheme. One way that JCDecaux has tried to counter this is by launching self-service hybrid bikes with portable, personal batteries that users can remove from the bikes and charge at home or in work, removing the need for JCDecaux to install docking stations or employ staff to find and charge dockless e-bikes. On balance, it is difficult to assess whether moving from traditional to e-bike (or e-scooter) schemes would be a net positive or negative for JCDecaux.

[18] *The Last Mile A Call for Evidence on the opportunities available to deliver goods more sustainably* (July 2018)

Outside of Decaux, micromobility will have little impact on the sector, in our view. At the margins, mobile consumption should diminish somewhat (hard to look at screen while biking or scooting) but probably not enough to impact advertising market share.

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Oil

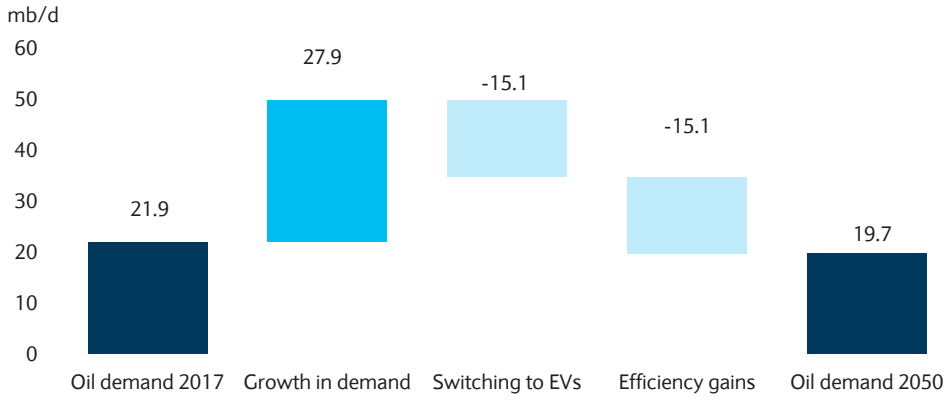
At this stage we think it is too early to understand exactly how the impact of micromobility methods will impact oil demand – particularly given that most of the journeys are likely to be short in nature. The section below outlines our thoughts on the wider evolution of oil demand from passenger cars.

Today there are close to 1 billion cars on the world's roads, consuming about 22 million barrels of oil per day, compared with total global oil demand of 98 million barrels per day. Passenger cars therefore account for c22% of total demand – the second-largest individual sector after Trucking.

Many factors determine how much oil these vehicles will demand in the coming decades, but in our view the three most important are:

- The absolute number of cars on the road
- Fuel efficiency of internal combustion engines
- Take-up of electric vehicles

FIGURE 60
Fuel efficiency gains have as much impact as EV uptake (Development scenario)



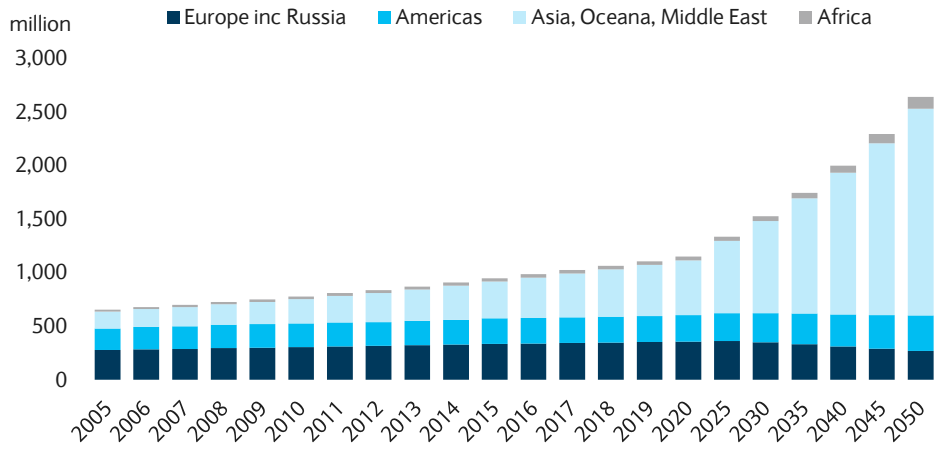
Source: Barclays Research

More cars on the road…

Taking into account population growth, an increase in vehicle registrations per person (particularly in Asia, Oceania and the Middle East) and the scrappage rate of cars, we project that the total number of passenger cars on the road will grow from 980 million in 2016 to 2.6 billion by 2050.

FIGURE 61

Barclays estimates the number of cars to reach 2.6 billion by 2050



Source: Barclays Research

…and more of those are electric

In our report *Value in a lower-carbon world*, (21 November 2018) we published our scenario analysis for varying degrees of EV penetration over the long term. There were just over 1.2m electric vehicles on the road in 2015, and in our base case (Development scenario) we expect this to grow to 160m vehicles by 2030 and over 1.2bn by 2050, representing 51% EV penetration, up from around 1% today. We also consider scenarios with lower (Deadlock) and higher (Dynamism) EV penetration:

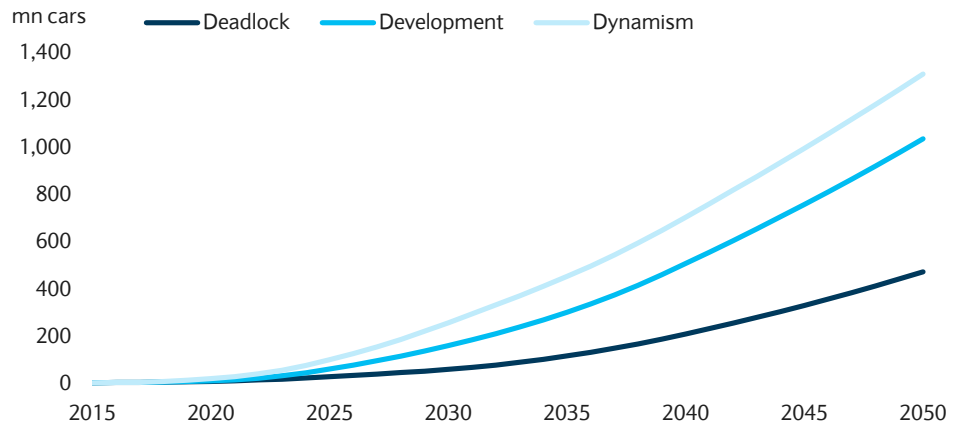
Our assumptions for each of our scenarios in terms of sales are:

- Deadlock – average global EV penetration of 30% by 2050
- Development – average global EV penetration of 51% by 2050
- Dynamism – average global EV penetration of close to 75% by 2050

Our 2030 base case forecast for electric vehicle count is above the 100m agreed after COP21 and the 140m predicted by the International Energy Agency's 2-degree scenario.

Longer term, we expect EV penetration to accelerate during the 2030s and 2040s, coinciding with a surge in autos delivered in Asia.

FIGURE 62
Number of EVs in different scenarios



Source: Barclays Research

Demand impact starts to grow

As the proportion of EVs in the sales mix rises, and starts to impact the overall car parc, the cumulative impact of EVs on oil demand starts to accelerate, on our numbers, from the middle of the next decade.

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Business Services – the AA

The implications of car sharing, fully autonomous vehicles or any development which results in a decline in car ownership (as micromobility adoption could) is, most likely, a negative development for the AA, in our view.

The evolution of a 'transport-as-a-service' business model where a customer requests a vehicle or mobility service 'on-demand', but no longer owns one, should decrease the addressable market for the AA's direct membership proposition, its most profitable business.

The AA has a leading B2B business, however, which is remunerated per vehicle breakdown. A fleet of shared or autonomous vehicles, in higher utilisation than standard cars, would not be immune from breaking down, so we would presume the AA could have B2B-style contracts for breakdown assistance/recovery with these fleets as it does currently with OEMs (the AA has a c70% market share for new cars). It is not clear whether it could offer the same service to micromobility fleets.

Another point to consider is the speed of change in the market. Even if micromobility adoption happens more quickly than expected and leads to an immediate reduction in vehicle ownership/household, it will take many years for the overall UK vehicle fleet to feel a significant effect, in our view, given the length of vehicle life (10-12 years on average).

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Sustainable & Thematic – Gen Z

Gen Z will likely further push mobility towards multi-modal usage patterns –

Our thematic deep dive on Generation Z (*Generation Z: Step aside Millennials – 28 June 2018*) painted this influential cohort aged 10-24 today as having embraced a unique set of values and preferences that are different to those of the Millennials. We focused our analysis on five key areas (technology, financial habits, values, lifestyle and attitude to work & education) to determine the key Generation Z characteristics that industries should understand to successfully monetise their coming of age. Furthermore, at 25% of the global population, not only are Generation Z larger in size than the Millennials, they have already proven they are more conscious consumers willing to challenge the status quo despite their young age.

So what does this mean for micromobility?

Driven by events like the great recession, we characterised Generation Z as pragmatic and future-focused – seeking both financial stability and independence. Within this, we took the view that they appear to be drawn more towards traditional forms of ownership than their predecessors, especially when it comes to home and car ownership. This may sound contradictory to our thesis on micromobility at first glance; but when looking specifically at 'micro-' in the context of rapid urbanisation and as a potential solution for the first-mile/last-mile travel, we believe Generation Z are likely to respond well to micromobility. This is because we also characterized the demographic cohort as social activists. That is, sustainability is heavily ingrained within their consumption behaviour, making them more socially and environmentally aware.

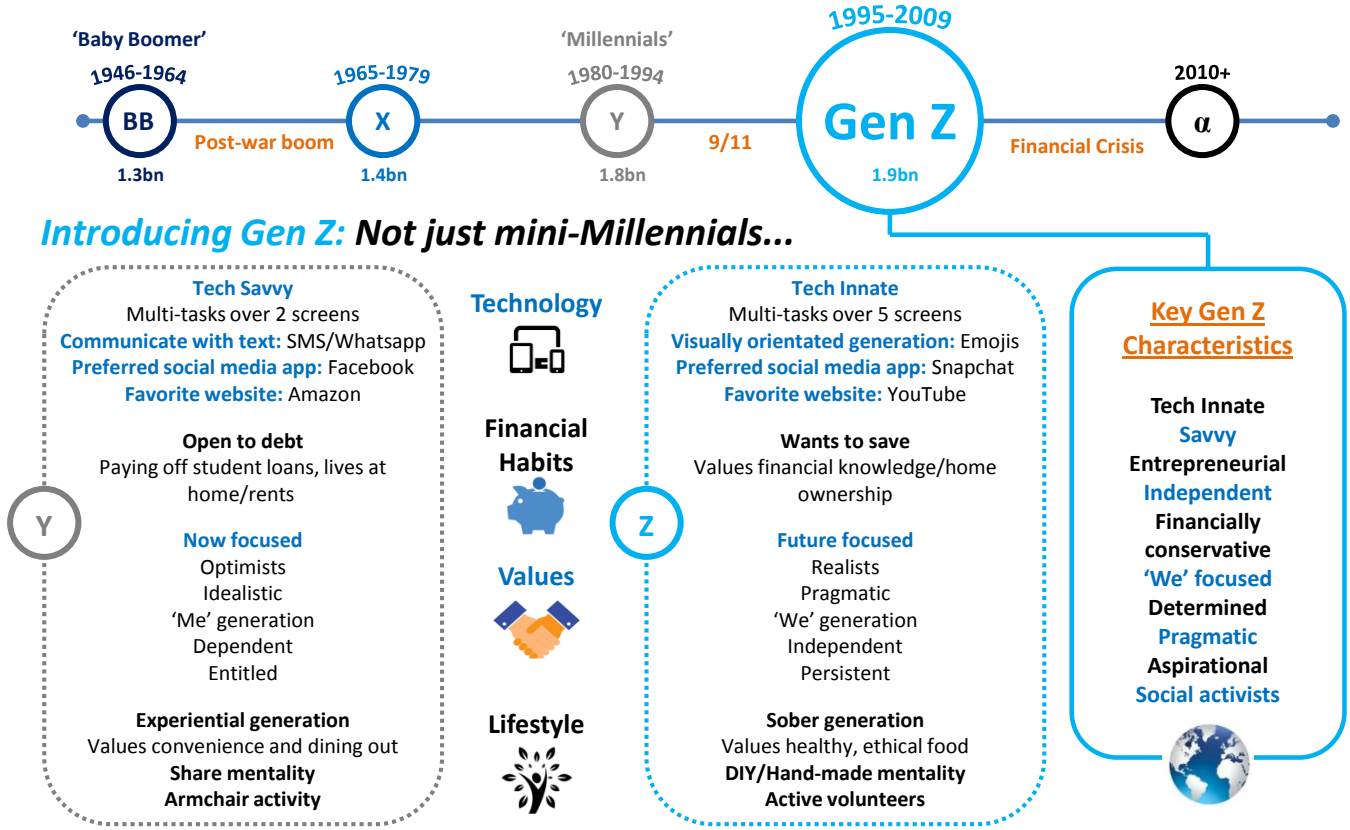
Gen Z more likely to endorse the multi-model usage pattern…

Gen Z will be mode-agnostic: Frost & Sullivan's study on Generation Z found the cohort will push mobility from a brand-centric, single ownership paradigm to integrated, multi-modal usage (*Frost & Sullivan – 2018*). Lead consultant Lynne Goulding argues that cities will be where Generation Z's mobility preferences are most rapidly shaped as shared and public transport systems are pushed by governments and transport bodies. It is likely that "*Generation Z will be mode-agnostic, choosing whichever mode gets them from one place to another most efficiently, based on preferences such as time, cost and environmental impact*."

Social activism and the focus on the environment: Generation Z have already shown they are open to car-sharing and ride-hailing within cities; however, this is likely to change as awareness and availability of alternative solutions such as e-scooters, e-bikes and traditional bikes increases. Not only is this better for the environment, but it is also an opportunity for the cohort to remain healthy and active. Encouragingly, we have seen several instances in recent years where Generation Z (despite their young age) have campaigned for industries to change and adjusted their consumption patterns if a company doesn't align with their personal values. Examples include animal rights, recycling and the anti-plastic movement.

Not forgetting safety: Within mobility more broadly, we believe the focus on safety and security is often under-appreciated especially given Generation Z are both cautious and practical consumers. A study by AutoTrader (*2016*), found Generation Z is less focused on style and brand than the Millennials and more focused on price and safety. Safety is likely more of a concern as they have grown up exposed to media messages and real-life experiences about the dangers caused by distracted drivers. From birth they were already accustomed to wearing a seat belt in a car, but more recently western governments have introduced penalties for using a smartphone while driving out of fear of digital distraction.

FIGURE 63
Sustainable & Thematic Investing – Introducing Generation Z



Source: *Barclays Research – Generation Z: Step aside Millennials (28 June 2018)*

Other investment opportunity in micromobility today

- **Micromobility start-ups.** The number of micromobility start-ups is now increasing at an exponential rate, with both **Bird** and **Lime** reaching unicorn status within months of launch but a number of other players globally looking to make inroads also into the vibrant Asian, African and European mobility markets. We would expect the number of M&A deals to increase in terms of both quantity and size as the market consolidates, with the buyers split between strategic acquirers and private equity investors. As micromobility companies mature and gain scale, some might look to go public. We will look at the economics of micromobility operators later in this report but note that to date US$9.9bn in investment has already flowed into the sector globally (77% in Asia) since 2011.

- **Global ride-hail specialists.** As yet there are no listed ride-hail companies, although earlier this month US TNC **Lyft** officially filed for IPO[19] and **Uber**[20] is reportedly also preparing to go public (although the company has not confirmed this). There are also a number of large shared mobility players across Asia, largely in China and SE Asia (**Didi Chuxing**, **Grab**, **Go-Jek**), Middle East (**Careem**) and Europe (**Taxify**, **Cabify**, **DriveNow**, **Car2Go**, **Share Now**) with smaller start-ups also appearing in Africa (**Gokada**, **MAXOkada**). Many of these businesses currently offer 2- or 3-wheel micro-vehicle options (as yet largely non-electric), as well as car and delivery services, or have invested in dockless shared micro business models.

[19] 'Lyft files IPO documents with US securities regulators', FT, 1 March 2019
[20] 'Uber 'on track' for IPO in 2019', Reuters, 5 September 2018

- **Micromobility hardware manufacturers.** The majority of the micromobility manufacturers in the market today are based in Asia and still privately owned (predominantly in China but also Taiwan and India), with **Ninebot-Segway** and **Xiaomi** providing many consumer-grade products to shared micromobility operators. However, **Niu Technologies,** which provides lithium-ion e-scooters, listed on the NASDAQ October 2018. Some micro operators are manufacturing their own vehicles or looking to new IoT businesses (such as US MIT start-up **Superpedestrian** or **Gogoro** in Taiwan) to provide safer, better connected, industrial-grade products to improve their offerings. As yet, it is hard to know whether the vehicle itself will become highly commoditised or a differentiating factor, but we do believe form-factors need to evolve to ensure better connectivity and safety.

We summarise below the main players we see in the micromobility landscape, including listed and private companies and relevant venture capitalists.

FIGURE 64

Barclays – Mobility and micromobility landscape

		Asia		NAFTA		EMEA	
Private	Micromobility Start ups	Meituan Bike/Mobike (now owned by Meituan-Dianping)	Obike (in liquidation)	Lime	Scoot	Wind Mobility	VOI Technology
		Ofo (to file for bankruptcy?)	Hello TransTech	Bird	Organic Transit	Donkey Republic	Yugo
		Vogo Automotive Pvt. Ltd	Neuron	Grow (Grin Scooters + Yellow)	Revel Transit	Tier Mobility	dott
				Skip Scooters	Remix	Flash	
				VeloMetro Mobility	Scooter Map		
	Mobility specialists/ TNCs	Grab	Didi Chuxing (Bluegogo)	Uber (Jump)	Gett	Taxify (Bolt Scooters)	BlaBlaCar
		Ola	Go-Jek	Lyft (Motivate)		Cabify	Share Now, Free Now
						Gokada	MAXOkada
						Careem	INVERS
	Hardware manufacturers (private)	Ninebot (Segway)	Ather Energy	Superpedestrian	Lit Motors	Micro Mobility Systems	Torrot Electric Europe
		Hero Electric	Dapu Motors			Riese and Muller	Scotts Sports
		Gogoro	Giant				
		Beijing Lingyun Intelligent Technology Company					
Public	Hardware manufacturers (public)	NIU Technologies	Yamaha	GM (ARIV)	ON Semiconductor	Bosch (eBIKE)	Continental (ebike systems)
		Xiaomi	Bajaj Auto Ltd	Texas Instruments	Monolithic Power	Valeo (LSEVs)	
		Toshiba	Renesas	Analog Devices	Cypress	Infineon	STMicro
				MediaTek	Silicon Labs		
		Merida		Maxim	Dialog Semi	VW (Streetmate, Cityskater)	BMW Motorrad (X2City)
	Incumbent mobility players	Toyota Motor	Hyundai	Ford (Spin, Go Bikes)		JC Decaux	Daimler (MyTaxi, Hive)
		Honda Motor Company					BMW (FREE NOW)
	Tech giants & Internet	SoftBank Group	Tencent	Google/Alphabet	Microsoft		
		Alibaba Group	Meituan-Dianping	Intel			
	Investment Vehicle			GSV Capital			
				Investment firms & VCs			
		Sequoia Capital, Temasek Holdings, SoftBank Vision Fund, Samsung Automotive Innovation Fund, Ant Financial, Toyota AI Ventures		TPG Capital, Bain Capital Ventures, Truck Ventures, Tandem Capital, Fontinalis Capital partners, AutoTech Ventures, GM		BMW i Ventures, Maniv Mobility, Jaguar InMotion Ventures	

Source: Barclays Research

FIGURE 65

Micromobility & Transport Startup Directory Asia, Middle East and Africa

Company	Country HQ	Founded	Micromobility product	Description	Valuation	Date of last funding	Round	Notable investors	Total Funding Amount
Ola		2010	rick-shaws and bikes (largely non-electric)	Indian based company which operates a mobile technology & ride-hail platform	$6bn	Feb-19	Series J	Temasek Holdings, SoftBank, Tencent Holdings, Tekne Capital, Steadview Capital	$3.5bn
Go-Jek		2010	motorbike taxis (largely non-electric)	Ride-hailing, logistics, digital payment and food-delivery business based in SE Asia	$9.5bn	Mar-19	Series F	Google, JD.com, Tencent Holdings, PT Astra International Tbk - TSO Salemba, KKR	$3.1bn
Youon Bike		2010	bike-share	A Chinese bike-share company with a focus on "green transport" and promotion of public bicycle projects. Owner of Hello TransTech since Oct 17	-	Mar-17	Series A	Ant Financial	-
Gogoro		2011	E-moped hardware and battery infrastructure	Gogoro manufactures smart, electric mopeds with swappable batteries and also develops a battery swapping infrastructure in SE Asia	-	Sep-17	Series C	Temasek Holdings, Generation Investment Management, Engie, Panasonic	$480m
Didi Chuxing		2012		A mobile transportation platform, offering a full range of commuting operations to 400 cities in China	$56bn	Dec-17	Corporate	Booking holdings, Mirae Asset Financial, Mubadala, Softbank, Foxconn Technology	$20.6bn
Ninebot		2012	micromobility vehicle manufacture	Manufacturer of electric, self-balancing vehicles for short range commuting. Acquired Segway in 2015	$1.5bn	Oct-17	Series C	Intel, Sequoia, China Mobile Innovation Industry Fund, SDIC Fund Management, GIC, Xiaomi	$247m
Grab		2012	motorbikes (largely non-electric)	Ride-hailing platform in SE Asia offering taxis, cars and motorbikes through a mobile application	$14bn	Mar-19	Series H	SoftBank, Central Group of Company, Yamaha Motor, Hyundai Motor, Toyota Motor,	$8.8bn
Careem		2012	motorbike taxis (largely non-electric)	Ride-hailing platform for United Arab Emirates	>$1bn	Oct-18	Series F	Did Chuxing, Kingdom Holding Company, Abraaj Group, STC Ventures, Daimler	$772m
Ather Energy		2013	electric 2-wheeler manufacturer	Focused on designing and selling electric 2-wheelers for the Indian market	-	Jul-18	Series C	HeroMotoCorp, Tiger Global Management	$59m
NIU (public)		2014	e-moped manufacture	A Chinese electric scooter company which listed on the NASDAQ in 2018	$542m (market cap)	Listed Oct-18	IPO	FutureCap, GGV Capital, IDG Capital	$45.5m (pre IPO)
ofo		2014	dockless bicycle share (non-electric)	A station-free bike-sharing platform operated via an online mobile application. Reportedly in financial	-		Series F		$2.2bn
Meituan Bike, formerly Mobike. Acquired		2015	bike share (mainly non-electric)	A Chinese station-less bicycle sharing system acquired by Meituan-Dianping in April 2018	$2.7bn	Apr-18	Acquired	Tencent, Temasek Holdings, Foxconn Technology Group	$928m
Hello TransTech (acquired)		2016	bicycle and e-bike sharing	Formely known as HelloBike, the company develops smart-sharing bikes, focuse largely on tier 2 and below cities in China	$2bn	Dec-18	Series G	Acquired by Youon Bike in Oct 2017, other investors include Ant Financial, Primavera, Fosun Group, WM Motor	$1.8bn
Neuron Mobility		2016	e-scooter sharing	SE Asian e-scooter sharing business operating in Singapore and Thailand	-	Dec-18	Seed	ACE Capital, Siri Ventures, SCB Group	$4m
Vogo Automotive		2016	dockless moped rental (non-electric)	An Indian dockless moped rental company for one-way commutes in Bangalore	-	Jan-19	NA	Matrix Partners, Ola, Alteria Capital, Kalaari Capital, Stellaris Venture Partners	$117m
oBike (now in liquidation)		2016	dockless bike sharing (largely	A station-less smart bike-sharing company based in Singapore	-	Aug-17	Series B	Grishin Robotics	$45m
Yulu		2017	electric 2 wheeler sharing	A micro-mobility platform that provides human and battery powered micro-light 2 wheelers	-	Mar-18	Seed	-	$7m
Gokada		2018	2 wheeler sharing (largely non-electric)	Providing 2-wheeler ride-hail transport to Nigeria (Lagos)	-	Mar-18	Seed	-	$337k

Source: Barclays Research, Crunchbase (funding data as of 12/03/2019)

FIGURE 66

Micromobility Startup Directory NAFTA & Europe

Company	Country HQ	Founded	Micromobility product	Description	Valuation	Date of last funding	Round	Notable investors	Total Funding
Uber		2009	e-bike sharing	Ride-sharing mobile application business	pre-IPO	Oct-18	Debt-financing	Toyota Motor Corp, Softbank Vision Fund	$24.2bn
Gett		2010	NA (as yet only cars)	A global on-demand transportation and delivery company	>$1bn	Jun-18	Corporate	VW, MCI Capital, Vostok New Ventures, Kreos Capital	$693m
Jump Bikes (acquired)		2010	e-bike sharing	A pedal-assisted, dockless, e-bike sharing company headquartered in NYC, previously	$200m	Apr-18	Acquired	Uber	$11.6m
Scoot		2011	e-mopeds and e-scooter sharing	An electric moped company based in San Francisco	-	2016	NA		$5m
Lyft		2012	e-bike sharing	US Ride-sharing mobile application business	pre-IPO	Jun-18	Series I	FMR, Magna, Rakuten, CapitalG, GM	$4.9bn
Organic Transit		2012	velomobile manufacture	Us-based company which designs, manufactures and sells the ELF, a solar and human-powered, electric-assisted velomobile.	-	NA	NA	-	$2.5m
Superpedestrian		2012	e-scooter hardware	Originally focused on converting traditional bikes to e-bikes via Copenhagen Wheel. Now develops lightweight, smart electric vehicles with integrated online platforms to monitor fleets	-	May-18	Series B	General Catalyst, Spark Capital	$43.7m
VeloMetro Mobility		2013	velomobile sharing	Candian-based, electric velomobile sharing service	-	Jan-18	Seed	VA Angels	$2m
Remix		2014	A public transit software platform	A platform for designing and managing a city's transport to help cities understand how streets, public transport and private mobility work together	-	Feb-19	Series B	Energy Impact Partners, Sequoia Capital, Designer Fund	$27m
Donkey Republic		2014	e-bike sharing	European bike-sharing service with a hub-centric model using custom-branded bikes. The company has a software platform	-	Feb-19	NA	VF Venture, HOWZAT Partners	$18m
Skip Scooters		2017	e-scooter rental	Formerly known as Waybot, Skip Scooters operates shared electric scooters for last-mile transportation in the US. Works in partnership	$75m	Dec-18	Debt-financing	Accel, A. Capital Ventures, Y Combinator, Trucks VC, Maven Ventures, Menlo	$131m
Bird		2017	e-scooter sharing	A Dockless e-scooter company developing a vehicle sharing platform	$1.7bn	Jun-18	Series C	Sequoia Capital, Tusk Ventures, Index Ventures, Upfront ventures, CRV, blisce/, Epic Foundation	$415m
Wind Mobility		2017	e-scooter rental	Micro-mobility company for last mile transportation services	-	Nov-18	Seed	Source Code Capital, HV Holtzbrinck Ventures	$22m
Lime		2017	originally e-bikes but expanded into e-scooters	A dockless, electric micromobility company	$2.1bn	Feb-19	Series D	Bain Capital Ventures, IVP, GV, GR Capital, Fidelity Ventures, Andreessen Horowitz, Alphabet	$765m
Spin (acquired)		2017	Dockless bikes and e-scooter	A dockless electric scooter company acquired by Ford Nov-18 based in San Francisco	$100m	Nov-18	Acquired	Ford	$133m
dott		2018	e-scooter sharing	A European scooter startup	-	Dec-18	Series A	Felix Capital, Naspers, Axel Springer Digital Ventures, EQT Ventures	$22m
Revel Transit		2018	e-moped rental	A free-floating e-moped sharing business, founded in Brooklyn, NYC	-	Nov-18	Seed	NA	$4m
VOI Technology		2018	e-scooter sharing	VOI Technology owns, operates and manages electric scooters for urban commuters in Scandinavia	-	Mar-19	Series B	Balderton Capital, Vostok New Ventures, Raine Ventures	$80m
Tier Mobility		2018	e-scooter rental	A dockless, electric micromobility company	-	Oct-18	Series A	Northzone, Speedinvest, Point Nine Capital	$31m
Grow Mobility		2019	bike and e-scooter sharing	Micromobility in Latin America formed after a merger of Grin Scooters and Yellow			Series A		$270m
Flash		2019	e-scooter rental	Micromobility start-up from Delivery Hero founder	-	Jan-19	Series A	Target Global, Idinvest Partners, Signals VC	$60m

Source: Barclays Research, Crunchbase (funding data as of 12/03/2019)

DEEP DIVE: MICROMOBILITY 101

What is micromobility?

Micromobility =
-Electric-assisted vehicles
- <500kg in weight
-used for utilitarian transport

They can be shared or personally owned

They are usually connected or 'smart'

We define micromobility as any utilitarian electric vehicle, able to carry 1-2 passengers, below 500kg in weight (from pedelecs/e-bikes, to e-scooters, e-rickshaw, velomobiles or any other low-speed electric vehicles, LSEV). Micromobility vehicles are sometimes described as Personal Transportation Vehicles (PTV), Personal Mobility Devices (PMD) or Low-Speed Vehicles (LSV). They can be owned or shared and in shared mode are largely dependent on smartphones to unlock, locate and pay for the service. In this report we have focused largely on micro-vehicles developed for personal transportation modes but we would also expect an upsurge in usage for inner city deliveries too. We see the micro form-factor as the perfect solution for the first mile/last mile and to support city targets to generate seamless, integrated, multi-modal mobility.

Micro vehicles can be personally owned or shared but what we think is key is that, under our definition, to qualify as 'micromobility' they must be electric. We discuss below the high penetration rates of owned 2-wheelers in India and SE Asia and personally owned LSEVs in China. We also look at the popularity of dockless bicycles (i.e. shared vehicles, which are unlocked via smartphone but can be collected and returned freely, with no docking station required) in China in the last few years. But we do not classify these vehicles as micromobility, because they are largely non-electric. However, we do think both trends highlight the growing popularity of using smaller vehicles for short urban trips and a growing preference among commuters for speed, convenience and multi-modal, shared mobility.

What we do classify as micromobility are the dockless electric bicycles and electric kick scooters that appeared on the streets of California in Autumn 2017 and have started to expand across US cities and many other global cities.

FIGURE 67
Example of a dockless electric scooter on the streets in San Francisco

Source: Barclays Research

FIGURE 68
Example of a dockless electric bike (pedelec)

Source: Barclays Research

FIGURE 69

E-mopeds avoid some of the regulatory issues of e-scooter and e-bicycles and potentially suit a longer-distance journey

Source: Revel, used with permission

FIGURE 70

Will we all be riding covered e-bikes/trikes/velomobiles like the VeeMo from Vancouver-based company VeloMetro?

Source: VeloMetro used with permission

FIGURE 71

…or the ELF from Organic Transit, a solar-powered velomobile

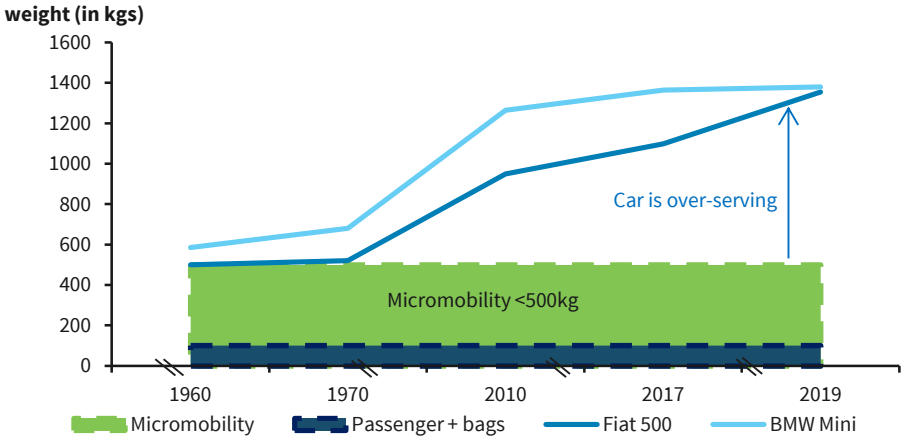
Source: Organic Transit, used with permission

Form factors are evolving

We attended the Micromobility Conference in the Bay Area, California last month, and returned even more enthusiastic about the prospects for micromobility to revolutionise personal transportation and aid the development of smarter cities. We don't see why a 1,000-3,000kg car is necessary to transport a single-occupancy load of c100kg for distances below 5 miles. We think this is over-serving and a much lighter, smaller, lower speed, shared, connected, electric vehicle could serve the purpose.

FIGURE 72

Cars have been getting heavier over the years and even the lightest city cars in production, are still >1,000kg in weight



Source: Company data, press reports

For decades, cars have been getting heavier and consumers have increasingly chosen larger and larger vehicles to drive (leading to the current global surge in SUV sales).

Today the lightest car commercially available is >1,000kg in weight. This has led to ever greater demand on city space – given the requirement for larger parking spaces, and more road infrastructure. But does it make sense to use a vehicle weighing 1,000-3,000kg to transport 100kg (the average person + bag)? Even assuming dual-occupancy, the weight to be moved is <200kg.

Legal considerations for micromobility

There is no official definition for micromobility but we define it as follows:

- An ELECTRIC vehicle below 500kg in weight
- Used for a utilitarian purpose (personal transportation or cargo/commercial delivery)
- It can be privately owned or in shared use
- While form-factor of the vehicle differs, a micro-vehicle is always 'smart' and equipped with IoT to ensure good data analytics, app integration, remote locking and mobile payment opportunities

Micromobility refers to vehicles that can carry one or two passengers and are an alternative to traditional modes of transportation. We believe micro-vehicles can provide customers **a substitute to first- and last-mile transportation**, and as such are largely thought of as being **complementary to public transport**, rather than cannibalising its user base. There are a multitude of vehicles in the micromobility bucket, sometimes known as **personal transportation vehicles (PTV)** including e-scooters (structured like a children's kick scooter), e-skateboards, e-bikes, e-moped etc but also small electric cars (sometimes known as low-speed electric vehicles or LSEVs) with one or two seats.

Regulations

With the rise in these mobility solutions, new regulations defining these solutions are emerging to ensure that they are properly classified. As a result, these solutions are defined by different nomenclatures across the globe and have to adhere to the specific regional standards. At the moment the response by many cities that have seen e-scooters appear on

the streets has been rather chaotic, but we expect as the industry matures, city regulations will become more uniform. We expect standards like the MDS (Mobility Data Specification), brought in by the Los Angeles Department of Transport to uniformly regulate data-capture by micromobility operators, may become more universally adopted.

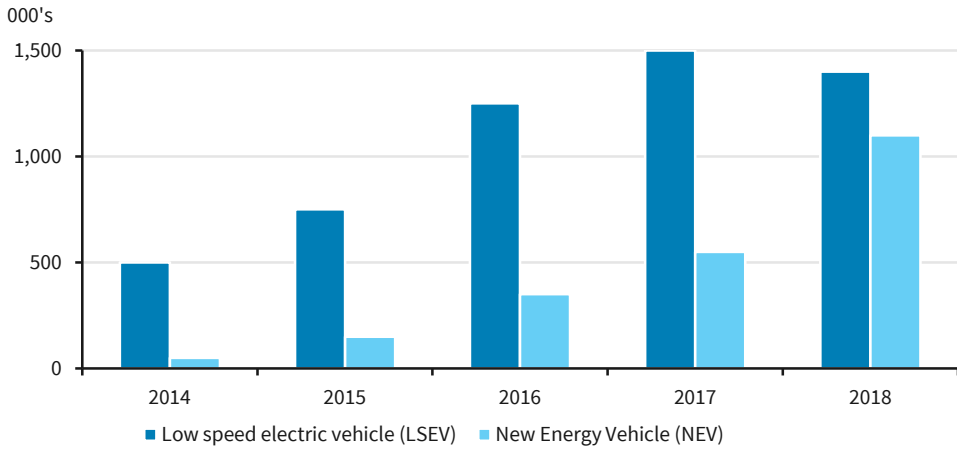
China

LSEVs in China

In China, personally owned micro-cars are widely known as LSEVs and grew in popularity in China 2012-2015 due to their affordability and the fact that no driving licence was required to ride them. Many of these vehicles are powered by lead-acid batteries, so less environmentally friendly than lithium-ion equivalents. Also due to safety requirements, the vehicles are not classified as NEV (new energy vehicles) by the government. Sales of LSEVs increased from 750k units in 2015 to 1.2m in 2016 but since 2016 have decreased in popularity vs NEVs. 5 years ago, the ratio of LSEV:NEV sales was 15:1 but, with sales of 1.4mn LSEVs in 2018 (vs 1.1mn NEVs), the ratio has dropped significantly[21].

FIGURE 73

NEVs are catching up on LSEV sales in China, aided by state subsidies



Source: Barclays Research, MIIT, BNEF, 2018 figures are Barclays Research estimates

To date in China micro-EVs have been favoured by elderly people and women (who account for 25% of LSEV drivers), due to the ease of the mode, although many students also use the mode.[22]

LSEVs are currently unregulated in China

The National Standard Commission published a timetable for a Recommended National Standard on 4-wheel LSEVs in October, 2016, saying the standard would come into effect October, 2018, but to date the standard is still in draft form. Currently anyone can drive an LSEV while they remain unregulated, but if they become regulated as normal automobiles drivers would need a C2 or C3 licence (small automatic vehicle or 3-wheel automobile licence). This may limit the number of potential LSEV drivers. Or if LSEV are regulated as motorcycles, drivers would then need a D or E licence (motorcycle), which is much easier to obtain. The third method could be to set up a new sub-category under NEVs and regulate LSEVs with a lower barrier. Or finally, the regulator could treat LSEVs as non-motor vehicles like electric bicycles. This would mean no licence would be needed, no plate and no insurance – i.e. no change from the current treatment of the vehicles.

[21] 'Dispelling the myths of China's EV Market', Bloomberg, 02-08-2019
[22] *http://www.tyncar.com/diandongche/20150726-17512.html*

Draft regulation does provide specifications for LSEVs

LSEVs do have to meet requirements with respect to size, speed, weight, battery and impact protection standards as per the draft of 4-wheel LSEVs specifications:

1. Size

   Smaller than 5000mm*1500mm*1700mm

2. Top Speed

   Between 40-70km/h

3. Weight

Less than 750kg

4. Battery

Lead-acid cell is not allowed. Battery density should be no less than 70kw/kg.

5. Impact protection

Front impact use standard GB 11551 'Automobiles' protection for passenger with front impact'. Which is lower than normal vehicles.

Side impact use GB 20071 'Automobiles' protection for passenger with side impact' and GB/T 31498 'Safety requirement under impact for EVs'. Which is the same as normal vehicles.

There is some debate regarding bans on lead-acid batteries and side impact protection but to date the regulation is still in draft form.[23]

E-bikes in China

In China, e-bikes currently come under the same classification as bicycles and therefore do not require a driving licence to operate. Previously it was required that users registered their bike in order that it could be recovered if stolen, although this is no longer a requirement. Due to a recent rise in electric-bicycle-related accidents, the Chinese government plans to change the legal status so that vehicles with an unladen weight of 20 kg (44 lb) or more and a top speed of 30 km/h (19 mph) or more will require a motorcycle licence to operate, while vehicles lighter than 20 kg (44 lb) and slower than 30 km/h can be ridden unlicensed. In the southern Chinese cities of Guangzhou, Dongguan and Shenzhen, e-bikes, like all motorcycles, are banned from certain downtown districts. There are also bans in place in small areas of Shanghai, Hangzhou and Beijing due to concerns over environmental, safety and city image issues. Beijing has re-allowed use of approved electric bicycles since 2006 but some other cities in China still ban electric bikes.

Shared micromobility in China

As yet, the multiple shared bike systems in operation across China do not meet our classification for micromobility due to the fact that the majority of the bikes in use are not electric. This may take time to change, especially given the predominance of less environmentally friendly lead acid batteries in the electric bikes that are in use and the cost differential between these and lithium-ion batteries.

[23] *https://www.jianshu.com/p/782d8a88f50b*

Europe

Multiple classifications of micromobility vehicles in Europe

In Europe, there are currently multiple designations for vehicles that are not cars. The type designation for a car is 'M4' but there's also the 'L designation', which is anything that is not a car but is still motorized. There are currently >40 different L-type designation across Europe for both 4-wheel vehicles (L6-L7) and 2- or 3-wheel vehicles (L1-L5).

The EU vehicle definition classifies light quadricycles and heavy quadricycles in L6e and L7e categorization, which places additional requirements in respect of engine cylinder capacity and power output apart from those for mass and design speed (see Figure 74 below).

FIGURE 74

Classifications of micro-vehicles differ globally

Nomenclature	Definitions
L6e (Europe)	Quadricycles with unladen mass not more than 350 kg, Not including the mass of the batteries in case of electric vehicles. Maximum design speed below 45 km/h. Engine cylinder capacity less than 50 cm3 for spark (positive) ignition engines, or maximum net power output does not exceed 4 kW in the case of other internal combustion engines, or maximum continuous rated power does not exceed 4 kW in the case of an electric motor.
L7e (Europe)	Quadricycles other than those referred to in category L6e, whose unladen mass is not more than 400 kg (550 kg for vehicles intended for carrying goods), not including the mass of batteries in the case of electric vehicles, and whose maximum net engine power does not exceed 15 kW. These vehicles shall be considered to be motor tricycles and shall fulfil the technical requirements applicable to motor tricycles of category L5e unless specified differently.
Kei (Japan)	A Kei-car, K-car, or kei jidōsha is the Japanese legal category for the smallest and most limited power motor vehicles, including passenger cars, microvans and even pick-up trucks. Kei-cars are designed to comply with Japanese regulations such as vehicle length (below 3.4m), vehicle width (1.48m), engine volume (660cc) and power (63hp).
Neighborhood Electric Car (North America)	A Neighborhood Electric Vehicle (NEV) is a US classification for battery electric vehicles that are usually built to have a top speed of 25 miles per hour (40 km/h), and have a maximum loaded weight of 3,000 lb (1,400 kg). Depending on the particular laws of the state, they are usually legally limited to roads with posted speed limits of 45 miles per hour (72 km/h) or less. NEVs fall under the United States Department of Transportation classification for low-speed vehicles (LSV). The non-electric version of the neighbourhood electric vehicle is the motorised quadricycle.

Source: Country statistics, The AA, Transport Policy

E-scooters are currently unregulated in France…

Currently e-scooter (or trottinettes électriques) are unregulated in France, despite being capable of reaching speeds of 45 km/h. However, in November 2018 the Transport Ministry announced that it was an offence to ride scooters on pavements, for the safety of pedestrians, and restricted usage to bike lanes[24]. Paris has drawn up a 'charter of good practices' that it expects micromobility operators to sign and is also considering introducing licensing fees and testing fixed parking for e-scooters.

In Belgium, e-scooter operators have arrived but the vehicles are currently capped at 18kph. Regulators are considering raising the speed limit to 25kph, similar to e-bikes. Brussels has already had to ensure all micromobility vehicles are registered to operate and adhere to strict rules on vehicle concentrations and repair.

…but in the UK (and many other EU cities) e-scooters are illegal or severely restricted in their use

Although you do not require a driving licence to ride an e-scooter in the UK (as you do in some European cities), an electric kick scooter is classified as a PLEV, or Personal Light Electric Vehicles, which makes it illegal on British roads and pavements. This is making it

[24] 'E-scooters test Europe's old traffic rules', Politico 12 January 2019

tough for e-scooter operators to expand in the region, although in 2018 Bird was allowed to operate in the Queen Elizabeth Olympic Park for a pilot.

In Netherlands, mopeds are to be banned from bike lanes and, to date, neither Amsterdam or Rotterdam has given authorisation to any scooter-sharing companies to operate.

In Germany e-scooters are illegal on roads, although the government is preparing to introduce a new category of 'light electric vehicles' that will not require the use of a helmet, cap speeds at 20kph and restrict usage to bicycle lanes.

In Spain, 3 fatal scooter accidents have forced regulators to propose banning scooters on pavements and speed limits of 25kph. Madrid temporarily banned 3 scooter operators in 2018 for failing to comply with the city's restrictions.

In many other European cities, such as Austria and Switzerland, where e-scooter sharing is already in operation, electric scooters are allowed at speeds of up to 25km per hour in a road or cycle lane. But many countries require a valid driving licence to operate a 2-wheeler vehicle.

If operators work in partnership with local governments, launch with consent from city authorities, and provide more open-sourced data, we think regulators across Europe may become more willing to loosen regulations and allow usage.

E-bikes in Europe regulated largely similarly to analogue bicycles

Micromobility operators are largely having more success with e-bike expansion in Europe than e-scooter sharing to date because of the less stringent laws surrounding their usage. E-bikes have been in personal usage for many years in Europe and therefore already have good classification in terms of road usage and codes of conduct.

US micro-vehicles

In the US, Neighbourhood Electric Vehicles (NEV) is a 4-wheel battery electric vehicle with a top speed of 25mph but classified by different state laws as to the roads where they are allowed to operate. The vehicles have a maximum loaded weight of 1,400kg, so in many instances are larger than our definition of a micromobility vehicle. NEVs fall under the US Department of Transport's classification for low-speed vehicles (LSVs). The Renault Twizy classifies in the US as a NEV.

FIGURE 75

Micro-vehicle classifications can be confusing

Japan	North America	EU	China
e-Kei	Neighbourhood Electric Vehicle, NEV (or golf-cart)	L6e = Light Quadricycle	Rural vehicle
	Low Speed Vehicle, LSV (federal definition) - max speed 25mph	L7e = heavy Quadricycle	LSEV
	Personal Transportation Vehicle, PTV (state) - max speed 20mph		

Source: Country statistics, The AA, Transport Policy

Electric bikes in the US

Federal US law equates a low-speed (20mph) electric bike (pedal-activated) to a bicycle, such that the vehicles do not have to meet federal equipment requirements and are exempt from the definition of a motor vehicle. However, there are also additional state classifications and regulations in many states on road access. Any e-bike with speeds above 20mph or throttle-activated may be subject to more stringent motor vehicle regulations (similar to mopeds) and require helmet usage, driving licence and possibly also insurance.

E-scooter regulations in the US

In the US, e-scooters are largely regulated at the state level and scooter-sharing operators have found it much easier to expand than in many European cities. However, many states require a driving licence (or learner's permit) to operate an e-scooter. Unlike mopeds, there is generally no requirement for e-scooters to have insurance or licence plates. In some regions the vehicles are limited to roads with speed limits below 25mph and the vehicles themselves are capped at 15mph.

However, many cities are beginning to require caps on speed, limit usage and also cap numbers of vehicles on the streets. Many cities require a permit to operate and that trip data is made available. Some regulations require a certain percentage of vehicles to be made available in low-income areas and shut down usage at night-time. Many cities charge a fee for companies to operate (either an annual fee or a charge per scooter in operation) and other cities require proof of utilisation stats above 3x/day to allow continued usage.

In California's Legislature, there are currently proposals to loosen regulations on scooters. Assembly Bill 2989 would relax helmet requirements, stipulate that only riders under 18 need to wear protective headgear and allow electric scooters to be used freely on streets with speed limits up to 35 miles per hour, rather than the current limit of 25 mph.

ROW

In many other regions of the world, such as Singapore, micromobility vehicles are classified as Personal Mobility Devices (PMDs) or Power Assisted Bicycles (PABs). There are generally speed limitations and requirements for maximum weight and size of the vehicles.

In January 2017, the Land Transport Authority (LTA) in Singapore brought in the Active Mobility Bill to enforce the use of electric mobility devices. The regulation allows PMDs (or e-scooters) to ride on footpaths (max speed limit of 15 km/hr), and cycling/shared paths (speed limit of 25km/hr) but the vehicles cannot be ridden on roads. By contrast, power-assisted bicycles (as long as they have been approved under the Road Traffic Act) cannot ride on footpaths but can ride on cycle paths and roads. Both types of vehicle must be below 20kg unladen, must have an electric powertrain and have a maximum width of 700mm. There are severe penalties for lack of compliance and enforcement officers in place to conduct spot checks on PMDs and PABs.

China is leading the way on shared mobility and personally owned micro-vehicles

On our micromobility uptake estimates, the addressable market for micromobility in China could reach 220bn PMT by the mid-2020s?

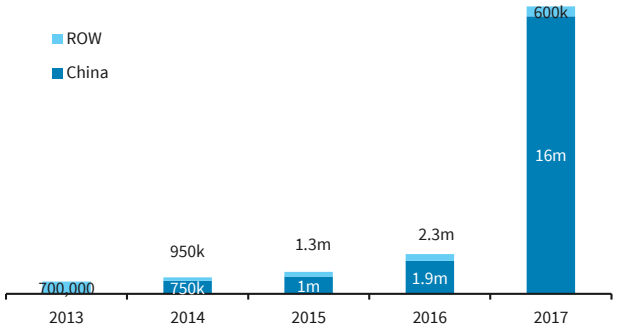
We believe Asia will become a key market for micromobility operators (with over time 50% of all MM miles potentially coming from this region).

- There were 1.4m annual sales of personally owned LSEVs (low-speed electric vehicles) in China in 2018[25]. This may change when draft government regulation comes into force to tighten ridership restrictions (for further detail see Appendix 1).
- LSEVs do NOT classify as NEV (new energy vehicles) for government subsidies.
- There is growing penetration of personally owned electric-bikes in China, but again with little clear government classification as yet (e-bikes may soon be regulated like motorcycles and thus require a driving licence).

[25] 'Dispelling the myths of China's EV Market', Bloomberg, 02-08-2019

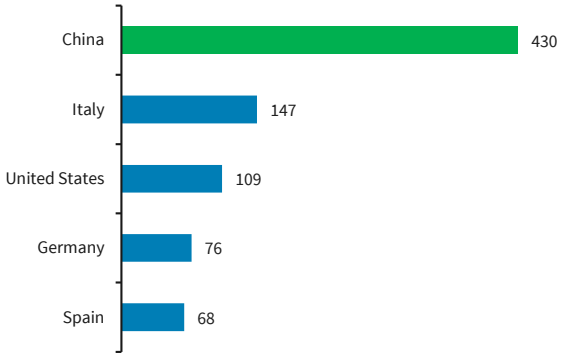
- The majority of electric micro-vehicles in China use lead acid batteries.
- China was the birthplace in 2014 of dockless bikeshare (which does not classify as micromobility under our definition when the bikes are not electric) but with little regulation, leading to oversupply.

FIGURE 76
The global market for shared bicycles has grown considerably since China's dockless schemes launched



Source: National statistics, EU Statista, bikesharingmap.com

FIGURE 77
Top 5 countries by number of public-use bicycle programmes



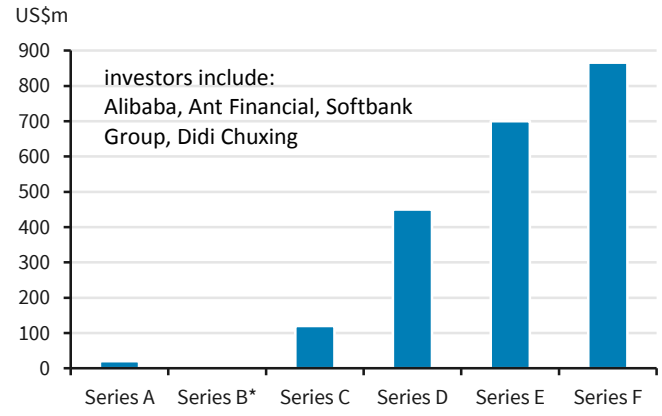
Source: bikesharingmap.com

- Dockless bikeshare peaked in 2017 with 70 operators, 400m registered users and 70m daily riders[26], according to the vice minister of the Ministry of Transportation, Liu Xiaoming. Liu was also reported as saying that shared bikes had reduced traffic costs by $2.6bn.
- By 2017, there were 16 million shared bikes in China, according to estimates from the Ministry of Transport of China[27], with 2.35m in Beijing alone.
- Two operators, **Ofo and Mobike**, had over 90% market share of bikeshare in China in 2018. Of the $2.6bn raised in 2017 by bikeshare schemes globally, $1.8bn was raised by Mobike and Ofo combined, according to Crunchbase).

[26] 'More than 20 of 77 bike-sharing startups close in China', ECNS.cn 11 February 2018
[27] 'Bike Boom Nibbles on Asia Gasoline Demand Growth', VOA, 26 Sept 2017

FIGURE 78

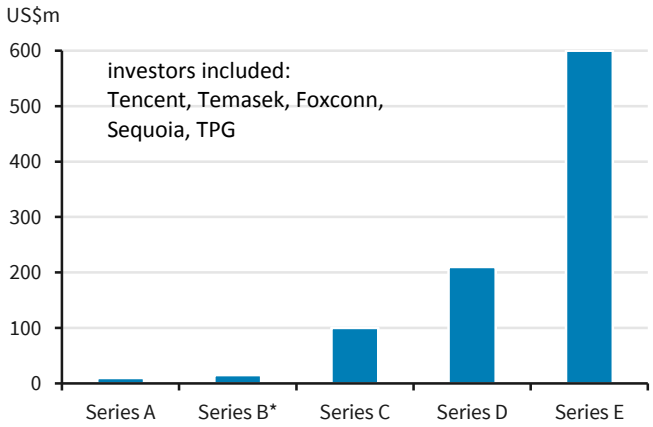
Ofo's fundraising rounds ($2.2bn in total) and high-profile investors did not protect it from failure



Source: Crunchbase *Series B funding not disclosed

FIGURE 79

Mobike's fundraising rounds pre-acquisition by Meituan-Dianping for $2.7bn in April 2018



Source: Crunchbase

- To date the Chinese government largely discourages the use of electric bikes in shared usage, apart from in smaller towns and cities where public transport is sparser and commuting distances larger, although there are a few electric shared bikes left in larger cities like that shown below, which we found in Beijing.

FIGURE 80

There are few electric bikes in shared use in China, although we found the below example in Beijing

Source: Barclays Research

- In late 2017 came the backlash to oversupply of shared bikes in China, with pictures of bike graveyards[28], over-supply and cities starting to regulate operations more stringently and restrict expansion.
- All bike-share operators in China offer low prices (starting as low as USD 0.14/hour), meaning operations expanded fast, some operators using customer deposits to fund further expansion.

[28] 'The Bike-Share Oversupply in China: Huge Piles of Abandoned and Broken Bicycles', The Atlantic, 22 March 2018

- In August 2017 country-wide regulation came into effect in China for dockless bike-sharing in an attempt to punish illegal behaviour and require local governments to distribute bikes evenly and set up designated parking spaces.

FIGURE 81
Many shared bike operators in China employ workers to ensure a regulated dispersal of bikes in urban areas…

Source: Barclays Research

FIGURE 82
…but dockless shared bikes often pile up outside stations, despite tougher government regulation

Source: Barclays Research

- Beijing now states that shared bikes in operation should not exceed 1.91mn and no new bikes can be deployed until old ones are recycled.
- But the schemes still prove so popular with customers that at peak times, riders often have to wait in line for bikeshare employees to unload bikes from trucks at metro stations.

FIGURE 83
Demand often surpasses supply at busy metro stations in China but bikeshare operators work to redistribute the vehicles

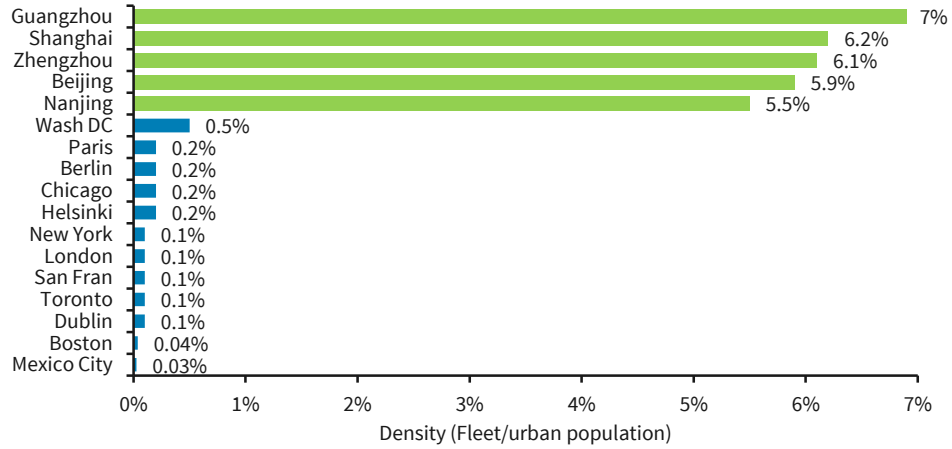
Source: Barclays Research

- 2018 saw many high-profile failures of bikeshare operators (at least 20 went into bankruptcy).

- Despite raising large amounts of capital, Ofo has now pulled out of many international cities and dissolved its international division and its website is now defunct, after the company declined a buyout offer of $2bn in August 2018[29]. Press reports claim the company is now contemplating bankruptcy, with 10 million users demanding deposit refunds[29].
- In 2018 China's lead ride-hailing operator, **Didi Chuxing**, took over another operator, **Bluegogo**, after it ran into cash issues and declared bankruptcy.
- **Hello TransTech** (formerly HelloBike) is the third-largest bikeshare operator in China, operating in 300 cities with 200 million registered users and 20 million daily rides. It focuses on second- and third-tier cities in China and is now expanding across transport modes to also offer electric bikes, ride-hailing and carpooling. To date, the company has raised $1.8bn, with reportedly $600m raised in December 2018 in the latest series G round of funding[30].

FIGURE 84

Bikeshare density by key city shows the surge in supply in China versus RoW



Source: Country statistics, Horace Dediu, Asymco.com

It is as yet unclear whether the dockless model offers enough economies of scale to cover its capital intensity, with no Chinese operator yet reporting a profit, despite big investments (of the $9.9bn invested in micromobility operators to date, 70% has been focused on China).

SE Asia already has strong penetration of 2-wheelers and ride-hail – could this bode well for electric micromobility?

Personally owned 2-wheelers proliferate in SE Asia

Although dockless shared micromobility systems are not as established outside of China, the maturity and density of the 2-wheeled and 3-wheeled micro-vehicle market in other parts of Asia, particularly SE Asia and India, could aid strong micromobility uptake. SE Asian ride-hail start-up **GO-JEK** has 400k drivers in 50 cities and offers e-commerce services, dominated by motorcycle deliveries. GO-JEK is also a non-electric personal micromobility operator as it uses mopeds for its consumer ride-hail business as well as cars. But it is unclear whether there will be a push to convert these vehicles to electric drive.

[29] 'The incredible rise and fall of China's bike firm Ofo', The Information, 5 February 2019
[30] 'Despite Ofo crisis, a growing rival pockets funding', techinasia.com, 28 December 2018

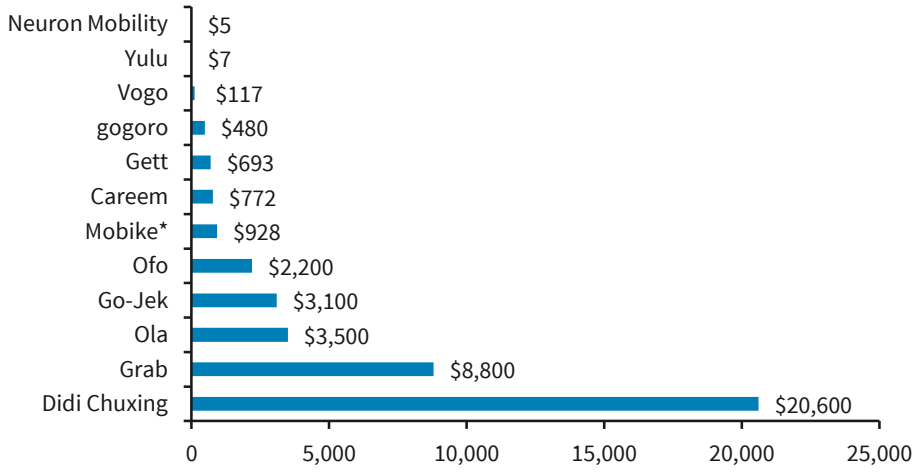
In the last ten years, non-electric moped sales in Indonesia have risen from 20% to 84%. As vehicle form factors evolve, we see Indonesia with an urban population of 55% (forecast by the UN to rise to 72% by 2050, well above the Asian average) – and where Jakarta is ranked by TomTom as the third most congested city globally and is set to be the 22nd largest city in the world with a population of c16mn by 2050[31] – as ripe for the electric micromobility market.

Electric micro-vehicle manufacture is developing to serve SE Asian market

Gogoro, a venture-capital-backed manufacturer of smart scooters, is set to bring connected, electric micro-vehicles to SE Asia. It manufactures electric scooters with swappable-batteries and launched its Smartscooter in Taiwan in 2015. To date electric 2-wheelers have failed to take off outside of China due to lack of charging infrastructure in Asia. But Gogoro is aiming to develop an electric vehicle infrastructure and has raised a total $480m in funding.

FIGURE 85

Funding has been abundant for Asian and Middle Eastern mobility start-ups, despite high-profile bikesharing failures (US$ m)



Source: Crunchbase, as of 12 March 2019 *now called Meituan Bike post-acquisition in April 2018

Not electrified yet

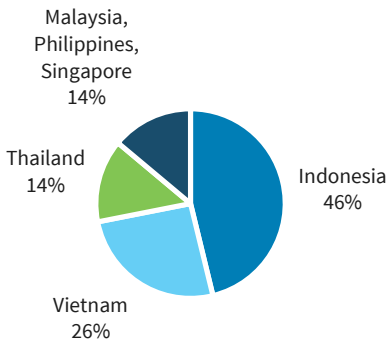
2-wheelers account for 76% of vehicles on the road in India, and reportedly 30% of the country's pollution[32]. And in SE Asia, more than 80% of households own a 2-wheeler. Costs of 2-wheel vehicles are low in Asia (below US$500 for an entry-level, non-electric motorcycle in India) and heavy congestion (and lack of parking) encourages consumers to look to bicycles and mopeds. Lack of charging and the high cost of lithium ion batteries to date have impeded consumer demand for electric versions, but in 2019 **Honda Motors** will offer a scooter with a switchable battery targeted at the SE Asian market.

At the recent MOVE 2019 conference in London, we met a number of micromobility operators focused specifically on the Asian market, including CEO Tarun Mehta of **Ather Energy** an Indian electric scooter manufacturer, which has established an electric vehicle charging infrastructure called AtherGrid. The business is backed by Hero MotoCorp.

[31] 'Socioeconomic Pathways and Regional Distribution of the World's 101 Largest Cities', Daniel Hoornweg and Kevin Pop, Jan 2014
[32] 'Two Wheelers could rule electric transportation of the future', Business Times, 15 October 2018

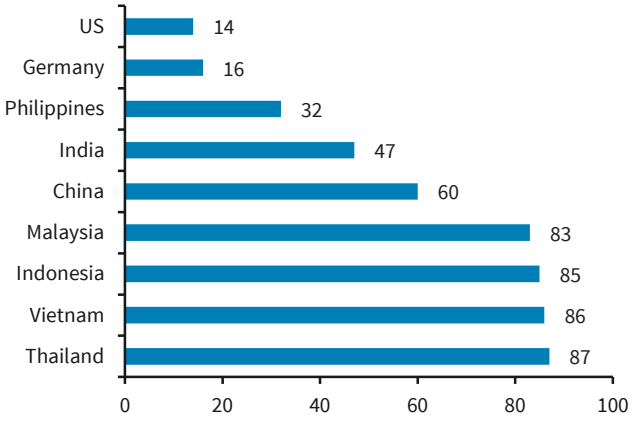
Government support is likely necessary for electric vehicles and charging infrastructure to take off faster in Asia, but given a government focus on both air quality and congestion, we can see electric micromobility offering an attractive business case in the region. Whether these vehicles will be predominantly owned, shared, in personal use or for commercial deliveries is yet to be determined.

FIGURE 86
SE Asian 2-wheeler sales by country, 2017



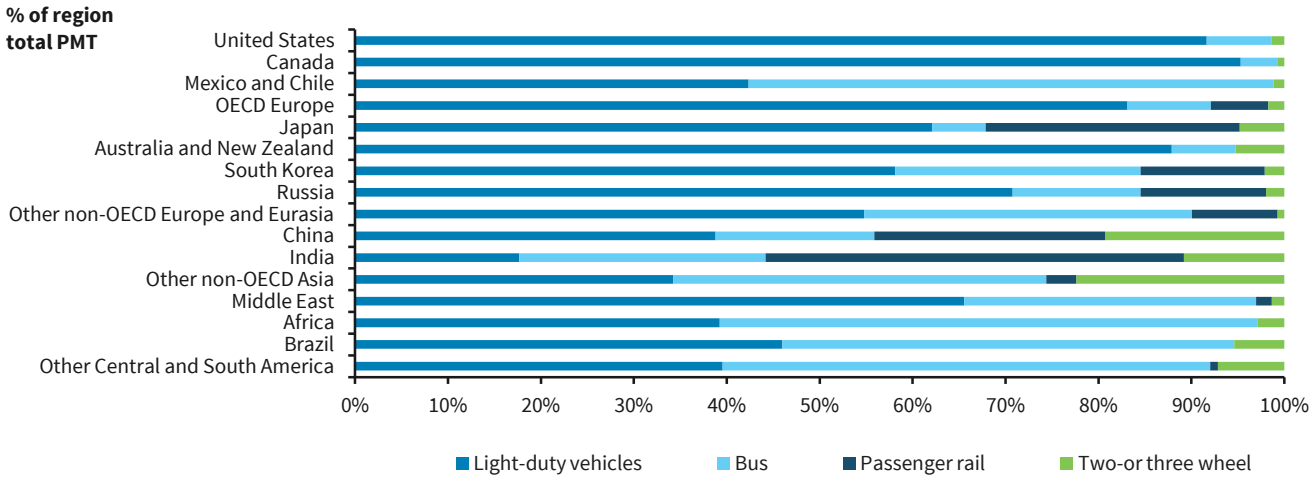
Source: Roland Berger

FIGURE 87
Percentage of households owning 2-wheelers (%)



Source: Roland Berger (based on 2014 data)

FIGURE 88
2-wheelers are a popular form of transport throughout Asia but as yet they are largely non-electric



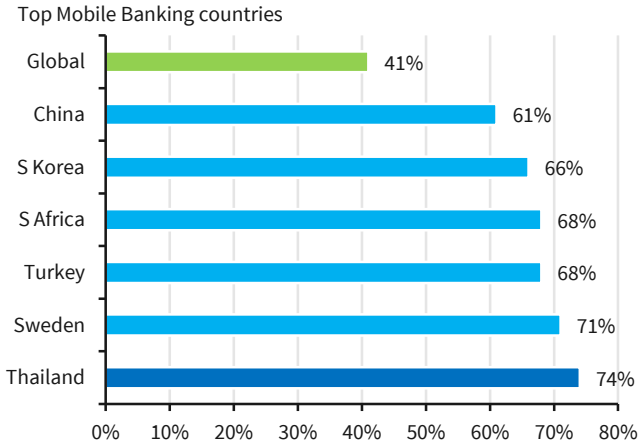
Source: EIA

E-commerce penetration in SE Asia is very supportive of micromobility

Another datapoint supportive of high micromobility uptake in SE Asia is the high level of mobile e-commerce. Indonesia has the world's highest mobile e-commerce penetration rate (76% versus rest of world at 55%), Thailand has the highest mobile banking penetration and Singapore leads the way for ride-hailing. Go-JEK can be partially credited with sparking the region's penchant for online shopping. A major part of the app's popularity is its Go-Food delivery service, which allows users to order meals from popular restaurants and

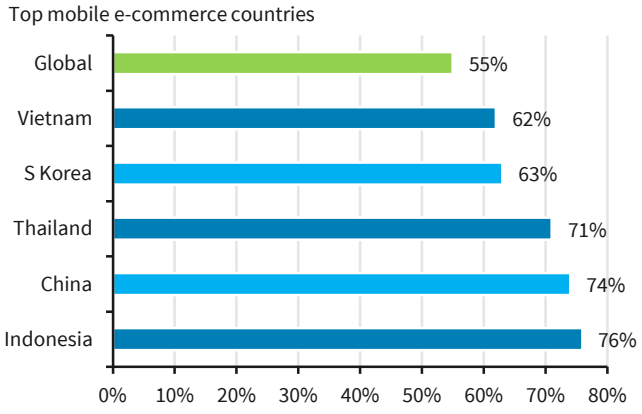
warung – small, family-owned shops. The company says[33] the service processes $2 billion of annualized gross transaction value. Could these deliveries in time be made by electric micro-vehicles?

FIGURE 89
Thailand leads the way for mobile banking (classified as % of internet users who access banking services via mobile)



Source: We Are Social, Hootsuite

FIGURE 90
For mobile e-commerce, Indonesia beats China (% of internet users who make regular purchases via mobile)



Source: We Are Social, Hootsuite

Ride-hailing is popular in SE Asia

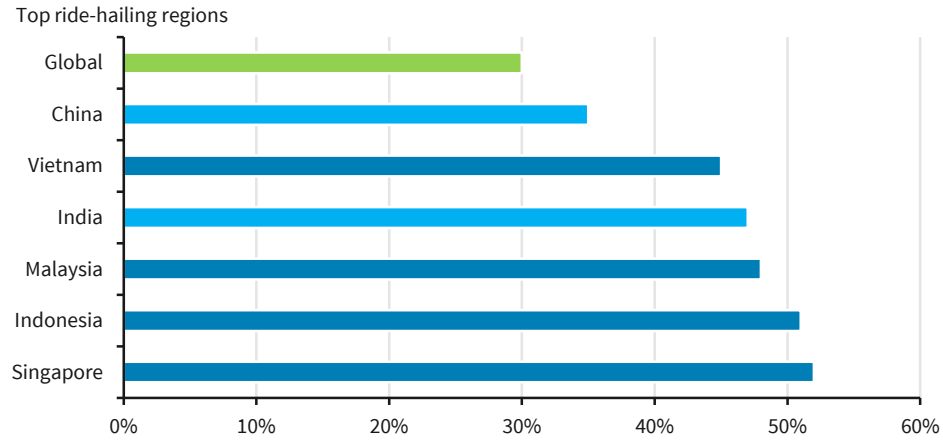
Similarly, e-commerce popularity in Singapore has helped its home-grown ride-hail business, **Grab**, grow since inception in 2013 to become SE Asia's largest ride-hail player. Similarly to Go-JEK's success in Indonesia and beyond, digital payments have helped Grab gain market share. In 2018 Grab acquired Uber's SE Asian operation.

But bikeshare expansion in SE Asia has not been without its failures. **oBike**, a Singapore-based bikeshare operator (which entered into a strategic partnership with ride-hailing company Grab in January 2018 to integrate GrabPay into its app) went into liquidation in June 2018 citing vandalism, strict regulations in many countries and fines, after expansion into Europe.

[33] 'Southeast Asia eclipses China as the world's mobile economy hot spot', Nikkei, 12 February 2019

FIGURE 91

Grab has helped Singapore lead the way globally in ride-hailing (% of internet users who use taxi/ride-hail apps at least once a month)



Source: We Are Social, Hootsuite

E-scooters are starting to appear in SE Asia

While to date the presence of e-scooters in SE Asia has been minimal (with those that were seen on the streets in Singapore in 2018 having largely disappeared, while the government finalises the regulatory environment for the vehicles), there are a number of companies seeking to tap into the market. One of these is **Neuron Mobility**, a Singapore-based e-scooter start-up which believes that being a local player will give it an edge in SE Asia versus Lime and Bird. Neuron raised its first round of seed capital in December, according to press reports [34] and plans to expand into Malaysia, following launches in Bangkok and Chiang Mai in December 2018. The company hopes to differentiate itself from peers by its internal development of a commercial-grade e-scooter (rather than relying on an off-the-shelf consumer product from Xiaomi or Ninebot-Segway), its internal IoT development and predictive analytics.

>380bn PMT could switch to micromobility in Asia ex-China

In summary, we think these combined characteristics of:

- high 2-wheel density
- high smartphone penetration
- strong e-commerce culture and popularity of mobile payments
- speed of ride-hail uptake

bode well for consumer appetite for shared, electric micromobility when it arrives in SE Asia and India. We see a total addressable market of 380bn passenger miles travelled each year which could switch to micromobility in SE Asia (we discuss the basis for these calculations in Figure 35.

[34] 'E-scooter sharing startup Neuron Mobility bags $5m seed funding from SeedPlus', The Straits Times, 6 December 2018

US – dockless micromobility has arrived and it's not just a West Coast phenomenon

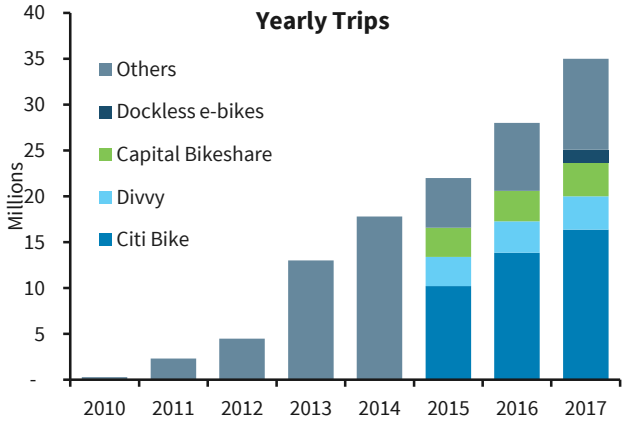
We forecast c70bn PMT could be ripe for MM adoption in the US by the mid-2020s?

Docked bikeshare schemes have been in operation in the US since 2008 with 119 such schemes in operation across US cities at peak. One of the largest docked bikeshare operators in the US is **Motivate** (acquired by **Lyft** in July 2018) which had 63% share of all shared bikes in the US in 2016, according to NACTO (National Association of City Transportation Officials).

However, smart bikes were only introduced into the US bikeshare system in 2014 and by 2016 still only made up 13% of the total bikeshare fleet. The inconvenience of having to find a docked bike at the beginning of a journey and re-dock it at the end has led to some under-utilisation. Some smaller schemes in cities across the US have shut, including the Pronto! scheme in Seattle[35], due to poor economics and/or strict regulations on helmet-use.

FIGURE 92

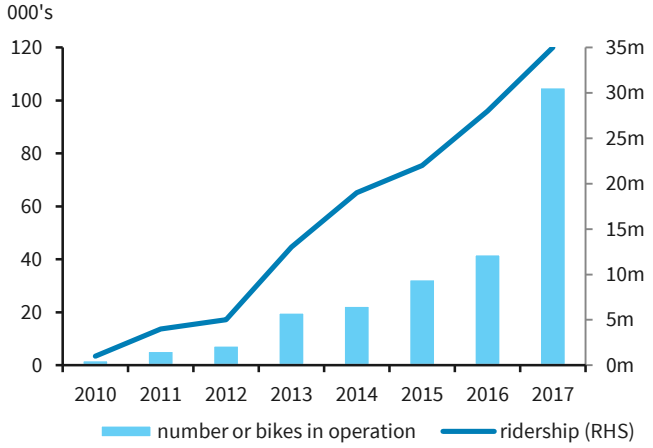
Bikeshare schemes have grown in popularity across the US over the last 8 years (ride/annum)…



Source: NACTO *dockless bikeshare data is currently relatively scarce so 2017 estimates could underestimate usage

FIGURE 93

…but by end 2016, only 42k bikes were in shared operation in the US. In 2017 an additional c60k dockless bikes arrived

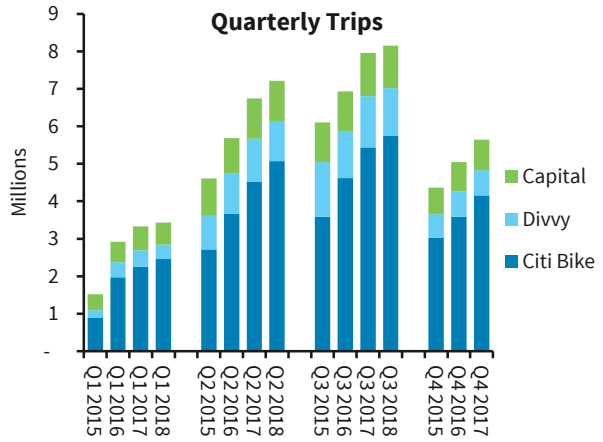


Source: NACTO, Barclays Research

Until recently, docked bikeshare schemes predominantly used non-electric bicycles and have not proved as popular in uptake as ride-hail.

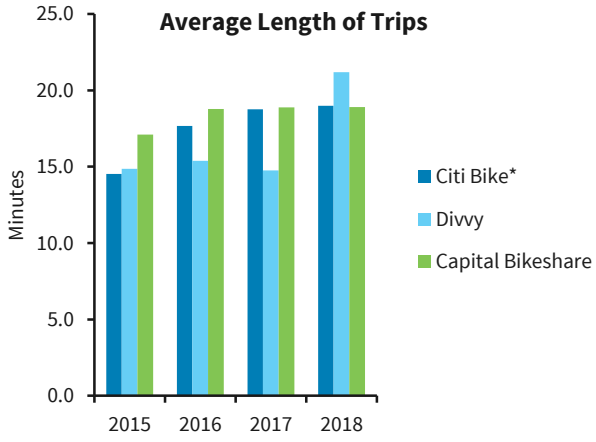
[35] 'The Four Horsemen of the bike Share apocalypse', City Lab 31 Jan 2017

FIGURE 94
Trip data from the three largest docked bikeshare schemes in the US shows strong seasonality



Source: Company data

FIGURE 95
The average docked bikeshare trip is 20mins

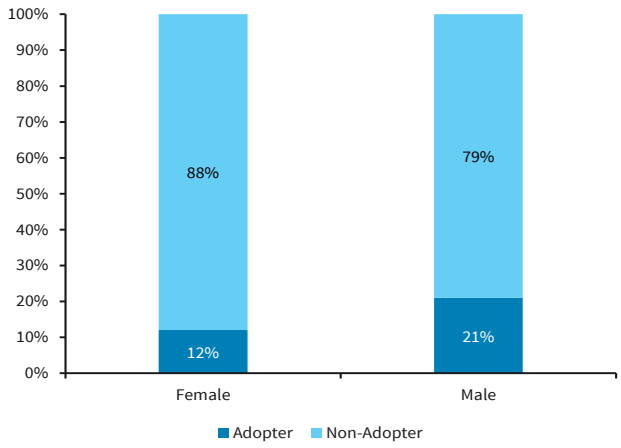


Source: Company data

2017 saw a dockless revolution in the US

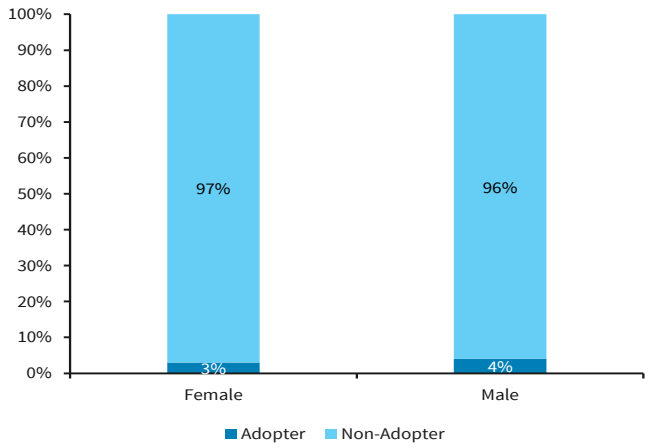
In 2017 non-electric dockless shared bikes arrived in the US in their masses, with Chinese-based Mobike dropping 400 bikes in Washington and Ofo 15k shared bikes across US cities, while US-based **LimeBike** deployed 9k bikes and Spin 4k. By the end of 2017, dockless bikes made up 44% of the total shared bike park in the US but only 4% of all bikeshare trips, according to NACTO (although data from dockless operators was much scarcer than that from the docked system, so the 4% may be an underestimate). Cities soon started requiring permits for operators of dockless systems, scared by the bike graveyard press pictures emerging simultaneously in China.

FIGURE 96
Bikeshare adoption in the US has been growing fast from a low base…



Source: Populus Groundtruth 2018

FIGURE 97
…e-scooter adoption is even more in its infancy



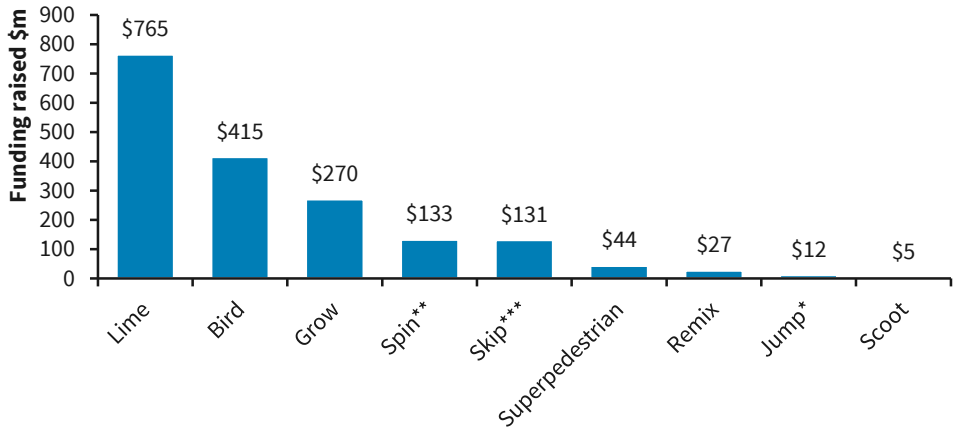
Source: Populus Groundtruth 2018

The same survey found that, overall, 70% of the population in regions with e-scooter offerings viewed the vehicles favourably (albeit this percentage was significantly lower in San Francisco, where e-scooter permits have been capped).

With the purchase of JUMP by Uber in April 2018 (as well as its investment in Lime), Motivate by Lyft in July 18 and Spin by Ford in November 2018, it seems that multi-modal mobility is coming increasingly into focus in the US. Ride-hail operators, or TNC (transport network companies), are clearly aware of the rapid popularity of dockless micro and keen to ensure they do not experience cannibalisation of their shorter-journey trips.

FIGURE 98

Lime and Bird have each attracted valuations of <$2bn and Spin was acquired by Ford reportedly for $100m[36]



Source: Crunchbase, TechCrunch, Company announcements *pre acquisition by Uber, ** pre acquisition by Ford, incl $125m security token, ***$31m equity and $100m in debt

[36] https://www.theverge.com/transportation/2018/11/7/18073046/ford-electric-scooter-spin-acquisition

It's not all about e-scooters, as start-up moped-operator, Revel, is hoping to prove

Case study: interview with Revel Transit (e-moped startup) co-founders Frank Reig and Paul Suhey

Frank Reig and Paul Suhey, co-founders of electric-moped startup Revel in New York, are counting on both the fun factor of electric mopeds and the higher speed than cars in urban areas to ensure strong uptake for their shared offering. The company launched in Brooklyn in July 2018 and plans to take on Scoot, Muving and Scoobi, three other US-focused moped-sharing businesses. During its pilot, Revel users took 22k rides and all 68 mopeds employed remained in operation with zero payouts necessary. The company hopes to roll out a further 1000 mopeds later in 2019. Rides cost $4 upfront for the first 20 mins and then $0.25/min thereafter.

In our recent conversation with the Revel founders, they argued that mopeds are well suited to cities as they exist today and should help city planners circumvent the classification issues that surround e-scooters and e-bikes. E-mopeds are very clearly classified in most countries geographically – while they require a driving licence, a licence plate and the rider must wear a helmet and cannot ride on sidewalks or in bike lanes (which is much more restrictive than regulation for e-scooters), the tighter legal framework allows for more effective checks on riders and also seems to have kept vandalism and theft at bay.

CEOs Reig and Suhey believe their product is more comparable to ride-hail than e-scooter share and can be used over greater distances than scooters. In their recent pilot the average trip was 2.9 miles but that was within a very small (4sqm) area. With a larger operating area, moped distances could compete more readily with urban cars. With a battery life of up to 50 miles, and speed capped at 30mph, vehicles can last 2-5 days and do not need sweeping off the streets to charge every night. The mopeds have fully swappable batteries and a five-year asset life currently. Moped prices have fallen in recent years (currently c$3k from $5k a couple of years ago) and quality has improved dramatically, helped by new players such as **NIU** (NR) providing more customer-focused products at scale.

MM is also popular in LatAm despite low banked rates

In January, the two largest bike and scooter sharing operators in Latin America, Grin and Yellow, agreed to merge. The new holding company is called Grow Mobility and operates 135k vehicles across 6 countries with plans to expand aggressively. LatAm combines high population density with insufficient public transportation, so demand for micromobility is high. But digital payments services and food delivery are also key to the mobility offering. Grow's digital payments platform allows the significant number of underbanked and unbanked users in LatAm to transact. The company allows customers to purchase ride credits with cash, usually at a discount, and use these ride credits for other purchases and payments such as for utility bills or in shops and restaurants, as well as for money transfers between friends.

130bn PMT annually could switch to micromobility in LatAm

Based on our proprietary analysis of micromobility's addressable market (see Figure 35), we believe there are currently 140bn passenger miles that could be made available to travel via micromobility in Latin American by the mid-2020s.

Middle East and Africa potentially ripe for micromobility adoption, albeit with low electric infrastructure as yet

Ride-hail uptake is strong in the Middle East, with homegrown TNC Careem reaching Unicorn status[37] with 30mn registered users in 120 cities (12 countries). The company recently started offering its 'box' delivery service via moped, albeit non-electric vehicles. Superior road infrastructure in the UAE may leave personal transportation less ripe for micromobility disruption, but we do see the potential for micro uptake for food and commercial delivery.

In Africa, with congestion a key issue and urbanisation trends only exacerbating this, as well as a scarcity of public transport, 2-wheeler penetration is already high in terms of both ownership and 2-wheeler taxis or boda-bodas. A number of start-ups, such as Gokada and MAXOkada are trying to capitalise on this space but as yet the vehicles are largely non-electric.

Whether micromobility as we define it takes off in the region will depend on a better electric charging infrastructure and regulatory push.

Europe – bikeshare schemes have been in operation for many years

Bikeshare schemes in Europe have been in operation since 1965 in Amsterdam. In 1995 Copenhagen introduced the ByCylken programme, which used specially designed bikes (with parts that could not be used on other bikes) and locking stands. Other docked schemes followed, such as JCDecaux's Cyclocity operations in Vienna and Lyon in 2015, and in 2007 the hugely popular Velib system started in Paris which gained 20 million users in its first year on c20k bikes. However, many of these bikes were stolen and the City of Paris had to reimburse operators an estimated $2million/annum under its contractual agreement[38]. The Netherlands has a very comprehensive docked bikesharing scheme, 'OV-fiets', which started in 2003 and operates, mainly at train stations, all over the country and works in conjunction with both personal bike ownership and public transport.

Originally most schemes in Europe used non-electric bikes, with Copenhagen the first city to phase in electric bikes in 2016.

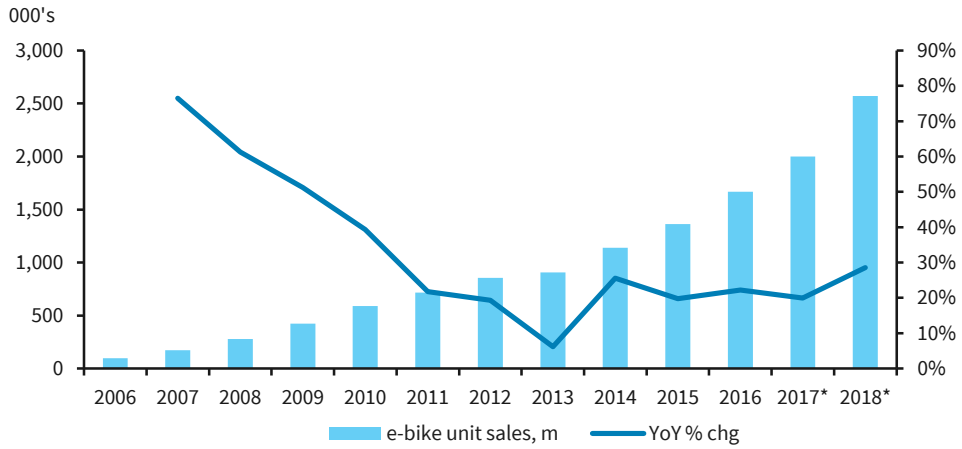
E-bike ownership levels are high in Europe

Nowadays, the Netherlands is the top bicycling nation in Europe, with 27% of all trips made by bike (versus 1% in the US) and 22.5m bikes in use for a population of 17 million.

In addition, e-bike (or pedelec) sales in the Netherlands have grown strongly over the last two years since e-bikes achieved regulatory approval on 1 January 2017. At year-end 2018, pedelec sales made up 15% of the total market for 2-wheel electric vehicles in the country and the electric vehicle market has grown by 80% over the last 5 years, according to Bike Europe statistics. The high-end Swiss brand Stromer (retailing at €4,500-9,500) continues to be the best-selling pedelec in the region. Sweden has also seen strong growth in e-bike sales recently, driven by government subsidies of up to €1k/bike (or 25% of purchase price). The government has set aside SEK 1bn in 2018-20 to encourage e-bike sales.

[37] 'Uber rival Careem closes $500m raise at $1bn+ valuation as Daimler steps in', Techcrunch, 14 Jun 2017
[38] 'French Ideal of Bicycle-Sharing Meets Reality', The New York Times, 30 October 2009

FIGURE 99
European e-bike/pedelec sales



Source: EU Statista, *www.bike-eu.com* *Barclays Research estimates

GM is targeting European e-bike ownership with its new pedelec brand Ariv

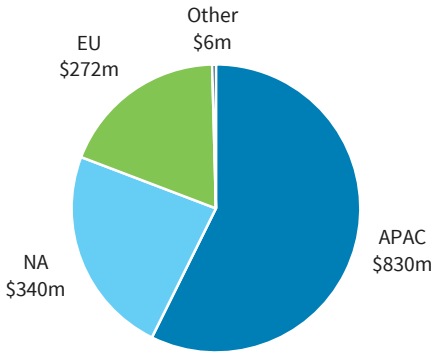
In Germany, e-bike sales rose from 720k in 2017 to c900k in 2018 and, given the high ownership stats in Europe for pedelecs, it is no surprise that, when GM announced its new e-bike brand Ariv, it targeted the European audience first. The GM Ariv Meld and Merge bikes will be first available in Germany, Belgium and the Netherlands because of the *"popularity of lithium-ion electric-powered ebikes in those markets"*, according to a company release. GM's bikes will be connected and with *"automotive grade capabilities"*, according to a company press release, with parts based on development of the electric car, Bolt. Shipments will begin Q2 19.

While the majority of e-bike manufacturers in Europe started life as bicycle manufacturers, some now come from the auto industry (e.g. Bosch, Bridgestone, Yamaha). The majority of the pure-play firms, though, are Asian start-ups. Electric bike imports into the whole of Europe increased 36% in 2018 YoY to 1mn units, despite anti-dumping regulations on Chinese-produced vehicles. Taiwanese-based Giant and Merida are the two largest Chinese manufacturers of e-bikes, estimated by bike-eu.com to make US$170m each from e-bike sales, and Yamaha and Dapu Motors in Japan both make e-bike components and drivetrains. Domestic European e-bike manufacturers include as Riese and Muller in Germany and Scott Sports in Switzerland, as well as auto industry manufacturers such as Bosch. It is estimated that global annual revenue from e-bike sales stands at US$1.5bn ($830m from Asia, $340m from N Am and c.$270 from Europe)[39].

[39] 'E-bikes already at $1.5bn annual revenue & being fought for globally', CleanTechnica28 November 2018

FIGURE 100

Close to 60% of the estimated US$1.5bn of global annual revenue from e-bike sales comes from Asia



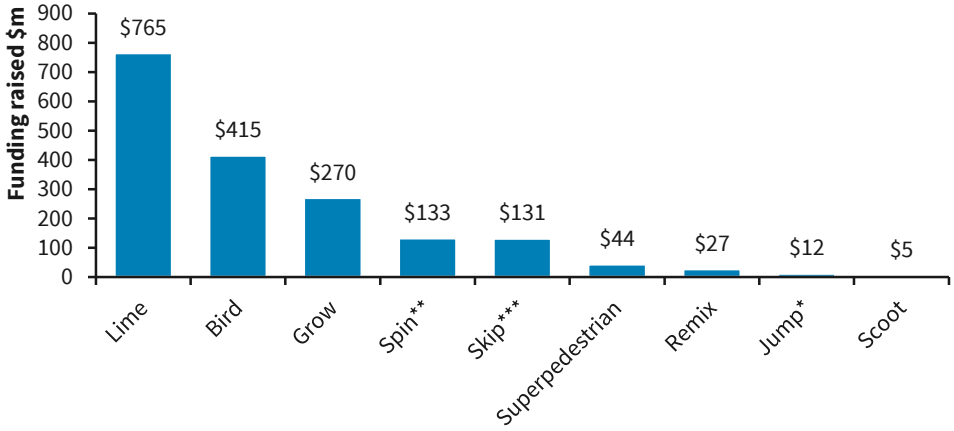
Source: CleanTechnica

Dockless bikeshare and electric bikeshare are still in their infancy in Europe

Dockless micromobility operations are still in their infancy in Europe and face more regulatory impediments than in the US and China. Nextbike has been operating in Germany for 14 years and now offers dockless (or flex) as well as docked bike systems in collaboration with public transport, operating in 200 cities in 26 countries, with electric-assisted bikes available in some regions (it purchased 20k electric bikes in 2018). In 2017 Ofo arrived in a couple of UK cities but withdrew service the following year. In 2017 Singapore-based oBike launched in many European cities (although was asked to leave London in 2017 for operating without permission) and several European start-ups have also launched, including Pony Bikes in the UK and Denmark-based Donkey Republic. US-based Lime Bike also arrived in Europe in 2018. However, the most cycling-friendly city in Europe, Amsterdam, has banned the use of dockless bikes, according to the European Bicycle Manufacturers Association (EBMA).

FIGURE 101

Funding for micromobility in Europe is accelerating but remains far below that in the US and Asia



Source: Crunchbase, TechCrunch, Company reports

APPENDIX 1 – NATIONAL HOUSEHOLD TRANSPORT SURVEY

The US Federal Highway Administration has with partners performed eight iterations of the National Household Transport Survey since 1969. The 2017 NHTS collected surveys from 129,112 households, recruited using primarily physical mail and subsequent responses by phone or web. Utilising data from the US census and American Community Survey, the individual responses for households are given weights in order to estimate the overall behaviour of the US population.

For every household in the survey, anonymised demographic information is collected such as census region population density, household income, count of household members, household state and if applicable the large conurbation resided in. Subsequently every person in the household lists their personal vehicles, any medical conditions, and transport summary questions: for example, whether respondents have access to a bike and number of uses of bike in last 30 days[40]. The personal vehicles are listed by make, model and age.

The survey is centred around 264,000 1-day travel diaries for these household members. The diary lists every trip taken during the 24-hour period for a comprehensive list of transport modes, including private vehicles, transit, walking, taxis, rental. Each stage in a multi-mode journey is defined as a separate trip, such that every change of transport mode is defined as a new trip. Data recorded for each trip includes the day of the week, the trip time, the purpose, the transport mode, the vehicle ID when applicable, the trip mileage and whether the respondent is a worker.

This detailed record of actual mobility behaviours enables behavioural trends of the US populace to be compared, with appropriate use of weights and their error estimates. Comparisons can be made among demographics or transport modes within a survey or for the changes in behaviour vs. previous surveys.

In the model described above we make particular use of the following data fields:

- Category of population density (persons per square mile) in the census block group of the household's home location
- Count of bike trips (in past 30 days)
- The range of 'Medical Device Used: xyz' fields to filter for the able-bodied population
- Trip transport mode
- Whyfrom/whyto, both to select trips starting or ending at home and also to filter out trips for exercise purposes
- Trip length in miles

[40] For 2017 survey, previously in past 7 days

APPENDIX 2 – ADDITIONAL DETAILS ON BARCLAYS' PROPRIETARY MODEL

We discuss here further details of the formulation of our US micromobility market estimates using the NHTS survey.

We define our signal sample as 'cyclists at home'. We define these signal respondents as:

- They are a bicyclist; defined here as having a bike available and responding positively to having ridden a bike in the past 30 days – analogous to the availability of scooters if they were fully penetrated.
- The trip starts or ends at home[41] – analogous to the ease of finding and dropping off a scooter, or the first stage of a longer journey with multiple modes of transport (e.g. riding bike to station and take train).

We define our target demographic as able-bodied non-cyclists. We believe they do not currently have ready access to alternatives for short trips, but will estimate a % of trips where they might switch if access were available. In the survey, respondents classify themselves in regards to having any medical conditions. We take the conservative view of only including the able-bodied. This sample includes 269m members of the population.

Our calculation can be written formally as:

$$Est_{\{p\}} = \left(\frac{Sb_{\{p\}}}{St_{\{p\}}} - \frac{Tb_{\{p\}}}{Tt_{\{p\}\}}}\right) * A * X$$

Where {p} is the population density range, A is the total able-bodied trips under 5 miles for the target demographic. Sb (Tb) represents the number of <5 mile trips on bikes for the signal (target) sample and St (Tt) the total sample (target) trips under 5 miles. For each population range we apply a linear assumption for the availability of micromobility, X.

The availability assumption X, for each census population band, represents Barclays' estimate for the % of households where micromobility is ready accessible. In the most densely urban areas of the US, such as Manhattan, micromobility operators can locate their solutions close the majority of the population. For other areas X is materially below 100%, linearly scaling down the number of trips that we estimate might switch to micromobility. For the large suburban sprawls of American metro areas, this estimate becomes less intuitive. However, we believe a number of the emerging players in the field do indeed target such areas. We have chosen availability assumptions based upon our understanding of the potential business models without explicitly modelling for capacity constraints or traffic.

[41] Excluding trips for exercise

ANALYST(S) CERTIFICATION(S):

We, Kristina Church, Ryan Preclaw, Ben McSkelly, Nabil Ahmed, Sander Bunck, Paul May, CFA, Vicki Stern, Patrick Coffey, Dorothee Cresswell, Erwann Dagorne, Brian A. Johnson, Andrew M. Gardiner, CFA, Blayne Curtis, Gerardus Vos, Andrew Ross, CFA, Alvira Rao, James Anstead, Nicolas Champ, Julien Roch, Lydia Rainforth, CFA, James Rose, CFA and Hiral Patel, hereby certify (1) that the views expressed in this research report accurately reflect our personal views about any or all of the subject securities or issuers referred to in this research report and (2) no part of our compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this research report.

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