Exclusive Insights in 2024 Micromobility Trends:
The Future of Urban Mobility

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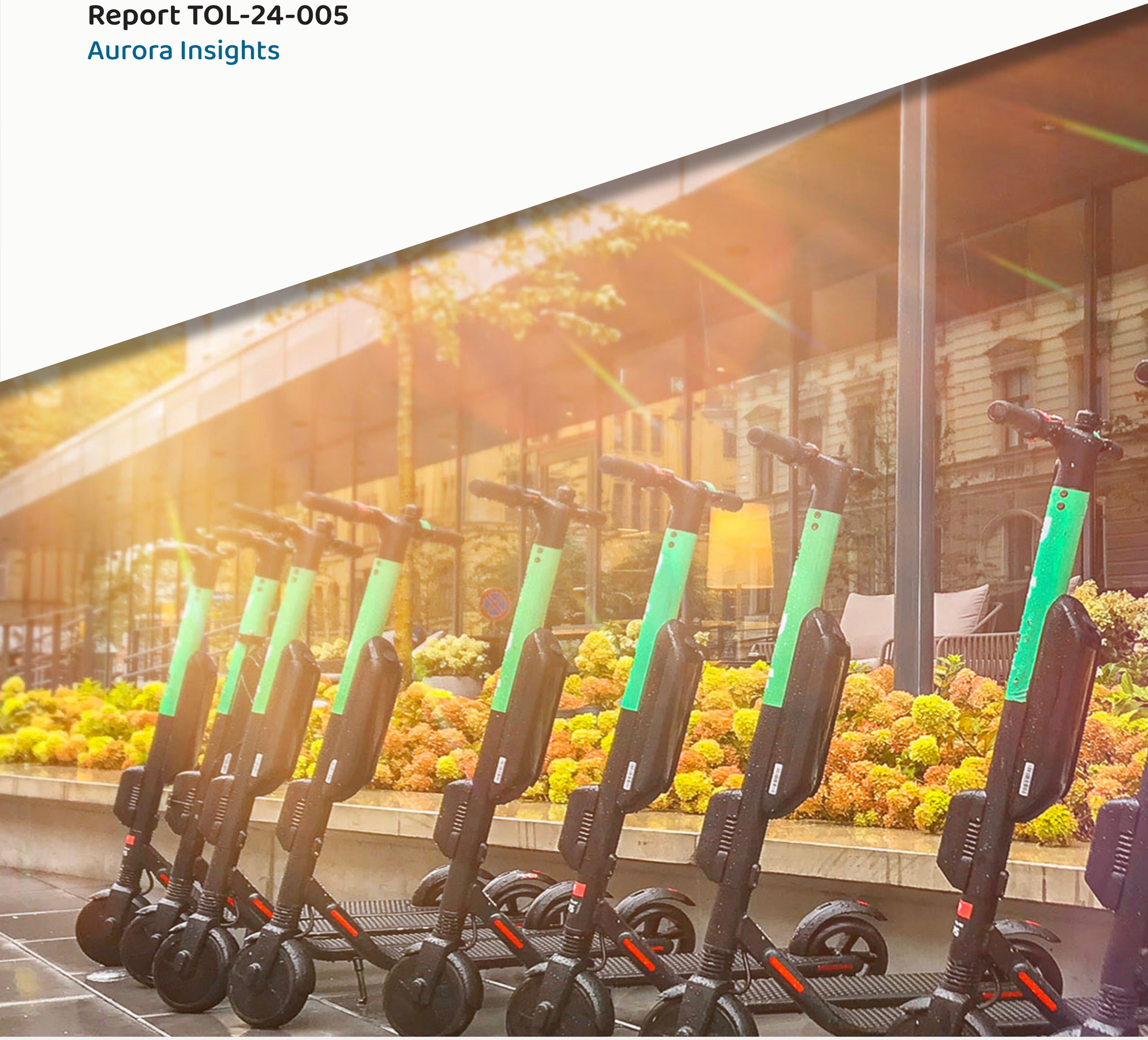

aurorainsights.co.uk
research@aurorainsights.co.uk
subscriptions@aurorainsights.co.uk
marketing@aurorainsights.co.uk

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Document Information

Author contact details

research@aurorainsights.co.uk

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Abstract

Micromobility is experiencing significant growth in the transportation and logistics sectors, driven by increasing awareness of sustainability, public health considerations, and its potential to enhance business profitability and user satisfaction. Offering an alternative to high emission vehicles and transportation modes, micromobility is set to revolutionize sustainability for both the private and public sectors. Beyond its core function of enabling environmental-friendly urban commuting, micromobility can reduce congestion, improve efficiency, and enhance both accessibility and equity. This paper explores key trends in the growth of micromobility, including challenges in its implementation, technological advancements, and the broader impacts on the transportation and logistics sectors.

Keywords

Micromobility, sustainability, public health, congestion reduction, efficiency.

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Aurora Insights is the intelligence and consultancy division of Akabo Media. They have a sector focus on supply chain and logistics, robotics and automation, and tolling and road user charging.

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1. Introduction

The micromobility industry is experiencing significant growth, with global market projected to reach USD 360 billion by 2030 (Heineke et al., 2024). This trend is evident across different regions. In Europe, the micromobility market is expected to reach USD 140 billion by 2030, representing the largest share of global market value (McKinsey, 2025). In North America, 172 million shared micromobility trips were recorded across 421 cities in 2023, using e-scooters, e-bikes, or pedal bikes (Herr, 2024). The Asia Pacific region is following a similar trajectory, with China emerging as the leading player (World Economic Forum, 2022). The uptake is also accelerating in the Middle East, where the region's market share is projected to more than double between 2022 and 2030 (Heineke et al., 2024).

This rapid global adoption reflects micromobility's growing relevance across urban transportation systems. Micromobility serves a wide range of use cases, including leisure, daily commuting, shopping, and food or last-mile deliveries. Its widespread adoption offers several benefits. First, micromobility reduces dependence on fossil-fuel-powered vehicles for short distance trips, lowering carbon emissions (ITF, 2024). It also helps reduce noise pollution, as these vehicles rely on human or electric-powered drivetrains that operate more quietly than internal combustion engine vehicles (ICEVs) (Walton et al., 2023). In addition, micromobility can alleviate urban congestion, as these vehicles can travel in cycle lanes and park on sidewalks, thereby freeing up road space (Büttgen et al., 2021). Finally, micromobility can promote public health by encouraging physical activity and reducing exposure to environmental and noise-related health risks (WHO, n.d.; UK Health Security Agency, 2023).

Despite its rapid growth and clear benefits, the micromobility industry faces several challenges. Although micromobility vehicles reduce environmental and noise pollution, the environmental impact of electricity generation used to power e-micromobility remains a concern (Barkenbus, 2017). Accessibility is another challenge, particularly for people from lower socioeconomic backgrounds, individuals with disabilities, and residents of rural areas

(Perry, 2020; Sight Loss Councils, n.d.; Armstrong, n.d.). Theft is another growing concern, driven by the portability and rising market value of micromobility vehicles (Mini Walker, 2023). Improper usage, anti-social behavior, and noncompliance with traffic regulations raise safety concerns. Additional barriers include limited charging infrastructure for e-micromobility, GPS inaccuracy, and the high computational demand of implementing geofencing systems (White, 2020; Boyle, 2024).

We add to existing literature through our analysis of current micromobility trends using an exclusive data pool of 25 case studies, consisting of 62 companies. To access this data, we conducted interviews with major players in the industry on current projects being undertaken. Data was collected in September 2024. From these interviews, we gathered information on the challenges these projects sought to improve, the solutions implemented, technologies employed, and benefits reaped.

From our sample, we identified three key challenges. The first of these was environmental concerns, reported by 76% of the case studies. These concerns include high Scope 3 emissions, carbon emissions, excessive energy consumption, pressure from climate change mandates, and poor air quality. In response, 56% of the sample focused on supporting modal shift away from car dependency to more environmentally friendly mode of transportation. Road safety emerged as another recurring challenge, identified by 36% of the sample.

To address these challenges, the projects in our sample deployed a range of technologies, including e-micromobility solutions, digitalization tools, data analytics, monitors, and sensors. Following implementation, companies reported a variety of benefits. Environmental improvements were observed in 60% of the case studies, while 36% reported enhanced operational performance. Around 32% of the projects promoted active and public transportation, and an equal share reported reductions in traffic congestion. Other reported advantages included improved operational efficiency and visibility, enhanced data collection, increased accuracy, and better user experience.

The remainder of the paper is structured as follows. Section 2 reviews background information and relevant literature on micromobility industry, focusing on its market landscape as well as the associated challenges and benefits. Section 3 expands on our data source and sample. Section 4 outlines the results of our analysis, and Section 5 concludes with actionable insights.

2. Background and Literature Review

Micromobility vehicles are small, lightweight transportation devices designed for short-distance travel (Marie, 2023). These devices are typically single-user, operate at speeds no greater than 25km/h, and weigh less than 227kg (Marie, 2023; SAE International, 2019). Common forms of micromobility include bicycles, scooters, skateboards, roller-skates and their electronic equivalents, as well as tuk-tuks, and segways (US Department of Transportation Federal Highway Administration, 2021; Marie, 2023). Micromobility solutions provide a versatile and increasingly relevant alternative to short-distance car trips, particularly in urban transport systems. Micromobility is widely used by the public for commuting, leisure, and shopping (UK Department for Transport, 2023), and promotes health and fitness while simultaneously offering an environmentally sustainable alternative to high-emission vehicles. Furthermore, micromobility is increasingly being implemented for first- and last-mile delivery, with companies such as Fin, Delivery Mates, and Amazon using e-cargo bikes and other forms of micromobility to provide sustainable parcel delivery services.

Public-private collaboration is essential in ensuring the efficient adoption of micromobility. Governments and local jurisdictions are responsible for developing and maintaining infrastructure, implementing regulations, and ensuring the public's responsible use of micromobility infrastructure. Meanwhile, private companies provide micromobility solutions through the production and provision of micromobility vehicles like bicycles and e-scooters for private renting and sharing schemes (Heller, 2021). In this literature review, we discuss and assess the overall benefits and challenges of increasing micromobility, both in the public and private sectors, and public-private micromobility partnerships.

Benefits of Micromobility

A major benefit of micromobility is reduced transport emissions. The adoption of micromobility solutions such as e-scooters and bicycles reduce reliance on fossil-fuel-powered vehicles for short trips, significantly lowering greenhouse gas emissions. From a life-cycle assessment perspective, micromobility emit only 15 to 61g CO_2/pkm, depending on the specific vehicle type. In comparison, a typical EU fossil-fuel passenger car emits 160 gCO_2/pkm, while an EV under similar conditions emits 91 gCO_2/pkm (ITF, 2024). Additionally, micromobility delivery alternatives for last-mile logistics have reduced emissions by as much as 96% per year compared with regular delivery vehicles which previously accounted for 20% to 30% of a city's total CO2 emissions (Davies, 2020; Büttgen et al., 2021; Pleeth, 2023). PostNL showed that its operations in Utrecht, Netherlands, has reduced its CO2 emissions by 35,000 kilograms annually using electric bicycles and small electric vehicles (EVs) (WSP, 2022). In 2023, PostNL achieved a 30% reduction in carbon emissions per packages compared to 2020 (PostNL, 2024). Furthermore, two pilot programs conducted between 2020 and 2022 in Bogotá, Colombia, employed e-cargo bikes to reduce CO2 emissions by over three tons (P4G, 2024).

Another significant benefit of micromobility is its ability to reduce congestion. Traditional car transportation and truck deliveries contribute heavily to congestion by excessively using roads, double parking in cycle lanes, and occupying parking spaces (Büttgen et al., 2021). In 2024, congestion in London alone caused drivers to spend an average of 101 hours sitting in traffic, culminating in an annual cost of GBP 942 (USD 1,267)[1] per driver (INRIX, 2025). Micromobility offers a solution for this, as micromobility vehicles can park on sidewalks and travel in cycle lanes, freeing up road space (Büttgen et al., 2021). Further, these reductions in congestion can even improve cost-effectiveness for companies using micromobility in the delivery sector. Micromobility vehicles such as cargo bikes contribute less to congestion by using designated bike lanes. This allows delivery companies to significantly reduce delivery times and make their operations more cost-effective than if they used trucks short-range deliveries (Pointer and Sood, 2022). In Bogotá, Colombia, for example, the pilot project BiciCarga (2020-2022) deployed e-cargo bikes for last-mile deliveries and, on average over the two-year implementation period, reduced driver working hours by 2.3 hours daily and increased deliveries made per hour by 67% (P4G, 2024). Reducing delivery times allows

[1] Currency conversions retrieved as of July 15th, 2025.

delivery companies to increase their operational productivity and fulfill more orders with lower labor costs.

Micromobility's market growth has also facilitated improvements in public health both directly and indirectly. Micromobility, particularly cycling, directly promotes physical activity, which in turn helps to improve public health. For example, the British government plans to encourage active travel, including walking and cycling, with the aim of halving childhood obesity from 23%[2] and to reduce adult obesity from its current level of 26% by 2030 (Department of Health and Social Care, 2023; Metcalfe and Sasse, 2023). Indirectly, the increase in micromobility has also improved city residents' health by reducing emissions from combustion engines, which is linked to respiratory conditions, pneumonia, ischemic heart disease (WHO, n.d.). In England and Wales for example, it has been noted that regularly cycling reduces the risks of cardiovascular diseases by 20%, cancer deaths by 16%, and cancer incidences by 11% (Patterson et al., 2020). In Shanghai, increased micromobility use reduced particulate matter and nitrogen oxides emissions by 2.7% and 0.9%. Improved air quality, coupled with increased exercise levels and reduced numbers of traffic incidents, has led to reduced premature death rates (Sudmant et al., 2020).

Micromobility also has a positive impact on noise pollution. The noise generated from traffic has been linked to health issues such as sleep disturbance, strokes, heart disease, diabetes, depression, and anxiety (UK Health Security Agency, 2023). A further study commissioned by the British Government found that 40% of adults in England were regularly exposed to long-term road traffic noise exceeding 50 decibels, with over 60% of residents in major cities regularly experiencing the same dangerous levels (UK Health Security Agency, 2023). The noise difference for ICEVs and micromobility solutions is significant. Whereas regular traffic produces significant noise between 70 and 75 decibels (VAC, 2024), micromobility vehicles produce very little sound, with an average noise level between 45 and 50 decibels during normal operation (The University of Montana, 2023; E-Dash Mobility, 2023). This reduction

[2] Statistic for children aged 10 – 11.

is primarily due to micromobility vehicles relying on electric or human-power drivetrains (Walton et al., 2023).

Market Growth of Micromobility

Micromobility offers various benefits, including reduced pollution and congestion, improved public health, and cost-effectiveness. Driven by these benefits and its wide range of applications, micromobility use is rising globally in both public and private sectors. The global market for micromobility was estimated at USD 175 billion in 2022 and is projected to reach USD 360 billion by 2030 (Heineke et al., 2024). London alone generated 29 million dockless shared bike trips in 2024 (Musa, 2025a). Meanwhile, 1.45 million units of mechanical bikes sold in 2024 in the UK, with a projected 2% growth in 2025 (The Bicycle Association, 2025). Similarly, micromobility use is growing in other European countries. Private bike rental company Swapfiets has expanded its operations to 60 cities across Europe, with a total of 280,000 active users. Other companies like Fifteen, Donkey Republic, and Nextbike are covering similar sized areas with equally large customer bases (Bearne, 2023). By 2030, the European micromobility market is expected to reach USD 140 billion, representing the highest share of the global market value (McKinsey, 2025). This market dominance correlates to the European Union's high private ownership. Roughly 57% of Europeans own a mechanical bike and 19% own an electric bike in 2024 (Ipsos, 2024). The number of e-scooter users in Europe has also risen, with shared e-scooter trips in Europe increasing by 4% in 2024 compared to 2023 (MMfE, 2025). The high popularity of micromobility in Europe reflects the high market value and prominence of micromobility schemes in the region.

North America's micromobility sector has also undergone a period of significant growth, with 172 million shared micromobility trips taken across 421 cities in 2023 (Herr, 2024). Among these trips, 40% were made using e-scooters, 51% with e-bikes, and the remaining trips with pedal bikes (Herr, 2024). These schemes have facilitated over 130 million trips on shared micromobility in the United States and Canada (NACTO, 2023). In terms of market share, in 2022 the United States accounted for USD 30 billion of the micromobility market, a figure projected to double by 2030 (Heineke et al., 2024).

The Asia-Pacific region has recently seen significant growth in the adoption of micromobility as well. In China, the micromobility market is experiencing rapid expansion, with its 2022 market share of USD 45 billion anticipated to reach USD 64 billion by 2030. China's adoption of micromobility is predominately concentrated in urban areas, with bicycles representing the most common mode of transport (World Economic Forum, 2022). Notably, approximately 73% of residents use micromobility solutions alongside public transportation, suggesting that the convenience of this modal shift makes it an attractive alternative to cars (World Economic Forum, 2022). Additionally, China accounts for about 75% of the total global ownership of dockless shared bikes[3], reflecting the country's advanced infrastructure and widespread adoption of micromobility (Sudmant et al. 2020). At the end of March 2023, China had around 14.9 million shared bicycles deployed in over 410 cities, with 1.768 billion registered users with a daily average order volume exceeding 27 million (CRTA, 2023; Dai et al., 2024). Micromobility use is also prevalent across the APAC region. In Australia, between 55 -58% of households have had regular access to a bike since 2011 (CWANZ, 2021). The adoption of e-scooters among Australian adults is also high, with 3.6 million residents (18% of the adult population) using them in 2022 (We Ride Australia, 2023). Overall, Australia's micromobility uptake has contributed to reducing congestion, cutting greenhouse gas emissions, and promoting active travel (Buning and Pham, 2023).

The micromobility landscape in the Middle East is also growing, with market share in the region expected to more than double between 2022 and 2030 (Heineke et al., 2024). Dubai leads the region in terms of micromobility licensing, infrastructure development, and pilot programs, while Abu Dhabi and Bahrain are making promising progress in regulating shared micromobility schemes (Hubbard, 2022). Additionally, the global rideshare company Lime has expanded its operation into Doha, Qatar, deploying a fleet of 500 e-scooters and e-bikes

[3] Dockless shared bikes allow users to unlock and park bikes without fixed docking stations.

(Lime Micromobility, 2025). Nonetheless, despite these developments, the comparatively small size and slower growth rate in the Middle East region suggests micromobility remains a smaller focus.

Beyond leisure, commuting, and shopping, micromobility is increasingly being used for food and last-mile deliveries. For instance, in San Francisco, 76% of DoorDash food deliveries are completed using two-wheeled vehicles such as bikes, e-bikes, and scooters (DoorDash, 2024). In New York City, Amazon has announced plans to upscale its micromobility fleet, aiming to deploy over 250 new cargo bikes across Manhattan by the end of 2025 (Musa, 2025b). In London, increasingly more companies are using microhubs to support cargo bike deliveries and expand their micromobility networks. Currently, Amazon operates four micromobility delivery hubs, covering a significant portion of the city, while another delivery company, Delivery Mates, manages seven micromobility hubs (Amazon, 2024; Dodds, 2024). Venture capital investment has played a pivotal role in the growth of the global micromobility sector. Between 2018 and 2022, private investors and VC firms injected over USD 8.4 billion into the industry, with USD 4.5 billion invested during 2018–2019 and USD 3.9 billion during 2020–2022 (Heineke et al., 2022; Mobility Innovators, 2023). However, this momentum slowed between 2023 and 2024, as many micromobility companies failed to meet investor expectations for rapid profitability, leading to a decline in PE/VC interest (Bharucha and Vidal, 2024). This shift highlights the increasing importance of public sector support in sustaining and scaling micromobility initiatives.

The geographic distribution of investment also changed markedly. During 2018–2019, Asia dominated with 60% of global investment, followed by North America (28%) and Europe (12%). But by 2020–2022, Europe had surged ahead, accounting for 49% of global investment, while North America rose slightly to 42%, and Asia dropped sharply to 10% (Heineke et al., 2022). This decline in Asia’s share is likely due to Covid-19-related lockdowns (especially in China) and market saturation, which eroded investor confidence. In contrast, Europe's pro-micromobility policies—including investment in cycling infrastructure—and a wave of industry consolidation made the region increasingly attractive to investors.

Investment trends have also shifted by vehicle type. In 2022, 90% of global micromobility VC funding was directed toward bicycle-focused companies. By 2024, this had flipped: e-scooters attracted 78% of the total investment, while bicycles received just 22% (Bharucha and Vidal, 2024). This reallocation reflects changing patterns in micromobility ownership, use, and perceived profitability.

Challenges with Micromobility

Despite the rapid market growth and the numerous benefits brought about by micromobility, it also presents challenges. Firstly, while the use of e-micromobility reduces noise and pollution from a lack of tailpipe emissions, the production of the electricity used for many micromobility vehicles raises concerns. The electricity used to charge micromobility vehicles can be generated using fossil fuels, reducing the overall sustainability benefits of the vehicle itself. Therefore, electricity usage must be considered when determining the overall emissions and sustainability impact of e-micromobility solutions. This is a particular concern for China, which generates electricity by burning fossil fuels (Barkenbus, 2017). Additionally, the origins of battery components should also be considered. For example, much of the cobalt used in battery production comes from the Democratic Republic of Congo, an area with noted environmental and human rights issues stemming from the mining of raw materials. (Ambrose and O'Dea, 2021; NMIS, n.d.; Amnesty International, 2016; World Economic Forum, 2021).

Furthermore, accessibility remains a significant challenge for micromobility, contributing to equity issues. For individuals from lower socioeconomic backgrounds, accessibility to micromobility is limited due to high costs. Pay-per-ride services can be expensive, with a 15-minute e-scooter ride in the UK costing between GBP 1.8 (USD 2.4) and GBP 4 (USD 5.4), depending on location, for an average trip of 17 minutes covering 2.5 km (O'Brien, 2022; Transport for London (TfL), 2023). Private micromobility solutions like e-scooters is also unaffordable for them, as they can cost over GBP 1,000 (USD 1,345) (Beech, 2024). Additionally, as more pay-as-you-go micromobility solutions use apps for payments, individuals without smartphones may encounter an accessibility barrier due to the cost of owning one (Perry, 2020). To address these accessibility issues, companies such as Bird, Spin, and Lime have implemented initiatives that provide discounted, or subsidized, fees for those without the means to pay higher prices (Perry, 2020). Additionally, Bird provides both the ability to pay by cash with certain vehicles and to lock and unlock vehicles using SMS text messaging which does not necessarily require a smartphone (Bird, 2023). Nonetheless, while these are viable solutions to accessibility issues, they are not available globally, making accessibility for lower socioeconomic groups a persistent concern in micromobility (Perry, 2020).

There are also accessibility barriers for blind and partially sighted people. For example, e-scooters and bicycles that are abandoned at the top of staircases, outside doorways, and in the middle of pavements present a significant risk to sight-impaired people, creating tripping hazards (Sight Loss Councils, n.d.). Consequently, people with sight problems have reported anxiety about tripping over e-scooters, as well as not being able to detect them while they're in use as they emit little sound (Sight Loss Councils, n.d.). To promote the inclusion of sight impaired people, micromobility vehicle manufacturer TIER[4] collaborated with the Sight Loss Councils to create a public awareness campaign that aimed to encourage the responsible parking of scooters and bicycles (Intelligent Transport, May 2023). Furthermore, TIER and the Sight Loss Councils collaborated to develop an acoustic vehicle alert system to give blind and partially sighted people increased opportunities to detect e-scooters (Sight Loss Councils, n.d.). Designated parking docks and fines for parking outside geo-fenced areas, as implemented by micromobility provider Bolt, further help reduce street clutter. According to Bolt, this creates a more accessible and safer road environment, particularly benefiting blind or partially sighted individuals. Finally, to further improve accessibility, solutions such as specially designed vehicles are being explored to enable the differently abled access to micromobility. For example, TIER has created an e-scooter design that allows wheelchair users to attach their wheelchairs to the scooter, enabling them to use it similarly to non-wheelchair users. This design is compatible with 95% of wheelchairs.

[4] TIER merged with Dott in 2024, and the combined company now operates under the Dott brand.

Rural accessibility presents another challenge, as micromobility schemes are generally concentrated in urban centers (Armstrong, n.d.). Delivery companies also focus on urban areas due to location requirements for micromobility hubs and the range of micromobility vehicles. That is to say, micro-hubs are most efficient when established in high demand density areas (Amazon, 2024; Carracedo and Mostofi, 2022). This urban-centric approach limits the benefits of micromobility in terms of reducing pollutants such as O_3 and NO_2 in rural areas, where these emissions remain high (UK Health Security Agency, 2023; DEFRA, 2021). The reported decline in cycling in rural regions, attributable to a lack of safe active travel routes, also offsets potential reductions in emissions and noise (Cycling UK, 2021). To solve this issue, solutions such as reduced traffic speeds, cycle-friendly infrastructure, better off-road access, and new mobility programs have been proposed to increase micromobility uptake (Cycling UK, 2021).

Another problem facing micromobility in both the public and private sectors is theft, with theft rates especially high in areas with widespread micromobility. The portability and lightweight nature of micromobility like e-scooters, as well as their rising market value, makes them targets for theft. Additionally, the speed at which they can be dismantled makes catching thieves difficult (Mini Walker, 2023). For example, in the Netherlands, between 468,000 and 772,000 bikes are stolen annually (Proctor, 2023). In the United Kingdom, 77,000 bikes were reported stolen between 2022 and 2023 (Clark, 2023; Office for National Statistics, 2023). Additionally, over 2,300 e-bikes and e-scooters were stolen from rental schemes in London between June 2022 and June 2023, a 17% increase from the previous year (Lee, 2023). Moreover, of the thefts in London during this period, only 1.1% of suspects were charged, meaning theft largely goes unpunished (Lee, 2023). To prevent this, private owners are encouraged to invest in quality locks, choose parking locations which are well-lit with high foot traffic, use built-in security features like alarms and GPS tracking, purchase insurance, and personalize their micromobility devices for easy identification (Mini Walker, 2023).

Moreover, safety concerns related to micromobility continue to be a significant issue. One major concern is related to traffic incidents. Between 2017 and 2023, one cyclist per week in the United Kingdom was killed or seriously injured due to potholes and road defects (Jones, 2023). Furthermore, from 2018 to 2022, an average of 81 cyclists were seriously injured and two killed per week in road incidents (UK Department for Transport, September 2023). In the US, an estimated 117,600 e-scooter injuries were treated in the emergency department from 2017 to 2021, and during the same period, 121,300 hoverboard-related injuries were reported (CPSC, 2022). Female micromobility users face heightened safety issues. Looking at usage demographics, males are the most prevalent users, with females gravitating towards e-scooter use if they use shared micromobility schemes at all (Reck and Axhausen, 2021). This male-dominated demographic reflects safety concerns, as only 19% of women in the United Kingdom feel comfortable cycling alone at night. Barriers such as poorly lit roads, isolated cycle routes, lack of confidence, and antisocial behavior further discourage female users (Intelligent Transport, December 2023). To improve safety and expand micromobility adoption, governments and local jurisdictions are actively investing in public cycling infrastructure, improving street lighting, and offering cycle proficiency education in schools (Intelligent Transport, December 2023). For example, the UK Government has allocated GBP 1.6 billion (USD 2.2 billion) to local authorities between 2025 and 2026 for pothole repairs (GOV.UK, 2025). The private sector is also contributing to address this challenge with solutions like Lime's "follow my ride" feature, which enhances safety by allowing users to share their journey in real-time. Additionally, apps mapping well-lit routes and cycling infrastructure further support safer nighttime travel, particularly for women (Intelligent Transport, December 2023).

There are also several infrastructure challenges that limit micromobility uptake. One of the most significant challenges is the cost associated with developing micromobility infrastructure. For example, building docking stations for micromobility vehicles can cost between USD 30,000 and USD 60,000 (Clean Mobility Options, 2022), creating a financial burden for both private companies and governments. Another major challenge pertains to e-micromobility charging infrastructure. Similar to EVs, low infrastructure availability can lead to range anxiety concern[5] for riders with e-bikes and e-scooters (Boyle, 2024). While most e-bikes and e-scooters have a range of 15-50 miles, this range can change depending on terrain, weather, and pedal-assist level (Boyle, 2024). Additionally, despite most e-micromobility vehicles being able to be charged on standard 110-volt outlets, the limited availability of public charging points can further exacerbate range anxiety for some users (Boyle, 2024).

Additionally, technological challenges in implementing geofences to control e-scooter and e-bike speeds and parking create obstacles for shared micromobility schemes. For micromobility, geofences create areas that automatically enforce rules such as speed limits and designated parking areas (White, 2020). A primary issue with this is GPS inaccuracy, which can have a margin of error of between 8 and 15 feet (White, 2020). Another technological challenge is communication delays, as most geofencing systems rely on cellular networks to transmit data. The data transmitting process can take several minutes; such delays disrupt the ability to monitor and enforce geofence rules in real time, which is particularly problematic for vehicles moving at high speeds (White, 2020). The GPS imprecision and vehicle-cloud communication delays can result in scooters or bikes being registered outside geofence boundaries, causing issues for both users and providers (White, 2020). For users, this can result in unexpected fines or difficulties in locating in designated parking areas. For providers, it can disrupt fleet management and create operational inefficiencies. Additionally, misplaced micromobility vehicles can obstruct sidewalks, create safety hazards, and hinder micromobility accessibility. Further challenges include transmitting data packets, which are individual pieces of location information organized together and sent through a network path, and managing the computational demands of geofencing systems. Failing to resolve these issues may lead to inefficient and inaccurate enforcement (White, 2020; Walker, 2022).

[5] Range anxiety concern is a concern that a vehicle's charge will not be able to last for a user's entire intended journey.

Public-Private Partnerships for Micromobility Schemes

Both the public and private sectors play a critical role in harnessing the advantages of micromobility and in tackling the previously identified problems effectively. Governments are particularly crucial in facilitating micromobility initiatives through the development of infrastructure and the establishment of regulations.

Globally, there is a shared focus on enhancing public infrastructure to accommodate the growing micromobility sector, increase cyclist safety, and improve overall comfort for micromobility users. In the United Kingdom, public micromobility infrastructure has expanded in recent years, with the creation of TfL cycleways in 2019. The TfL cycleways are a consolidation, re-brand, and major expansion of the previous London cycle lanes "Superhighways" and "Quietways" (TfL, n.d.a). Since the expansion and consolidation of existing cycle routes in 2019, TfL has created 10 cycleways which are situated nearby shared micromobility scheme docking stations, with further plans to expand the network into eight more areas and reach a third of Londoners by the end of 2025 (TfL, n.d.a).

The United States of America is also investing in micromobility infrastructure. As part of the Infrastructure Investment and Jobs Act 2021, the USA invested USD 2.2 billion dollars into local infrastructure projects, including new bike lanes and pedestrian bridges (Tang and Lieb, 2022). In 2020, the San Francisco Municipal Transport Authority (SFMTA), with a total budget of USD 1.4 billion, allocated a substantial portion to improving walking, cycling, and e-scooter infrastructure. This mirrored the TfL plans to improve safety, speed and comfort for micromobility users (SFMTA, n.d.a; Coale, 2023). San Francisco has also implemented the "Slow Streets" program which has created designated low-traffic lanes in the city for vehicles that travel slower than 15 miles per hour. These slow streets help to reduce deaths and injuries resulting from road traffic incidents by slowing down and reducing the quantity of vehicle traffic near micromobility users and pedestrians (Coale, 2023). Additionally, this micromobility infrastructure reduces overall carbon emissions by encouraging micromobility and improving accessibility as there is more space for micromobility users.

Europe has also seen significant development in micromobility infrastructure. In 2022 alone, 42 European metropolitan cities implemented 1421.54 km of new cycling infrastructure (Hossein Sabbaghian et al., 2023). The Netherlands provides another strong example of government intervention in the planning, creation, and maintenance of public sector micromobility infrastructure. In 2022, a one-time budget of EUR 780 million (USD 912 million) was allocated to improve bicycle access in residential areas (EU Urban Mobility Observatory, 2024). This large budget was invested alongside a further EUR 18 million (USD 21 million) allocated to highway construction between 2024 to 2027 (EU Urban Mobility Observatory, 2024). These investments will connect micromobility users to the national road network, improving accessibility for micromobility users and accommodating the use of various micromobility modes across more of the country (Rijkswaterstaat, 2020). Additionally, the Netherlands has taken a proactive approach to micromobility infrastructure by improving the quality and accessibility of the existing cycling network, while promoting diversity among cycle path users in terms of speed and vehicle types, including cargo bikes, bikes, e-bikes, kick scooters, and e-scooters (Rijkswaterstaat, 2020).

Alongside the development of infrastructure, legislation too plays a significant role in influencing micromobility adoption. In Paris for example, e-scooter rental schemes have been banned, but private ownership and use by the public is still permissible providing users are insured and over the age of 14 (Carey, 2024; Le Monde, 2023). Additionally, in 2023, the French government published legislation related to micromobility safety issues. Helmets are mandatory for children under the age of 12, with non-compliance resulting in a fine up to EUR 750 (USD 877). For other users, helmet use is not required but strongly recommended (Sortir à Paris, 2023). In the United States of America, e-scooters are also heavily regulated, with federal level legislation regulating speed limitations and 10 states having helmet mandates and many other states having official helmet recommendations (Apollo, 2024). While there are no federal laws requiring helmets when using bikes or e-bikes, many states and local jurisdictions require minors to wear one when riding, with several cities such as Boone, Oklahoma City, and Seattle extending this requirement to all aged riders (Bicycle Helmet Safety Institute, n.d.). There are also age restrictions for e-scooter users in states like

California, New York, Virginia, North Carolina, Oregon, New Jersey (Apollo, 2024). This hands-on approach from local and governmental branches in mandating safety equipment and legally defining the context of micromobility vehicles demonstrates the government's role in regulating micromobility in the public sector.

The manufacturing of micromobility vehicles must also adhere to legislation and regulations to ensure safety. For instance, e-scooter manufacturers supplying vehicles to the United Kingdom are required to have markings on batteries which detail the manufacturers name, design specification and serial numbers, the year of construction, and the correct warning markings in accordance with the Supply of Machinery (Safety) Regulations 2008 (HM Government, 2008). Additionally, all battery chargers supplied within the United Kingdom must detail the appropriate safety information to satisfy the Electrical Equipment (Safety) Regulations 2016 (HM Government, 2016). With respect to bicycles in the United Kingdom, all bicycles sold and manufactured in the country are legally required to have hand-operated brakes, reflectors on the side of each wheel or tire, a red rear reflector, and yellow reflectors on each pedal to improve the safety of each bicycle in accordance with the Pedal Bicycles (Safety) Regulations 2010 (Juden, n.d.; HM Government, 2010). In the European Union, e-scooters are required to follow regulations which specify safety requirements and testing methods for both the vehicle itself and its components. These include guaranteeing that applicable traffic laws can be followed, reducing risk to the user, and adhering to noise pollution requirements (Micromobility for Europe, 2024). The United States also enforces similar safety regulations for micromobility devices. In 2022, the Consumer Product Safety Commission (CPSC) issued warnings to over 2,000 private manufacturers and importers of e-scooters for failing to adhere to applicable Underwriters Laboratories (UL) safety standards[6] (CPSC, 2022). Failure to adhere to these legislations can be detrimental, especially for electric micromobility vehicles (CPSC, 2022). Between 2021 and 2022, fires caused by faulty batteries occurred in 39 states, leading to 19 fatalities and a further 22 injuries (CPSC, 2022).

[6] UL standards are standards in electrical products. Applicable standards here include ANSI/CAN/UL 2272 - Standard for Electrical Systems for Personal E-Mobility Devices and ANSI/CAN/UL 2849 – Standard for Safety for Electrical Systems for e-Bikes.

The private sector plays an equally critical role in promoting micromobility. One significant approach to overcoming high development costs, improving accessibility, and encouraging adoption is through public-private partnerships (PPPs). PPPs refer to a collaboration between governments and private companies, where private companies contribute financing, planning, technologies, and expertise that may not readily available in the public sector, while governments establish regulations, ensure equitable access, and oversee that these projects align with public goals (Gerrard, 2001; Investopedia, 2024). These partnerships provide significant benefits in advancing micromobility initiatives.

A key advantage is cost savings for the public sector, with research in the UK indicating that PPPs can reduce expenses by 25%, up from 17% (Killick, 2024). This is achieved by sharing the financial burden of infrastructure development and operational costs with private companies. In return, private companies benefit from increased brand visibility though PPP participation, access to user data for optimizing operations and services, and potential opportunities for market expansion and revenue growth. Additionally, in the United States, PPPs have been used to offer free transportation services to low-income residents, improving accessibility and equity, and ensuring populations from lower socioeconomic background have affordable mobility options that enhance their quality of life (Ballinger, 2022). Moreover, PPPs help optimize the efficiency of public transportation system by using existing infrastructure more effectively, avoiding the need for costly new investments. By using private sector technology and expertise, PPPs enhance operational performance while reducing financial strain on public resources (Public Works Partners, 2022; Investopedia, 2024; Killick, 2024).

In micromobility, the most common PPP involves government-owned vehicles, such as (e-) bikes and e-scooters being sponsored by private sector companies. These partnerships not only reduce the financial burden on the public sector but also make micromobility services more affordable and accessible to users, encouraging their adoption for commuting, leisure, and other transportation needs. London's Santander Cycles scheme[7] is one such example of a PPP, with the international bank providing GBP 6.25 million (USD 8.4 million) per year in a seven-year funding deal from 2015 to 2022 to facilitate an expansion of the scheme, including extra docking points, more bikes, and an app to improve accessibility (EMTA, 2015). Santander later extended its sponsorship until 2025 at the end of the initial agreement (TfL, 2021). While the bikes and infrastructure are still the property of TfL, the capital investment from the private sector has allowed for an expansion of the system and increased cycling in London (EMTA, 2015). For Santander, the partnership demonstrates its commitment to local communities, while data shows that bike-sharing users are nearly twice as likely as non-users to hold a Santander account (PHAR Partnerships, n.d.).

Paris also has similar schemes. Vélib' Métropole, for example, is owned by the city of Paris but operated and funded by private sector partner, Smovengo (Smovengo, n.d.). As of 2022, Vélib' consisted of over 1,400 docking points, 19,000 bicycles (including 40% electric), and 390,000 subscribers. The scheme facilitates some 4.7 million journeys in peak months (Vélib' Metropole, n.d.), and is considered a massive success, with praise given to the scheme for increasing micromobility use and improving the city's image of being a pioneer in environmentally friendly transportation options (Huré, 2019).

PPPs are also gaining traction in the US as a tool to improve equity in transportation access. In Pittsburgh, Spin partnered with the city and Carnegie Mellon University on a two-year pilot (2021–2023) that provided free access to shared mobility services, including public transport, Spin scooters, POGOH bikes, and Zipcar, to low-income residents (Ballinger, 2022). This pilot project demonstrated how PPPs can be intentionally structured to address social and economic disparities in mobility. Similarly, in 2022, Nashville's Department of Transportation partnered with Bird, Lime, and Spin to improve micromobility affordability and accessibility in underserved neighborhoods (Herbert, 2022). While a final decision on contract renewal is still pending, Nashville Commission has already recommended extending

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[7] Formerly sponsored by Barclay's bank (2010-2015), popularly referred to as Boris Bikes.

the partnerships. New York City also launched an equity-focused e-scooter pilot in 2021 with Bird, Lime, and Veo, bringing thousands of scooters to historically underserved areas like the Bronx and Queens. Currently in its extended phase, the city is assessing the feasibility of a permanent rollout while placing a greater focus on enhancing micromobility infrastructures (NYC DOT, 2024).

In China, PPPs have also been used to tackle growing demands on transportation infrastructure in the country due to their efficiency advantages (Guo et al., 2022). The 14th Five-Year-Plan of China has placed an explicit emphasis on the role of PPPs to aid the efficient construction of sustainable infrastructure and new transport options (Guo et al., 2022). The PPPs have been very effective, with major schemes accommodated by private companies Mobike and Ofo in Huangzhou. Within the first six months, these schemes provided over one million bikes, surpassing the 800,000 bikes introduced over a decade by a purely government-led scheme (Huang, 2018).

While PPPs rely on a collaboration between the public and private sectors, the legal basis and regulatory control of the schemes are conducted by governments, with private partners expected to meet legislative requirements. For example, e-scooter trials in the United Kingdom between the Department for Transport and private sector providers are in the overarching legal remit of the national government and local authorities who produce guidelines and legal frameworks. In London, TfL, London Councils, and London Boroughs have created a set of requirements for the private sector partners. These included meeting strict safety requirements, high operating standards, as well providing all critical data to the government for legislative use (TfL, June 2023). Due to this regulatory control over PPP schemes, governments also reserve the right to adjust schemes based on the performance of a private partner. For example, the United Kingdom government issued new safety advice at the beginning of 2024, multiple years into the e-scooter trials, after consulting industry specialists and re-assessing the operations and requirements of the scheme. These new safety guidelines ordered the responsible disposal of vehicle batteries and related fire safety advice (Stoate, 2024). Furthermore, within PPPs such as Santander Cycles, the public sector retains control over pricing, demonstrating its authority in the partnership. While private companies contribute resources, governments ultimately direct PPPs to align with public sector goals rather than private sector interests (TfL, n.d.b).

In addition to their defined legal responsibilities, both public and private sectors can improve micromobility schemes by actively responding to user and community feedback. Polling data, for instance, can inform the development of micromobility models that align with public preferences and ensure support from both users and non-users (An et al., 2023). A notable example of this occurred in Paris in 2023, where a public referendum was held to determine the future of e-scooter services. Introduced five years earlier, the e-scooter scheme faced criticism over issues with improper parking, safety concerns, public health implications, and user behavior (Carey, 2024). With a 7.5% turnout, 90% of voters elected to ban e-scooters. In response, city officials shifted their micromobility strategy towards enhancing cycling infrastructure and expanding access to bicycles (Callery, 2023; Carey, 2024). Similarly, in London, the Santander Cycle scheme reinstated its original daily hire charge after users expressed dissatisfaction with pricing and structure, both through direct feedback and reduced usage (Mansfield, 2024). These examples underscore the importance of user feedback in driving effective policy and operational adjustments in micromobility systems.

To conclude, this literature review highlights the rapid global growth of the micromobility market and its diverse applications, underscoring its increasing relevance in urban transportation systems. The most overarching benefit of micromobility is its positive impact on sustainability. As micromobility vehicles do not directly produce emissions, they can directly and indirectly cut a city's emissions output. Additionally, users and the wider public benefit from micromobility's reduced noise pollution which has been linked to health defects, as well as congestion which otherwise costs users money in idle fuel and time. Furthermore, the private sector benefits from reduced congestion as it improves delivery efficiency. Despite these benefits, challenges such as battery production, accessibility and equity issues, theft, safety concerns, and infrastructure limitations must be addressed to ensure the long-term success of micromobility.

To overcome these challenges and fully realize the benefits of micromobility, collaboration between the public and private sectors is essential. The public sector must provide adequate infrastructure and regulations for micromobility to operate. Meanwhile, the private sector must drive micromobility by raising capital, attracting investments, fostering innovation, and expanding rental schemes to enhance accessibility and market growth. PPPs bridge these efforts by combing the financial resources and expertise of private companies with public sector goals to help deliver effective micromobility schemes and infrastructure.

3. Data

Our data is sourced from exclusive interviews conducted by Akabo Media, the United Kingdom's leading logistics, supply chain, sustainable urban transport, and robotics and automation technology information and intelligence business[8]. Each interview they conducted discussed a project being undertaken by one or more companies operating in the supply chain industry as well as government administrations. To maintain focus, the sample was limited to case studies involving the implementation of micromobility schemes for both urban transportation and logistics use. Case studies include end-users and suppliers, both in the UK and internationally, and interviews lasted 30 minutes. In combination, they provide an exclusive and real-time peek into industry trends, challenges, and innovations.

3.1 Population of interest

In this report, our population of interest includes private and public entities that integrated micromobility solutions into their supply chain operations or urban planning strategies. This could include micromobility projects that optimize last-mile delivery, reduce reliance on traditional freight vehicles, alleviate congestion, or enhance urban sustainability through low-emission mobility options. Throughout the paper, we categorized the sample into two groups:

(1) **Logistics-focused projects**, which apply micromobility for last-mile delivery; and
(2) **Social-focused projects**, which aim to promote the use of micromobility for daily urban transportation.

[8] Their portfolio includes industry-leading B2B publications Logistics Manager, City Transport & Traffic Innovation (CiTTi) and Robotics & Automation, which, in turn, support a stable of world-class exhibitions, conferences and awards events both domestically and internationally. These include IntraLogistex, Robotics and Automation, Supply Chain Conference, Supply Chain Excellence Awards, CiTTi Awards, Robotics & Automation Awards, as well as the Road User Charging Conference series in Belgium, the USA, Asia-Pacific, and the Middle East and Africa.

3.2 Dataset construction

For each project, we manually collected a range of variables from the interviews conducted. These included company demographics such as company size, as well as project demographics including the number of companies involved. We also collected data on the challenges projects sought to overcome, the solutions employed, technologies used in the solution implementation, features required for the solution, and any benefits resulting from the project. For these variables, we constructed binary identifiers to classify the company's challenges, solutions, technologies, and benefits into distinct groups for ease of analysis.

For each company involved in our sample, we supplemented company demographic information with publicly available data from Company House. This included company headquarters location, company industry codes, and number of employees. This enabled us to analyze our population of interest, as outlined in Section 3.3.

3.3 Descriptive statistics

Descriptive statistics for the sample are given in Table 1. The first column summarizes the characteristics of social projects that use micromobility for transportation and the second column summarizes the characteristics of projects that use micromobility for logistic purpose. Column three combines the two populations.

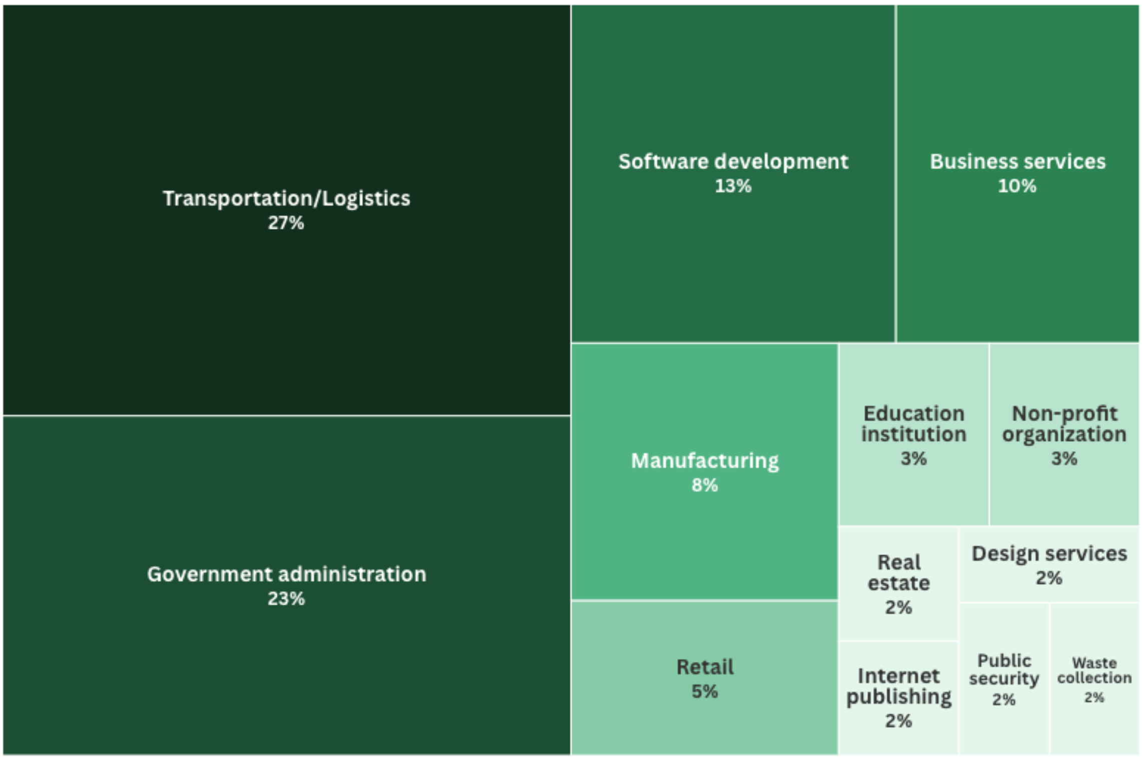
Table 1: Descriptive Statistics

	Social	logistics	Total
Projects:			
Number of projects in category	17	8	25
Number of companies in category	39	23	62
Average number of companies on a project	2.3	2.9	2.5
Number of employees:			
<10	2.6 %	4.4%	3.2%
10-49	10.3%	30.4%	17.7%
50-249	23.0%	21.8%	22.6%
250-1000	10.3%	13.0%	11.3%
1000+	53.9%	30.4%	45.2%
Headquarters:			
Outside UK	5.1%	17.4%	9.7%
UK	94.9%	82.6%	90.3%
UK headquarter by nation:			
England	97.3%	100%	98.2%
Wales	0.0%	0.0%	0.0%
Ireland	0.0%	0.0%	0.0%
Scotland	2.7%	0.0%	1.8%
Industry:			
Government administration	33.3%	4.4%	22.6%
Business services	10.3%	8.7%	9.7%
Manufacturing	2.6%	17.4%	8.1%
Software development	20.5%	0.0%	12.9%
Transportation/Logistics	15.4%	47.8%	27.4%
Retail	0.0%	13.0%	4.8%
Education institution	5.1%	0.0%	3.2%
Real estate	0.0%	4.4%	1.6%
Internet publishing	2.6%	0.0%	1.6%
Non-profit organization	5.1%	0.0%	3.2%
Design services	2.6%	0.0%	1.6%
Public security	2.6%	0.0%	1.6%
Waste collection	0.0%	4.4%	1.6%

Overall, 25 projects were analyzed, consisting of 62 companies. On average, 2.5 companies were involved in each project. Around 90% of our sample consisted of companies headquartered in the UK, with 10% headquartered outside of the UK. When stratified further, we found around 98% of the UK companies were based in England and 2% in

Scotland. To determine the size of each of the involved companies, we also collected each organization's employee counts and reclassified these into five distinct subgroups. These were less than 10 employees, 10 – 49 employees, 50 – 249 employees, 250 – 1000 employees, and over 1000 employees. Overall, we found over 45% of companies within our sample had over 1000 employees and around 11% had 250-1000 employees. Small companies with less than 250 employees accounted for approximately 44% of the sample cumulatively.

Figure 1: Company Industries



The companies included within our sample covered a wide array of industries. The most common industry was the logistics and transportation industry, with just under 28% of organizations within our sample operating in this sector. The next most common was government administration, represented by around 23% of companies in our sample. Some other represented industries included software development, business services, manufacturing, retail, education, and non-profit organizations. Figure 1 illustrates this breakdown.

4. Results

In this section we analyze common trends observed among our sample of micromobility case-studies. These trends have been split into four sub-sections: challenges, solutions, technology, and benefits.

4.1 Challenges

In this section, we summarize the most common challenges within the case-studies analyzed. These proportions, shown in Table 2, are split into two panels consisting of three columns. Panel A contains common challenges experienced within each sample. Each of these challenges are also shown graphically in Figure 2, listed in descending order from most to least common challenge. Appendix 1 splits these challenges by social micromobility and logistics micromobility. Panel B categorizes the environmental challenges reported by companies into distinct sub-groups. The first column shows the proportion of case-studies in the social micromobility category that experienced each challenge, while columns two and three show the proportion of case-studies experiencing each challenge for the logistics micromobility category and in total respectively. Note, companies could experience multiple challenges, so columns can sum to over 100%.

Overall, the most common challenge reported in our sample was environmental concerns, found in 76% of case-studies. Despite variations in their sustainability objectives, several case-studies sought to alleviate environmental impacts or achieve sustainability goals. To support government's net zero commitment, 65% of UK business have set their own 2050 net zero targets (UK Business Climate Hub, 2024). Increased regulation on corporate sustainability will be implemented to respond to the declared climate emergency and to meet net zero targets the declared climate emergency and the pursuit of net zero goals, an increasing number of regulations will be implemented to govern corporate sustainability performance. This will further incentivize businesses to reduce their environmental impact.

Table 2: Company Challenges

	Categories		
	Social	Logistic	Total
Panel A			
Challenge:			
Transportation pollution	23.5%	50.0%	32.0%
Supply shocks	5.9%	0.0%	4.0%
Health issue	29.4%	0.0%	20.0%
Inequity	17.7%	12.5%	16.0%
Poor performance	17.7%	0.0%	12.0%
Poor data	17.7%	0.0%	12.0%
Noise pollution	11.8%	0.0%	8.0%
Demand side requirement	17.7%	12.5%	16.0%
No technology	11.8%	0.0%	8.0%
Through traffic	5.9%	0.0%	4.0%
Modal shift requirement	82.4%	0.0%	56.0%
Low space	11.8%	12.5%	12.0%
Disadvantages of EV	0.0%	12.5%	4.0%
Congestion	35.3%	0.0%	24.0%
Poor management	5.9%	0.0%	4.0%
Low accessibility	29.4%	0.0%	20.0%
Low carrying capacity	0.0%	12.5%	4.0%
Poor behavior	11.8%	0.0%	8.0%
Road safety	47.1%	12.5%	36.0%
Disabled community	11.8%	0.0%	8.0%
Environmental concerns	70.6%	87.5%	76.0%
Panel B			
Environmental Issue:			
Scope 3 emissions	0.00%	14.3%	5.3%
GHG emissions	58.3%	100.0%	73.7%
Energy consumption	0.0%	14.3%	5.3%
Climate emergency	33.3%	14.3%	26.3%
Air quality	41.7%	28.6%	36.8%

The second most common challenge reported was the modal shift requirement, with 56% of the sample requiring modal shifts by government administrations. Due to the significant environmental impact of human activities, governments are increasingly promoting modal shift as a strategy to make urban transportation more sustainable. Modal shift involves encouraging a transition from car travel to more environmentally friendly modes of transport, such as walking, cycling, public transit, and car-sharing (Müller and Reutter, 2022). This, again, was an unsurprising finding. An increasing number of government administrations have begun to promote a modal shift towards active travel and other clean forms of transport to reduce GHG emissions, improve air quality, reduce energy consumption, tackle climate emergency, reduce car ownership and use, improve safety of pedestrians, and resolve health issues (Greater London Authority, 2018).

Road safety was another recurring challenge, reported by 36% of the sample. Road safety is a major social concern for both pedestrians and micromobility users, and more government administrations are setting their own road safety targets to reduce accidents and improve overall public well-being. For instance, TFL and SFMTA have planned on improving safety and comfort for micromobility users. Since 2019, TfL has expanded and integrated ten cycle routes near mobility scheme docking stations, with plans to extend the network to eight additional areas and reach a third of London's population by the end of 2025 (Transport for London, n.d.a). Similarly, San Francisco SFMTA has invested in developing bicycle routes, low-traffic lanes for cyclists and shared-micromobility users (SFMTA, n.d.b). Despite government efforts to improve micromobility infrastructure for safety, poor user behaviors, such as irregular parking, overloading, improper use, and disregard for traffic rules, continue to pose significant road safety concerns and may worsen this issue (Comi et al., 2024). The referendum against the e-scooter micromobility scheme in Paris highlights the impact of poor parking and user practices on road safety, underscoring the need for more stringent measures (Carey, 2024). Within our sample, 8% of the companies reported the challenge of poor behaviors among micromobility users. In accordance with road safety and poor user behavior concerns, many government administrations have carried out various regulations, such as having reflectors, front lights, hand-operated brakes, speed limits in certain areas, or requiring a helmet when using a bicycle (Apollo, 2024; Bicycle Helmet Safety Institute, n.d.).

Additionally, 24% of our sample from the case studies reported overcoming traffic congestion as a challenge. The prevalence of numerous vehicles and large delivery trucks significantly exacerbates road congestion, particularly in London, leading to substantial time delays and increased operational costs for drivers (Pleeth, 2023). Alongside wasted time and fuel, congestion can also lead to negative social impacts such as noise pollution and taking up parking spaces (Büttgen et al., 2021), evidenced within our sample with 12% of case-studies having reported limited road space and 8% having reported challenges regarding noise pollution. As traffic congestion intensifies, more vehicles will be on the road either searching for parking spaces or occupying parking lanes as part of their driving routes. This will further exacerbate the competition for available parking spots and road space (Arnott and Inci, 2006). Furthermore, congestion can cause low efficiency and poor performance in logistics because drivers often spend more time commuting or looking for parking spots, especially for last-mile delivery (McKinnon et al., 2009).

Furthermore, around 20% of our sample raised concerns regarding health issues. This challenge often serves as a significant motivator for promoting micromobility solutions to enhance public health and well-being. Health issues in relation to urban mobility can manifest in several ways. On one hand, Long-term exposure to noise pollution and air pollution can cause a variety of health effects, including sleep disturbance, cognitive impairment, pneumonia, and increased risk of stroke (UK Health Security Agency, 2023). Alternatively, insufficient exercise due to a lack of active travel options can contribute to poor health conditions among the public. Both avenues contribute to conditions that decrease general well-being, and increase risk of chronic diseases (Paudel et al., 2021). By integrating micromobility options into the urban transportation network, cities can reduce reliance on traditional vehicles, which are major source of noise and air pollution. Additionally, micromobility encourages physical activity, offering an accessible means for the public to improve their health.

We also observed a relatively high occurrence of both low accessibility (20%) and inequity challenges (16%) within the sample in relation to urban transportation and logistics. This finding was expected in that extensive literature observes accessibility challenges related to people with disabilities and lower-socioeconomic backgrounds (Jette and Field, 2007; Beech, 2024). Individuals from lower socioeconomic backgrounds may be disadvantaged by urban logistics and micromobility schemes as they may be unable to afford associated costs or lack access to smartphones which can limit their ability to use the infrastructure or systems (Beech, 2024; Perry, 2020). Rural accessibility is a challenge for logistic companies. Most micromobility delivery companies centered their operations in urban areas due to the limited of cargo-bikes, thus excluding accessibility in rural areas (Armstrong, n.d.). People with disabilities also face the challenge of low accessibility. Individuals with disability make 38% fewer transport journeys than non-disabled people, and 92% report experiencing barriers with at least one mode of transportation (NCAT, 2024). Safety concerns related to micromobility vehicles further exacerbate the challenges and anxieties for people with disabilities, as well as for micromobility providers, who are required to pay more attention to safety and accessibility designs (Jette and Field, 2007). Within our sample, 8% of case-studies highlighted the difficulties faced by the disabled community. Low accessibility issues can in turn exacerbate inequity issues. Inequity challenges were of particular concern for citizens from low socio-economic backgrounds, who were more price sensitive, emission intensive, and who cannot afford EVs. Meanwhile, roads and public transportation are often inaccessible and unsafe for people with disabilities to navigate, further creating barriers to their ability to access social spaces like healthcare centers and workplaces, thereby exacerbating issues of inequity.

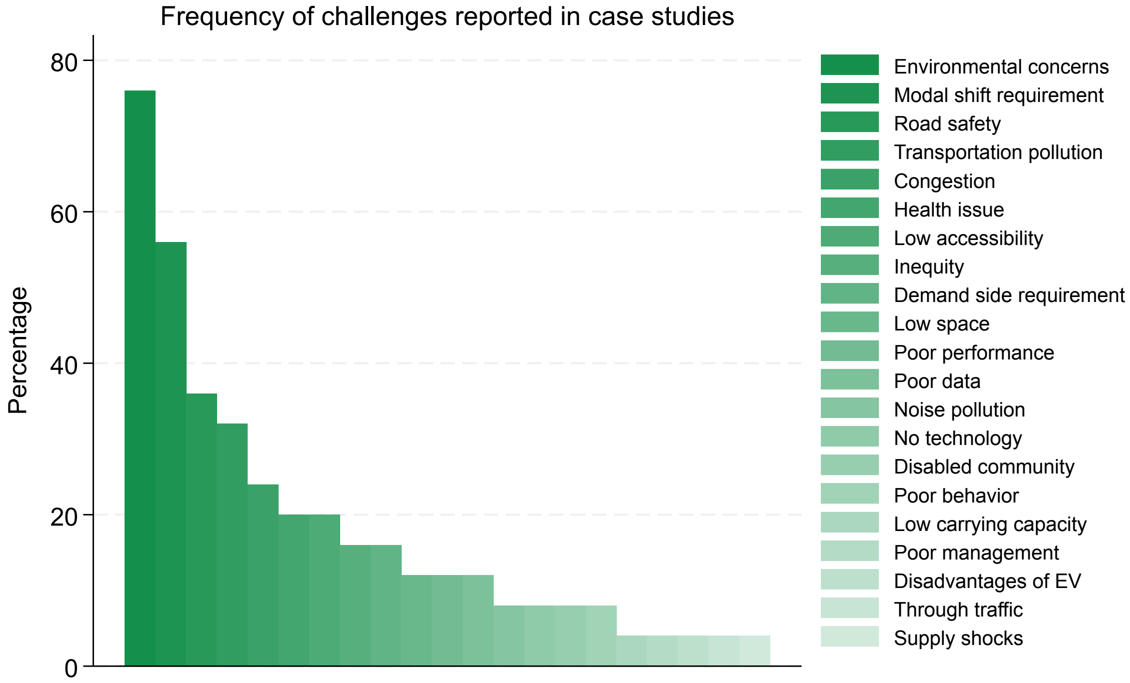
The high occurrence of demand-side requirements challenges, reported by 16% of the sample, was also unsurprising. Demand-side requirements include the growing need for public and shared transportation due to low car ownership, the demand for sustainable alternatives to EVs due to a lack of reliable and affordable charging infrastructure, and the desire for low-traffic neighborhoods. These factors, along with other individual mobility needs, create social pressure and offer potential reputation-building opportunities for businesses and government administrations. Local residents are more focused on their wellbeing and living environment than ever before (Van Kamp et al., 2003).

Through traffic contributes significantly to congestion, noise pollution, and other environmental challenges, yet offers little benefit to local economy. As a result, more communities are requiring the reduction of through traffic and the development of low-traffic neighborhoods to lower carbon emissions and encourage active travel (Sakuragi et al., 2017). Furthermore, delivery companies are facing rising complexity and growing demand from customers. In the UK, 55% of consumers prioritize reliability when choosing delivery services, with over 40% viewing speedy delivery as a necessity (Amazon, 2025). With this increase in consumer expectations, companies are facing a significant push for better services, necessitating the adoption of systems that enhance logistic efficiency (Louveau, 2023).

Poor development performance and poor data were also common challenges in developing and existing micromobility networks, each reported by 12% of the case-studies within our sample. Common poor performance challenges reported within our population included aging traffic infrastructure, poor urban development, and poor traffic design. Each of these performance challenges can exacerbate the previously mentioned challenges pertaining to the environment, road safety, and congestion. Data plays an important role in resolving these challenges as it can be used for monitoring and managing traffic, and for providing evidence to support policy implementation. For example, polling data can be effectively used to develop more widely accepted micromobility models by revealing the types of schemes that will be supported by both users and non-users (An et al., 2023). Additionally, usage data can offer valuable insights into users' preferences for existing micromobility schemes.

Lacking technology was another frequent challenge, reported by 8% of the sample. Technologies such as AI, IoT, and digital twins are essential as they can help with attaining required data, addressing routing challenges, and improving operations (Killick, 2024). Other challenges related to micromobility reported within our sample were poor management (4%), lack of scalability (4%), challenges with EVs (4%), supply shocks (4%), and limited last-mile delivery capacity (4%). Each of these have significantly affected the adoption of micromobility solutions, leading to difficulties in promoting these transportation options effectively.

Figure 2: Frequency of challenges reported in case studies



When we stratify the total sample into social micromobility and logistics micromobility, we find the prevalence of each challenge differs slightly across the two groups.

In the social micromobility category, modal shift requirements (82%) emerged as the most prominent concern. This is likely because micromobility has become a larger focus for governments in recent years due to the increase in ownership of private cars. As the number of cars on roads increases, problems pertaining to congestion, pollution, and health issues rise. Environmental challenges remain some of the top concern. 71% of case-studies reported environmental concerns, underpinning the urgent need to resolve environmental crises and how environmental sustainability encourages more micromobility (Abduljabbar et al., 2021). Additionally, high congestion was reported by 35% of the social micromobility case-studies, while concerns related to public health were noted by 29% of the sample. These, in turn, prompt government administrations to act and promote modal shifts towards active travel and public transportation (47%) for the purpose of improving public safety and health (29.41%), reducing congestion (29%) and improving the environment (47%)[9].

In the logistics micromobility category, environmental challenges were the most commonly experienced issues. An overwhelming 88% of logistics micromobility case-studies reported encountering these challenges, highlighting the significant impact of environmental factors on the implementation and operation of micromobility solutions within the logistics sector. Carrying capacity (13%) and the disadvantages of EVs (13%) were also reported as major challenges. This deviation from the challenges reported by the total sample makes sense in that electric heavy goods vehicles (eHGV) produce high GHG emissions during production as well as high electricity generation. Both are less sustainable than micromobility alternatives (Davies, 2020; Pleeth, 2023; Büttgen et al., 2021). Additionally, EVs and eHGVs can limit space capacity, with 13% of the logistics micromobility sample reporting this challenge. Traditional delivery vehicles can be too large for narrow streets, or can take up too many parking spaces, especially in busy city centers (Büttgen et al., 2021). Meanwhile, the transportation capacity of delivery vehicles can also present challenges for companies as it can largely influence delivery efficiency (Sheth et al., 2019).

Panel B of Table 2 stratifies the environmental challenges faced by companies into five sub-groups to identify the environmental foci reported within the case-studies. These are shown in Figure 3, listed in descending order from most common environmental challenge to least. Appendix 2 splits these by different micromobility category. Note, companies could experience multiple environmental challenges. The five sub-groups are as follows:

1. GHG emissions – Companies/regions which produce high greenhouse gas emissions are setting net zero goals in greater numbers. Greenhouse gas (GHG) emissions refer to the release of gases that trap heat in the Earth's atmosphere, contributing to global warming and climate change. These gases

[9] Refer to Appendix 1 for more benefits split by social micromobility case-studies.

include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.

2. Air quality – Companies/regions are producing high air pollution (particulate matter). Particulate matter (PM) consists of tiny particles in the air that can be harmful to human health, environment, and the climate. These particles are categorized based on their size, including PM2.5 and PM10[10].

3. Climate emergency – Companies/regions are concerned about the consequences of climate change, especially high temperature. A minor increase in temperature can significantly increase the frequency and magnitude of extreme weather events, including heatwaves, droughts, flooding, winter storms, hurricanes, and wildfires (IPCC)[11].

4. Scope 3 emissions – Companies/regions have high scope 3 emissions. Scope 3 emissions refer to indirect GHG emissions that occur in a company's value chain, excluding those from the company's direct operations (Scope 1) and energy consumption (Scope 2).

5. Energy consumption – Companies/regions are consuming excessive energy or are using fuel suboptimally. Excessive energy consumption or inefficient use of fuel can have significant negative impacts due to increased GHG emissions, rapid depletion of resources, low energy inefficiency, and high operational costs.

We find that 74% of companies reported high GHG emissions as a key sustainability concern. The second most common environmental concern was air quality, reported by 37% of the

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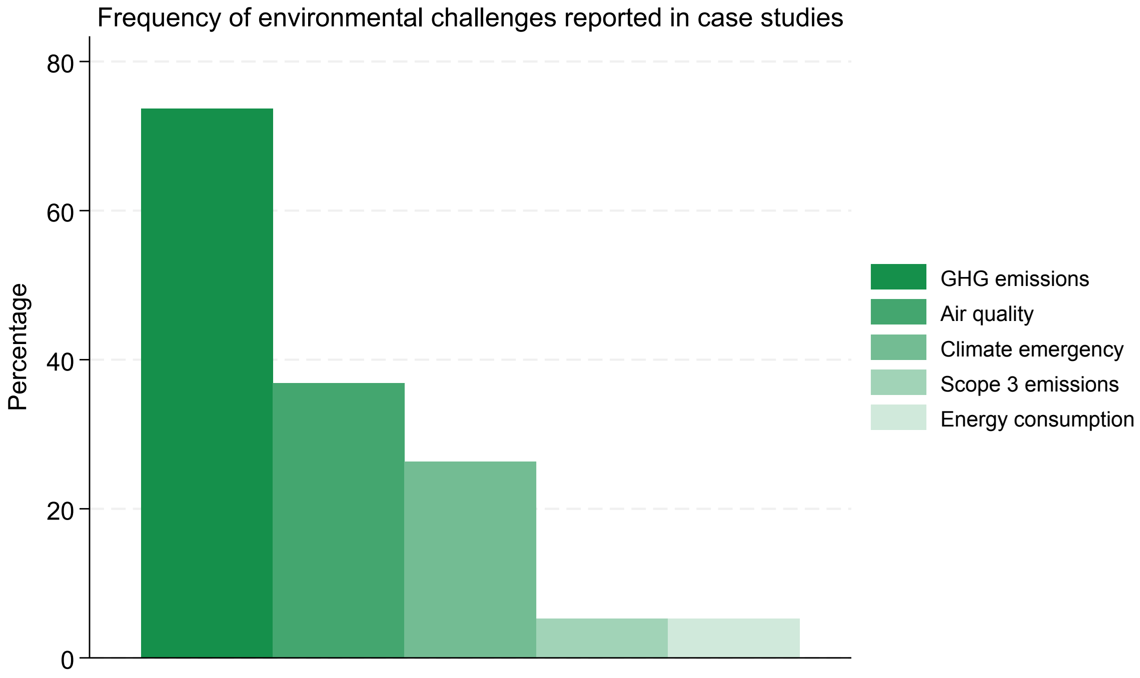
[10] Particular Matter (PM) ranges from a few nanometers (nm) to 10 µm (PM_{10}), $PM_{2.5}$ and PM_{10} are the most regulated ones due to their sizes, making them feasible to monitor.

[11] The Intergovernmental Panel on Climate Change (IPCC).

sample, and the third most common is climate emergency, reported by 26% of the sample. Scope 3 emissions and energy consumption were each reported by 5% of the sample as their environmental challenges.

Figure 3: Frequency of environmental Challenges reported in case studies



In identifying the cause of GHG emissions, high air pollution, and scope 3 emissions reported in Panel B, some 32% of our sample attributed these emissions to transportation. This is in line with existing literature which has found that the transportation sector ranks among the world's second-largest carbon emitter, accounting for around one quarter of the European Union's greenhouse gas emissions (Giannakis et ta., 2020; Sajida et al., 2019).

Additionally, we stratified the sources of pollution companies are experiencing into two groups: transportation pollution and other types of pollution, which include emissions from manufacturing, energy production, and construction activities. We also split these by different micromobility categories, as shown in Appendix 3. The figures illustrate that across all categories, more than half of respondents identified transportation as the primary source of their pollution. This finding underscores the critical need to transition from conventional transportation methods such as private diesel vehicles to more environmentally sustainable alternatives, including micromobility solutions (Giannakis et ta., 2020; Sajid et al., 2019).

Overall, these environmental challenges underscore the critical need for policymakers and stakeholders to prioritize and invest in cleaner transportation technologies such as micromobility. By addressing transportation-related emissions, we can significantly mitigate their adverse impacts on the environment and public health. Transitioning to micromobility will contribute to more sustainable urban development, improve air quality, and enhance overall quality of life, underlying the importance of strategic action in urban transportation and logistics.

4.2 Technologies

In this section, we summarize the technologies most commonly used within our sample to address the aforementioned challenges. These proportions, shown in Table 3, are split into three columns. Column one shows the proportion of case-studies in the social micromobility category that utilized each technology, while columns two and three show the proportions of case-studies utilizing each technology for the logistics micromobility category and the two categories combined respectively. These proportions are shown in Figure 4, listed in descending order from the most to least common technology. Appendix 4 splits these findings by social micromobility and logistics micromobility and graphs these technologies separately for each group category. Note, companies could use multiple technologies in their solutions, so columns can sum to over 100%.

Table 3: Technologies

	Categories		
	Social	Logistic	Total
Technology:			
Infrastructure	29.4%	50.0%	36.0%
EV charger	11.8%	12.5%	12.0%
Camera	29.4%	0.0%	20.0%
LED light	11.8%	25.0%	16.0%
Monitor/Sensor	35.3%	37.5%	36.0%
Integration	17.7%	0.0%	12.0%
Data analysis	41.2%	37.5%	40.0%
IoT	5.9%	0.0%	4.0%
Sustainable fuel	5.9%	12.5%	8.0%
Shared mobility	23.5%	12.5%	20.0%
EV	5.9%	50.0%	20.0%
E-micromobility	23.5%	100.0%	50.0%
Digitalization	47.1%	12.5%	36.0%
AI	23.5%	0.0%	16.0%
Telematics	0.0%	25.0%	8.0%
Robot	0.0%	12.5%	4.0%
Behavioral change technology	5.9%	0.0%	4.0%
Digital twin	5.9%	0.0%	4.0%

The most common technology employed to address the challenges outlined in Section 4.1 was electric micromobility (e-micromobility). Half of the sample (50%) used e-micromobility in their solutions, supporting governmental goals of modal shifting to improve environmental outcomes. The use of electric micromobility to address companies' challenges, especially low sustainability, makes intuitive sense. E-micromobility includes e-scooters and e-bikes which can be used more optimally for social transportation and logistics. E-micromobility also has strong benefits in terms of noise and pollution reduction. They do not produce tailpipe emissions, meaning their use in lieu of diesel vehicles can actively reduce emissions from a city or a company, and they are quieter than regular vehicles as they use all electric drivetrains instead of internal combustion engines (Walton et al., 2023). Meanwhile, an increasing number of delivery companies are using micromobility solutions instead of EVs, as traditional EVs still contribute to scope 3 carbon emissions and are more likely to be stuck in heavy traffic (Ellingsen et al., 2016). E-micromobility vehicles can also reduce congestion and improve cost-effectiveness as they require less space to operate, can park on sidewalks, and can travel in cycle lanes (Büttgen et al., 2021). For private delivery companies, e-micromobility deliveries have also been shown to increase sustainability, reduce congestion, and increase profits as micromobility vehicles don't generate tailpipe emissions and take up less space (Davies, 2020; Pleeth, 2023).

The implementation of data analysis was also a relatively common finding, as reported by 40% of the case studies. Improving data collection and conducting comprehensive data analysis can greatly enhance visibility and planning processes (Shi and Abdel-Aty, 2015). For instance, several companies within our sample used telematics data to monitor micromobility usage, in turn allowing them to optimize the planning and the efficiency of their logistic routes. Additionally, for delivery companies, the collection and analysis of data provides insight into service demands, affording companies a deeper understanding of customer preferences and enabling data led decision making. Data tracking also offers companies guidance for waste management practices by enabling companies to monitor and analyze the flow of their waste for more effective recycling. Through data analytics, these companies can improve micromobility management, streamline operations, and optimize route planning (Chu et al., 2023). Government administrations also benefit significantly from data collection and analytics, as it enables them to design more effective and informed urban transportation strategies that improve traffic management and transportation systems. As evidenced in our findings, these organizations are actively pursuing enhanced data collection regarding micromobility usage and environmental impacts to acquire comprehensive and precise datasets to guide decision-making processes (Transport for London, 2023; Department for Transport, 2024). As a result, there is also a requirement for data capture technologies to analyze the steadily increasing collection of data within these organizations. The most common data capture technologies within our sample include monitors and sensors (36%), cameras (20%), and IoT devices (4%).

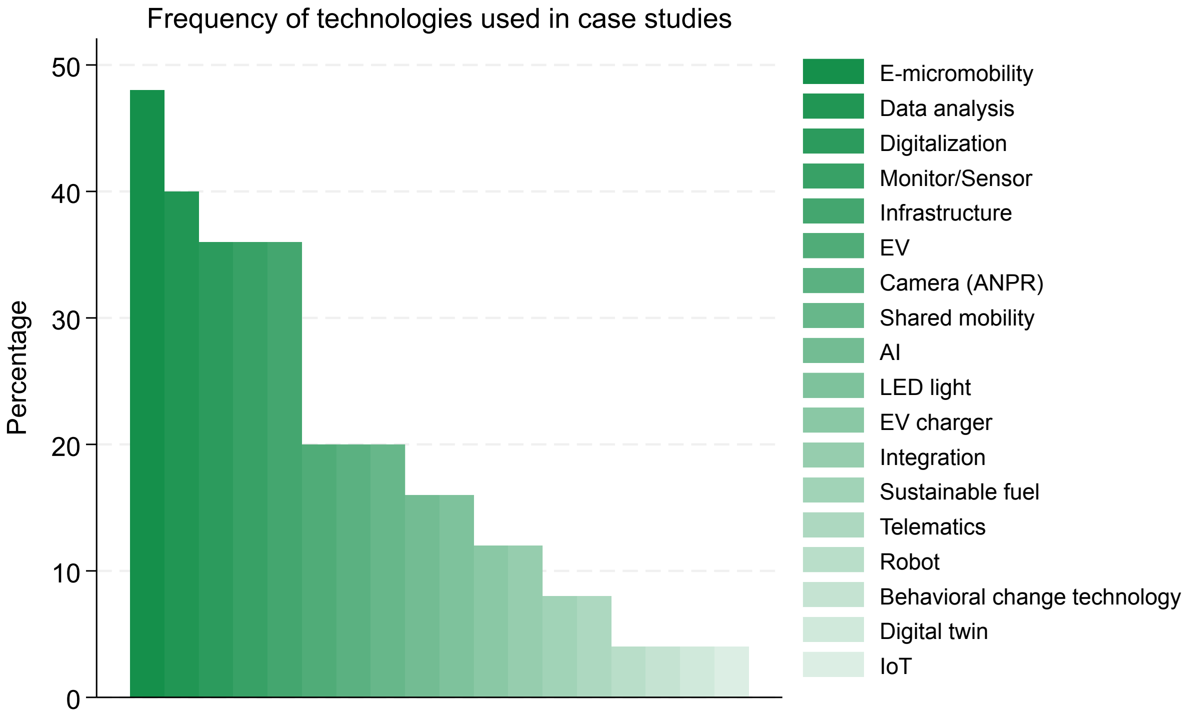
Digitalization was another popular technology within our sample, featuring in 36% of the case studies. It is defined as changes in ways of working, roles, and business offering through adopting digital technologies (Parviainen et al., 2017). Data dashboards are a commonly used digitalization technology. They are particularly beneficial for delivery companies as they can provide better data visibility, facilitate logistic routes planning, and enhance overall operational efficiency (Chu et al., 2023). AI technology and digital twins often help facilitate the use of these data platforms, optimizing resource allocation and reducing transit times. Mobile applications were another popular method of digitalization within our sample. They are used for information integration and assisting citizens in their journey planning, offering customers greater convenience. Another widespread digitalization tool used within the micromobility sector are digital payment systems and remote (un)locking, particularly prevalent in shared micromobility. Digitalization technologies are playing a transformative and multifaceted role in urban mobility by enhancing the efficiency, accessibility, and sustainability of transportation systems. Companies are embracing this digital shift, as it offers numerous benefits, such as improving user experience, providing real-time data, route optimizing, and better management of micromobility. However, it may also present additional obstacles in terms of accessibility and equity for elder individuals or those who lack access to smartphones (Perry, 2020).

We also find relatively high investment in micromobility infrastructure. Specifically, 36% of the case-studies within our population reported the use of shared microhubs[12] for shared mobility parking. These micro-logistic hubs offer cargo bike couriers and operators the opportunity to receive, sort, and dispatch deliveries, thereby reducing the need for space and supporting low-emission last-mile delivery. In addition, government administrations have made efforts to upgrade existing infrastructure and construct new cycling infrastructure to encourage active travel and micromobility, creating a more convenient and secure travel environment.

[12] Microhub is a location in the territory of the city where the delivery network operators should consolidate the shipments and from that location to deliver them to the customers' addresses by cargo bikes. See; Novotná et al., 2022.

To facilitate the transition towards cleaner transportation, EVs (20%) and shared mobility (20%) were also adopted as alternative transportation methods, while 4% of the sample also used robots as another logistic tool. EV charger (12%) and sustainable fuel (8%) were also adopted by the case-studies within the sample, in conjunction with micromobility and other clean transportation methods to contribute to sustainability. LED sensor lighting (16%) was another popular trend for improving road safety and reducing environmental impact. Some 16% of case-studies used AI in their solutions, while another 4% employed digital twin technology or telematics. Behavioral change technology like a joint-in-app campaign was deployed by 4% of the sample.

Figure 4: Frequency of technologies used in case studies



When split by category, we find that every case study in the logistics micromobility category used e-micromobility to support low-emission last-mile delivery, which allows for a sustainable alternative to traditional ICEV delivery. Additionally, EVs (50%) and infrastructure construction (50%) were also commonly used to facilitate delivery. Many delivery companies in our sample typically employ electric vans for bulk parcel transfers to shared micro hubs, followed by e-cargo bikes for last-mile delivery. This approach aims to minimize environmental impact and improve operational efficiency. For the social micromobility category, the most common technologies were digitalization (47%), data analysis (41%), and monitors/sensors (35%). In contrast to the logistics micromobility sector, which focuses on adopting cleaner delivery methods, the social micromobility sector prioritizes digitalization. This difference likely stems from the fact that most logistics companies did not initially rely on micromobility solutions, so their primary focus is on transitioning to cleaner transportation methods. On the other hand, in the social micromobility sector, both governments and companies are more focused on providing technological infrastructure, support, and data analysis to facilitate the adoption of micromobility. The digital transition often involves data-driven planning and decision-making to enhance user experiences and community engagement.

4.3 Benefits

In this section, we summarize the benefits experienced within our sample following the implementation of the solutions and technologies outlined in Section 4.2. These proportions, shown in Table 4, are split into two panels consisting of three columns. Panel A contains common benefits experienced within each sample, while Panel B categorizes the environmental benefits reported by companies. Column one shows the proportion of case-studies in the social micromobility category that experienced each benefit, while columns two and three show the proportions of case-studies experiencing each benefit for the logistics micromobility category and the two categories combined respectively. These proportions are shown in Figure 5, listed in descending order from the most to least common benefit. Appendix 5 graphs these benefits separately by each sub-group. Note, companies could experience multiple benefits, so columns can sum to over 100%.

Table 4: Benefits

	Categories		
	Social	Logistic	Total
Panel A			
Benefit:			
Increased accuracy	23.5%	12.5%	20.0%
Increased visibility	35.3%	0.0%	24.0%
Better planning	23.5%	0.0%	16.0%
Better performance	11.8%	87.5%	36.0%
Increased efficiency	17.7%	50.0%	28.0%
Increased reliability	5.9%	0.0%	4.0%
Lower costs	5.9%	12.5%	8.0%
Better user experience	23.5%	12.5%	20.0%
Better data collection	35.3%	0.0%	24.0%
Achieved integration	11.8%	0.0%	8.0%
Less noise pollution	0.0%	37.5%	12.0%
Less congestion	29.4%	37.5%	32.0%
Active and public transportation	47.1%	0.0%	32.0%
Increased accessibility	5.9%	0.0%	4.0%
Business creation	5.9%	37.5%	16.0%
Higher employment rate	0.0%	25.0%	8.0%
E-mobility promotion	11.8%	25.0%	16.0%
Improved safety	29.4%	0.0%	20.0%
Increased road space	17.7%	12.5%	16.0%
Less road damage	0.0%	12.5%	4.0%
Long-term solution	5.9%	0.0%	4.0%
Behavioral change	11.8%	0.0%	8.0%
Environmental improvements	47.1%	87.5%	60.0%
Panel B			
Environmental Benefit:			
Improved recycling	0.0%	14.3%	6.7%
Energy saving	25.0%	14.3%	20.0%
Water saving	0.0%	14.3%	6.7%
Lower emissions	75.0%	100.0%	86.7%
Better air quality	50.0%	42.9%	46.7%

The implementation of these micromobility initiatives provided companies with a range of advantages. The biggest benefit reaped from the case-studies was environmental improvements. Three fifths of the case-studies saw improvements in air quality, recycling, or reductions in emissions. This finding was anticipated and is consistent with existing literature. Traditional ICEVs contribute significantly to air pollution and GHG emissions. E-mobility and micromobility options lower the overall carbon footprint of urban transportation as they reduce reliance on ICEVs, produce zero tailpipe emissions, and can reduce the consumption of non-renewable energy (Davies, 2020; Pleeth, 2023; Krauss et al., 2022). In addition to minimizing environmental impact, micromobility also contributes positively to mitigating noise pollution due to its near-negligible sound generation; bicycles and e-micromobility vehicles are noticeably quieter than automobiles (The University of Montana, n.d.; Walton et al., 2023). A high proportion of our sample also reported a modal shift towards cleaner transportation like electric mobility (16%), active travel and public transportation (32%). While expected due to the nature of sample selection, this finding was still impressive given the potential benefits these modal shifts could bring. These findings suggest that improving sustainability and achieving net zero is becoming a more achievable goal, and micromobility can be a long-term solution for building a sustainable transportation system.

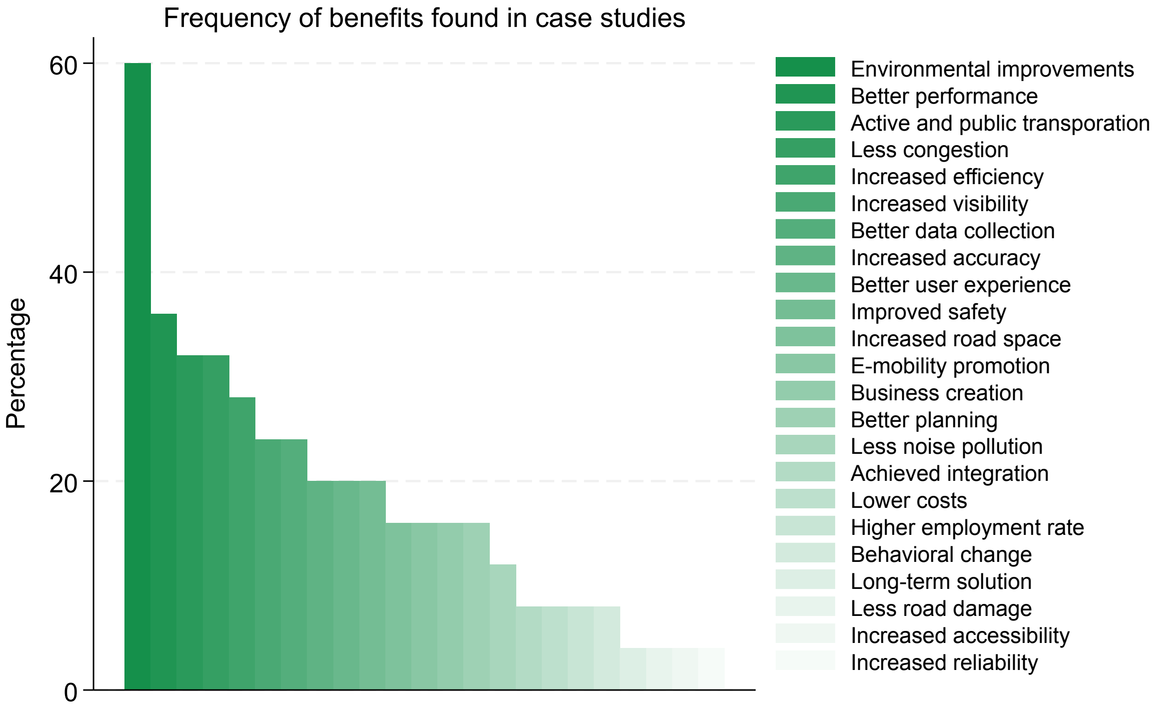
Companies within our sample also collected better data (24%) both in quality and quantity, leading to a range of additional benefits. These benefits are likely correlated and mutually reinforcing. For instance, by collecting better data, the visibility (24%) of micromobility usage can be increased. The enhanced visibility can then enable more effective and optimized route planning (16%), which will further lead to greater operational efficiency (28%) and lower costs (8%) (Pointer and Sood, 2022). With reduced costs and increased efficiency, there are also likely to be more opportunities for business expansion, which can further provide job opportunities and increase employment rate (8%) (Heid et al., 2018). Additionally, the reduction in traffic congestion due to micromobility usage not only saves companies' time but also saves costs and improves overall efficiency. This, in turn, enhances the performance of companies (36%) and can significantly improve user experience (20%) through improving service reliability and accessibility (Shamsudin and Hassim, 2023).

Consequently, these benefits collectively contribute to a more sustainable and efficient transportation system, and vice versa.

Additionally, 20% of cases found improved road safety. This suggests additional benefits such as behavioral modification (8%) and reduced road damage (4%) due to implementing micromobility solutions. With the implementation of micromobility schemes and other behavioral change technologies, case-studies within our sample reported improvement in users' parking behavior. Meanwhile, the development of public transit and shared mobility, as well as micromobility and improved user behaviors, reduces road damage caused by brake and tire pollution. Government administrations are also placing greater emphasis on safety improvement through policy regulations and the design of safety infrastructure. For example, both the SFMTA and TfL have invested in infrastructure projects aimed at enhancing safety for micromobility users (SFMTA, n.d.b; Coale, 2023). Consequently, road safety is increased.

We also found that promoting micromobility increased road space (16%). Büttgen (2021) offered a hypothesis on why this might be the case. Micromobility vehicles can park on sidewalks and travel in cycle lanes, both of which can largely reduce the usage of road space, and consequently reduce congestion.

Figure 5: Frequency of benefits found in case studies

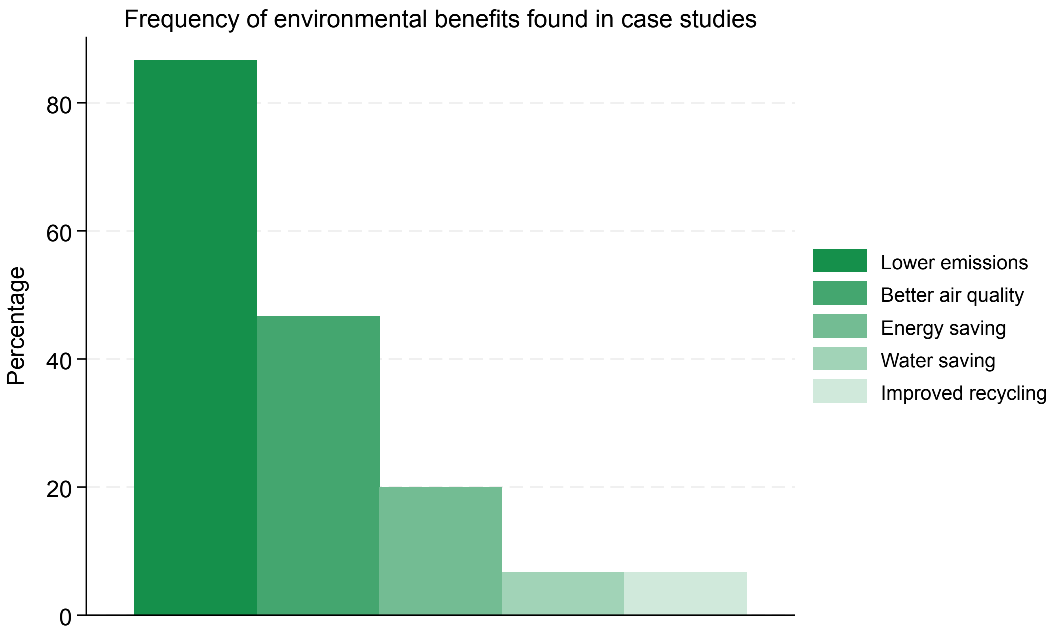


When our sample was split into the two sub-categories, we discovered that improved environment remained the most common benefit. This finding demonstrates that micromobility can be incredibly beneficial for sustainability development no matter the motivation for usage.

Looking at the logistics micromobility sub-group, the next most common benefits reaped were better performance (88%), increased delivery efficiency (50%), and business creation (50%). The order with which benefits were reported among the social micromobility sub-group varied, however. The next most common benefits included active travel and public transportation promotion (47%), increased visibility (35%), and improved data collection in both quantity and quality (35%). This variation in the reported benefits following micromobility solution implementations were expected. Social micromobility case studies within our sample tended to focus on promoting cleaner transportation services for the broader public. Logistics micromobility case studies tended to focus on company performance.

Panel B of Table 4 stratifies the environmental benefits reported in Panel A into five sub-groups. These are shown in Figure 6, listed in descending order form most common environmental benefit to least. Note, companies could experience multiple environmental benefits. Appendix 6 splits these by different micromobility category.

Figure 6: Frequency of environmental benefits found in case studies



In line with existing literature, we find that emission reduction is the most common sustainability benefit micromobility solutions can provide (Davies, 2020; Pleeth, 2023; Büttgen et al., 2021). Micromobility options, such as electric scooters and bikes, offer a cleaner alternative to traditional motor vehicles, thereby contributing to lower overall emissions as they don't emit direct tailpipe emissions. Similarly, improved air quality has been identified as a typical benefit of micromobility, reported by 47% of the sample, which is also in line with existing literature (Xu et al., 2022). This finding highlights that reduced vehicle emissions led to better urban air quality, which in turn can have significant public health benefits by decreasing the prevalence of respiratory issues and other pollution-related health problems (Silveira et al., 2016). One-fifth of the sample reported experiencing increased energy savings, likely due to the reduced fuel consumption as more people shift towards micromobility. A smaller proportion of the sample noted improvements in recycling practices (7%) and water conservation (7%) as secondary benefits, suggesting that micromobility can also bring ancillary advantages that contribute to broader environmental goals. Comparing the benefits reported by each category, we find that lower emissions and improved air quality were the most common environmental benefits in both social micromobility and logistics micromobility category.

Overall, these benefits demonstrate that promoting micromobility can be incredibly beneficial for delivery companies' operations, general urban development, as well as environmental improvements.

5. Actionable Insights

There is an increasing emphasis on reducing transportation-related pollution and achieving sustainability goals. Governmental administrations and corporations alike are advocating for micromobility as both a delivery and transportation method. As a logistics tool, micromobility alleviates road congestion, enhancing delivery efficiency and improving business performance. As a transportation method, it reduces reliance on traditional internal combustion engine vehicles, thereby lowering tailpipe emissions, improving air quality, and minimizing noise pollution. Given its extensive advantages, the micromobility market continues to grow globally. It remains pivotal that governments and companies invest and capitalize on this innovation. Failure to do so could be detrimental for organizations across logistics, food delivery, ridesharing, and municipal planning sectors, where micromobility adoption is becoming critical to remain relevant, competitive, and sustainable.

In our analysis we identified a range of challenges that motivated companies to pursue and promote micromobility solutions. These included environmental concerns, modal shift requirements from governments, road safety challenges, congestion, wellbeing concerns, accessibility, and equity. We also identified a range of benefits resulting from the implementation of micromobility systems across the public and private sector. Notable benefits from our data include:

- An improvement in sustainability. We observed significant environmental improvements following the adoption of micromobility vehicles. Emissions were reduced and air quality improved when users switched from cars and other large vehicles to micromobility vehicles like bikes and scooters.
- An increase in efficiency for both social mobility and logistic delivery. We observed a notable increase in efficiency and a reduction in congestion through the adoption of micromobility. It lessens vehicle dependency, optimizes road space usage, and reduces travel time. These enhancements, in turn, improved company performance for the private sector and provided all road users with a better driving experience.
- An increase in data visibility. We observed a significant improvement in traffic management data visibility, driven by increased investment in data collection and

greater availability of micromobility data. Increased visibility enables dynamic traffic management, thereby increasing transportation efficiency and delivery accuracy.

Given our results, we predict several future trends:

- We expect to see an increase in public-private partnerships. These partnerships improve the implementation and management of micromobility systems as they combine public sector regulatory and infrastructure support with private sector technological and operational expertise. This synergy helps streamline the development of micromobility networks, improve service delivery, and address micromobility challenges more effectively.
- We anticipate increased investment in electric micromobility. Already, we are observing a shift towards electric micromobility vehicles such as e-cargo bikes from an increasing number of last-mile delivery companies, especially in city centers. Furthermore, governments are increasingly promoting cleaner transportation methods and active travel through e-micromobility. We anticipate this trend will continue to grow, driven by evidence of reduced noise pollution, environmental improvements, and enhanced efficiency occurring due to micromobility shifts that have already occurred.
- We observed an increase in the use of data analysis throughout our sample. The applications for data are rising, and we are already beginning to see its usefulness in the micromobility industry. We predict that there will be increased demand for data collection technologies such as monitors, sensors, cameras, telematics, and IoT. Consequently, we also anticipate a growing demand for data analysis technologies, including AI and deep data analysis technologies. These technologies offer companies data-driven insights into service demand and customer preferences, enabling improved micromobility management, streamlined operations, and optimized planning, ultimately providing business with a competitive edge.
- We observed a steady use of digitalization within micromobility industry. Digitalization offers companies cutting-edge advantages, such as enhanced data visibility, optimized traffic route planning, efficient resource allocation, and

increased overall efficiency. As a result, we expect a growing number of businesses to invest in software systems that facilitate the digitalization of their processes to harness these benefits. By doing so, they can stay ahead of the competition and improve operational efficiency.

- We predict an increase in the construction of micromobility infrastructure such as shared microhubs for cargo bikes and cycling lanes. As governments encourage the adoption of micromobility solutions, we predict that there will be a significant increase in demand for infrastructure designed to support micromobility solutions over the next few years. Presently, governments are upgrading existing infrastructure such as new bicycle lanes to facilitate micromobility. Additionally, numerous logistics companies are developing shared microhubs. We expect these trends will continue to expand.

In conclusion, as global concerns regarding traffic congestion and climate change continue to rise, adopting micromobility solutions is crucial for both companies and cities. Embracing sustainable micromobility options is key to reducing carbon footprints and enhancing cities' operational efficiency, ultimately supporting both long-term success and environmental stewardship.

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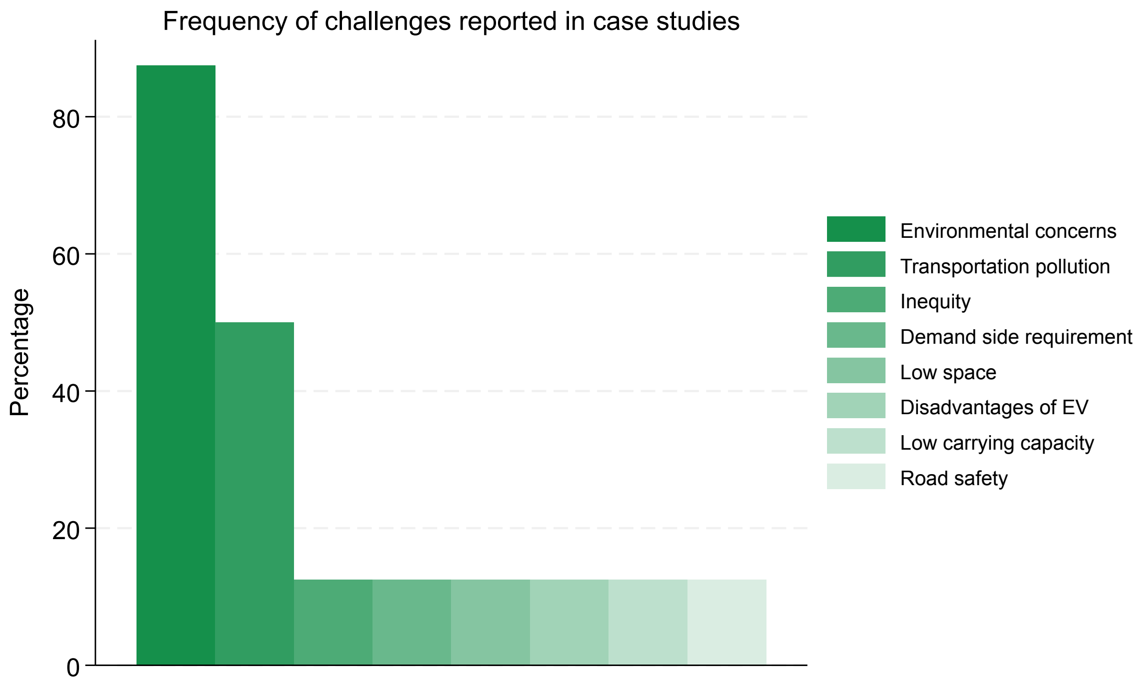
Acronyms

CPSC	Consumer Product Safety Commission
eHGV	Electric Heavy Goods Vehicle
EV	Electric Vehicle
GHG	Greenhouse Gas
ICEV	Internal Combustion Engine Vehicle
PM	Particulate Matter
PPP	Public-Private Partnership
SFMTA	San Francisco Municipal Transport Authority
TfL	Transport for London
UL	Underwriters Laboratories

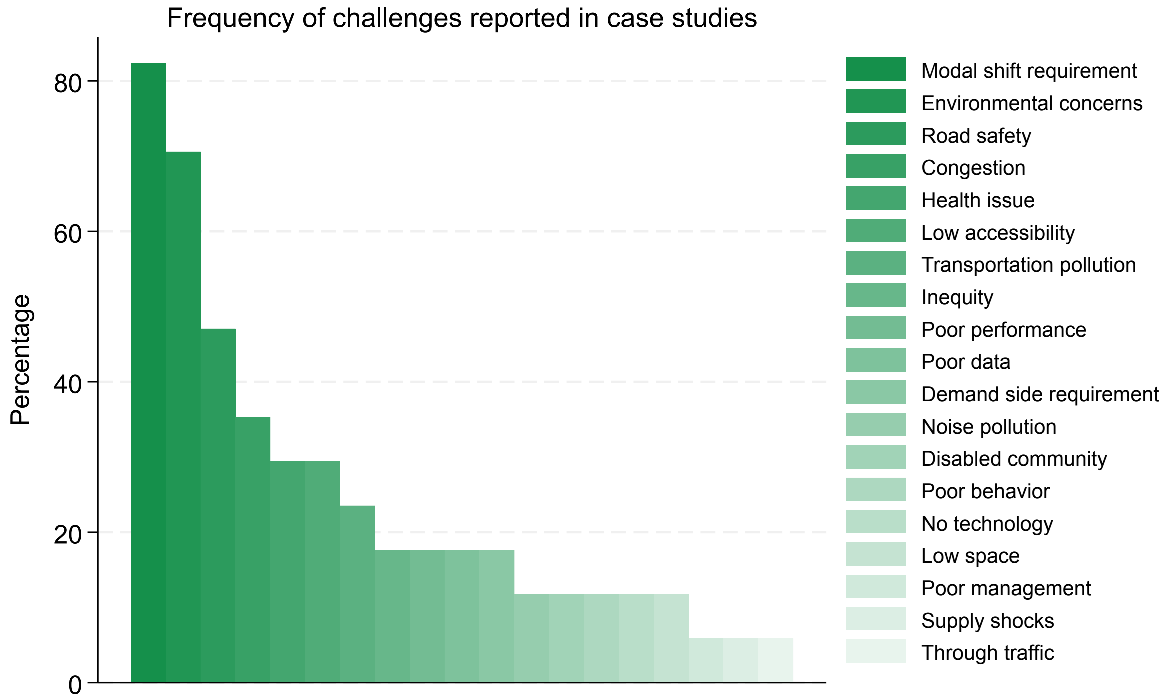
Appendix

Appendix *1*: Challenges by Category

Panel A: Logistics Micromobility

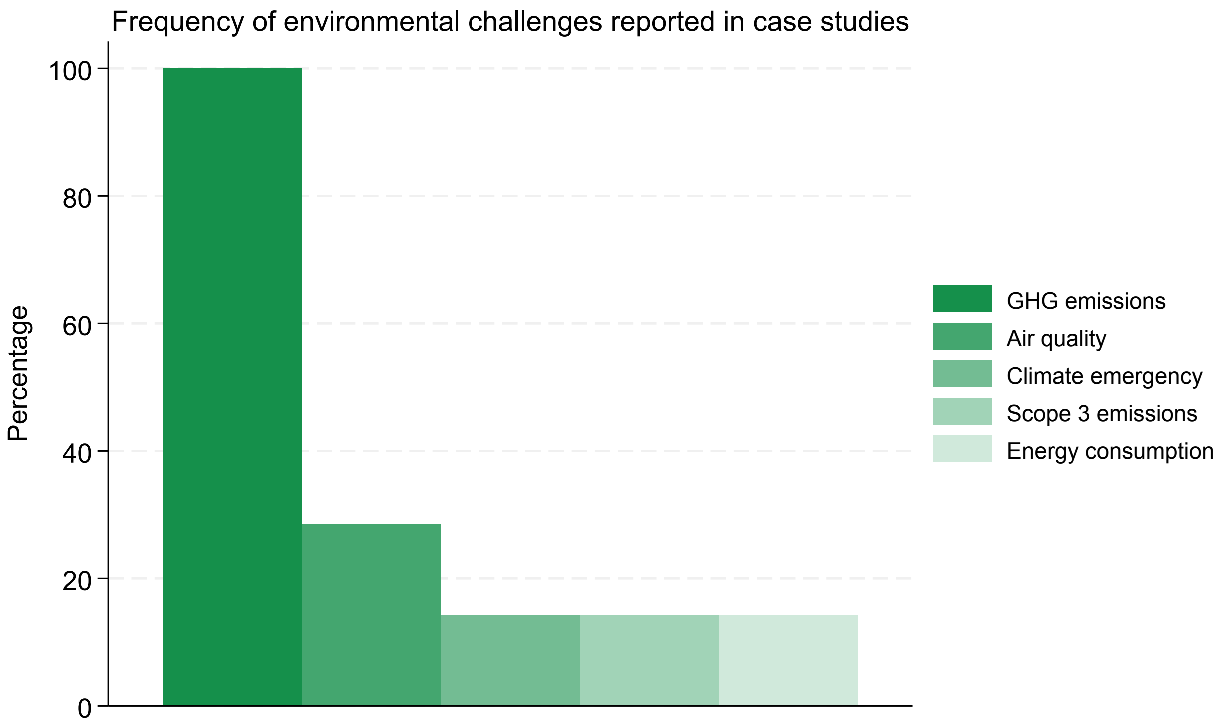


Panel B: Social Micromobility

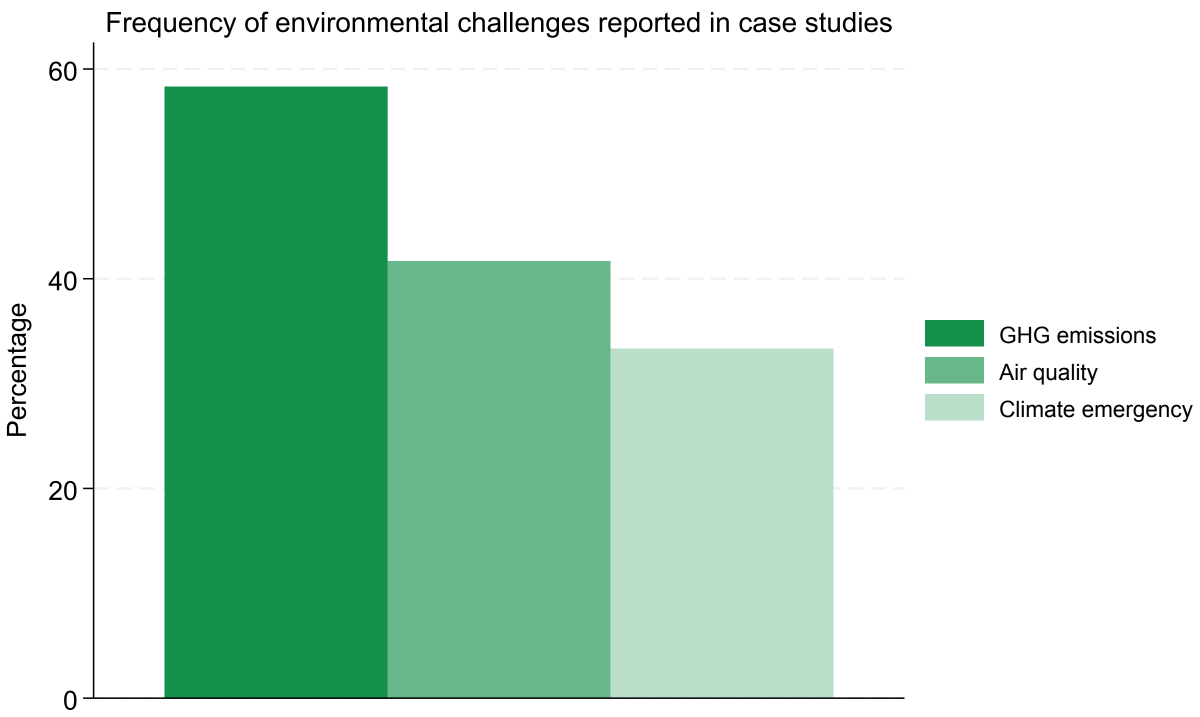


Appendix 2: Environmental Challenges by Category

Panel A: Logistics Micromobility

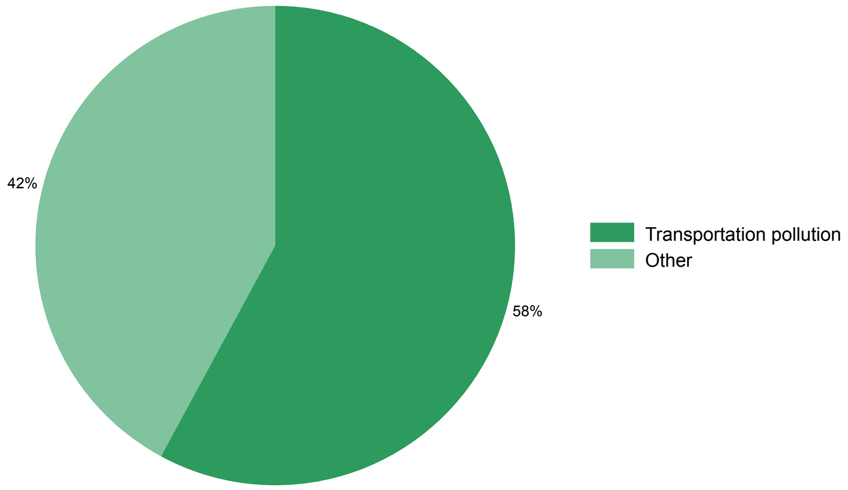


Panel B: Social Micromobility

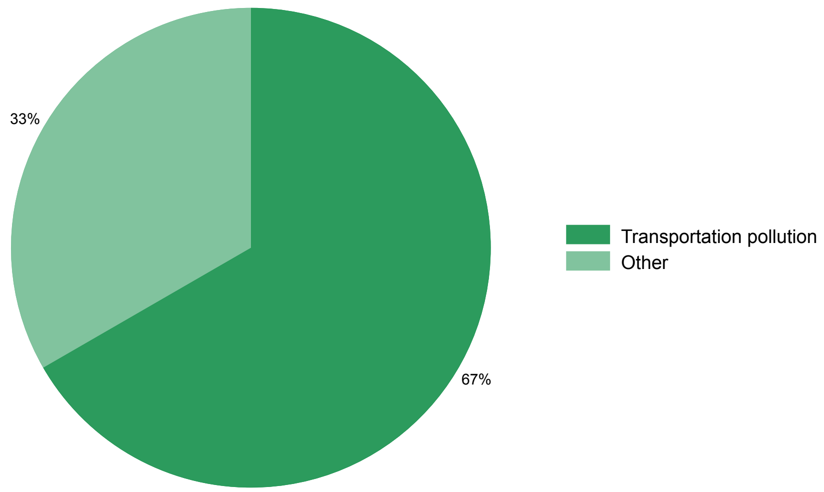


Appendix 3: Sources of Pollution

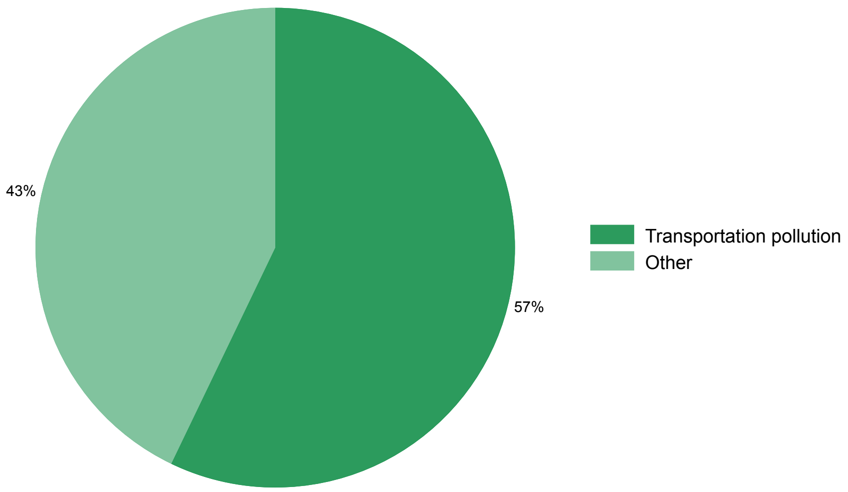
Reasons behind pollution (total)



Reasons behind pollution (social)

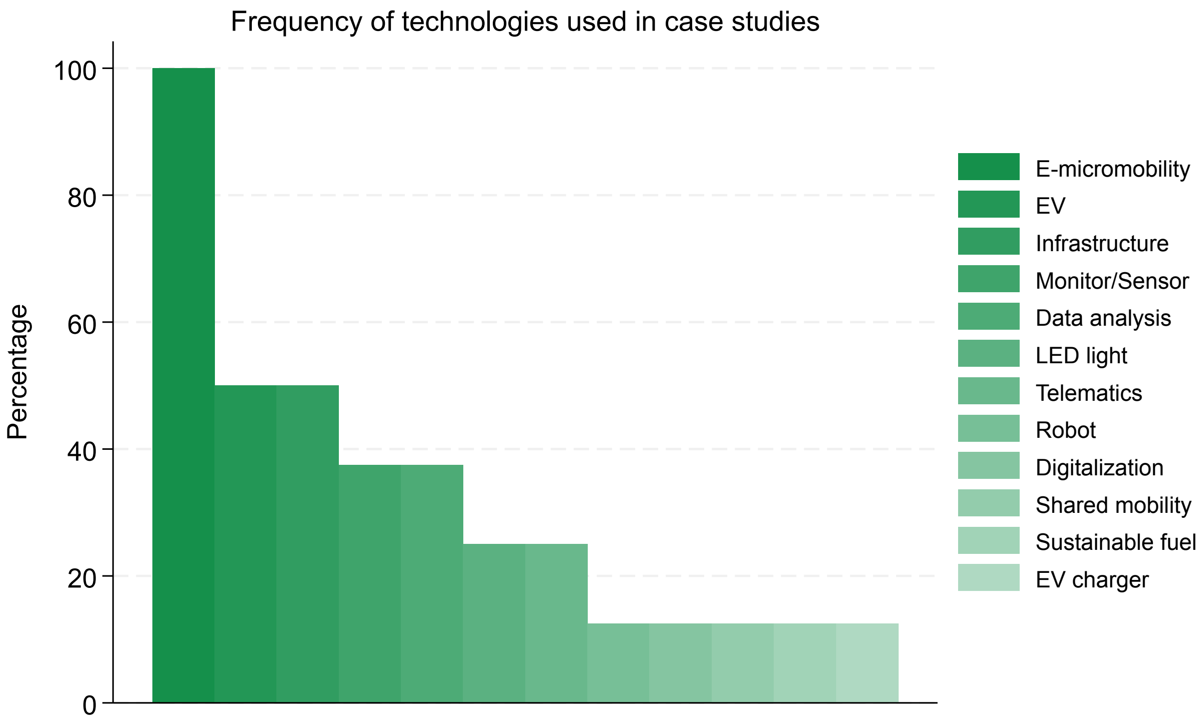


Reasons behind pollution (logistic)

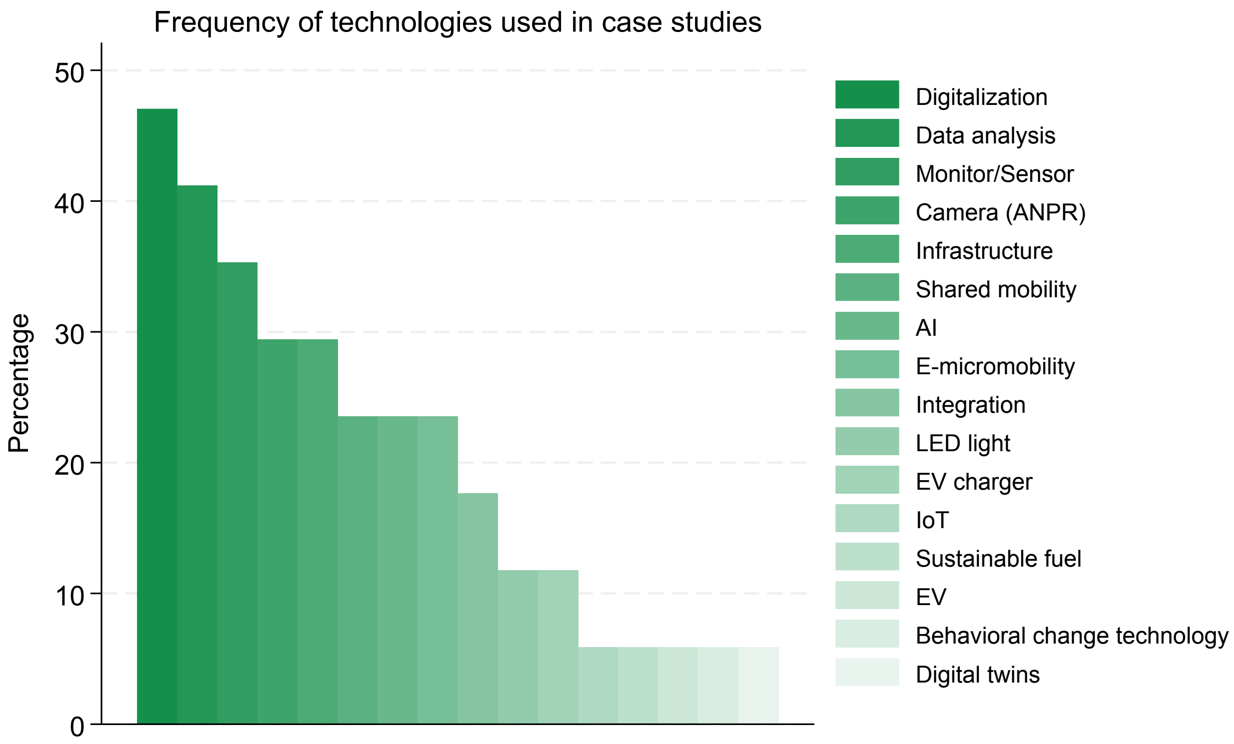


Appendix 4: Technologies by Category

Panel A: Logistics Micromobility

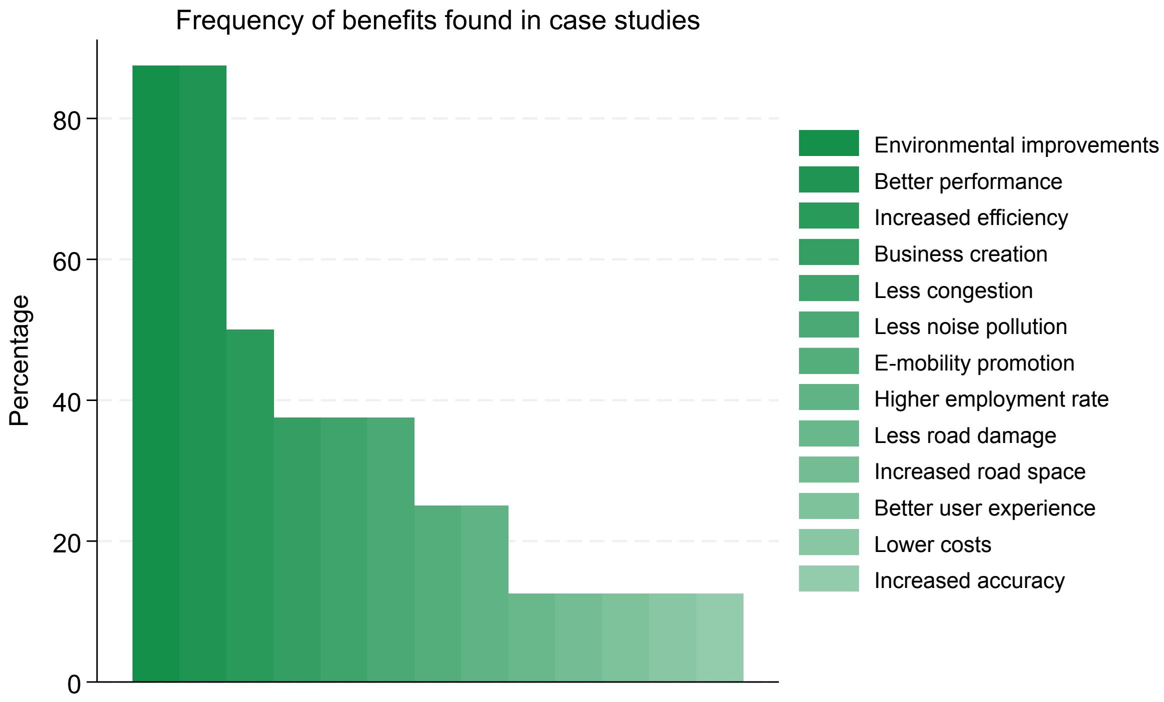


Panel B: Social Micromobility

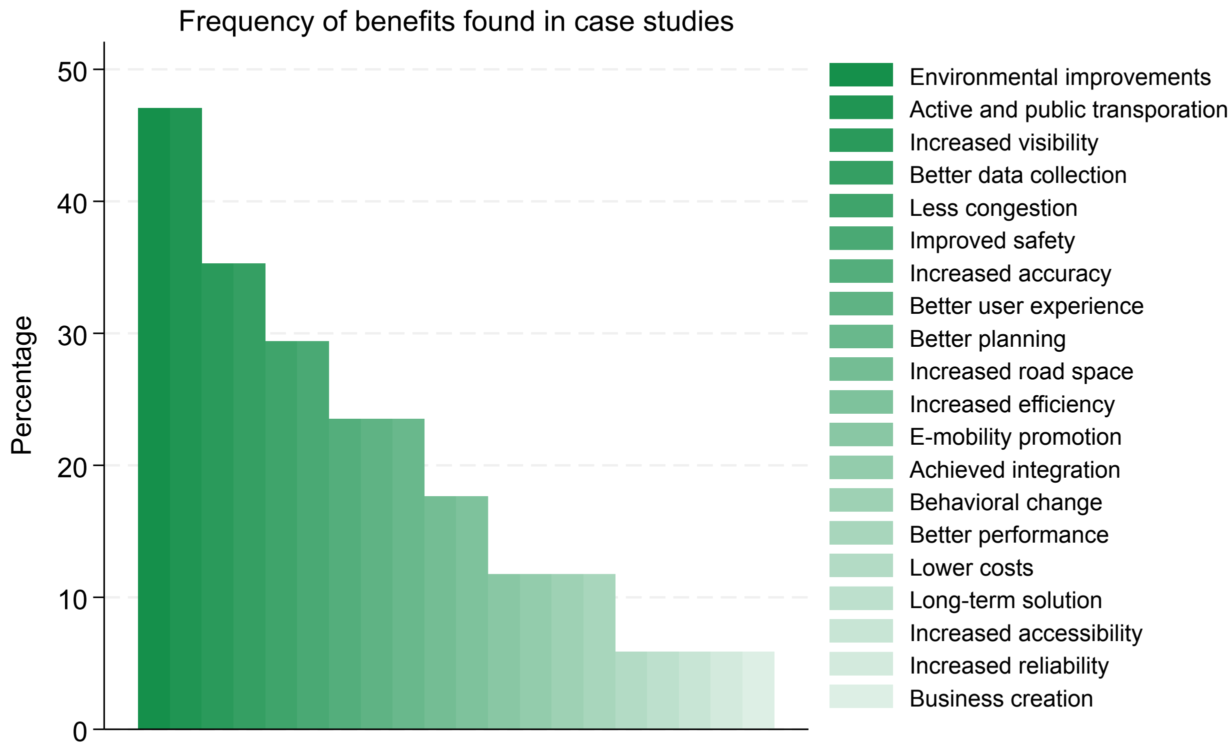


Appendix 5: Benefits by Category

Panel A: Logistics Micromobility

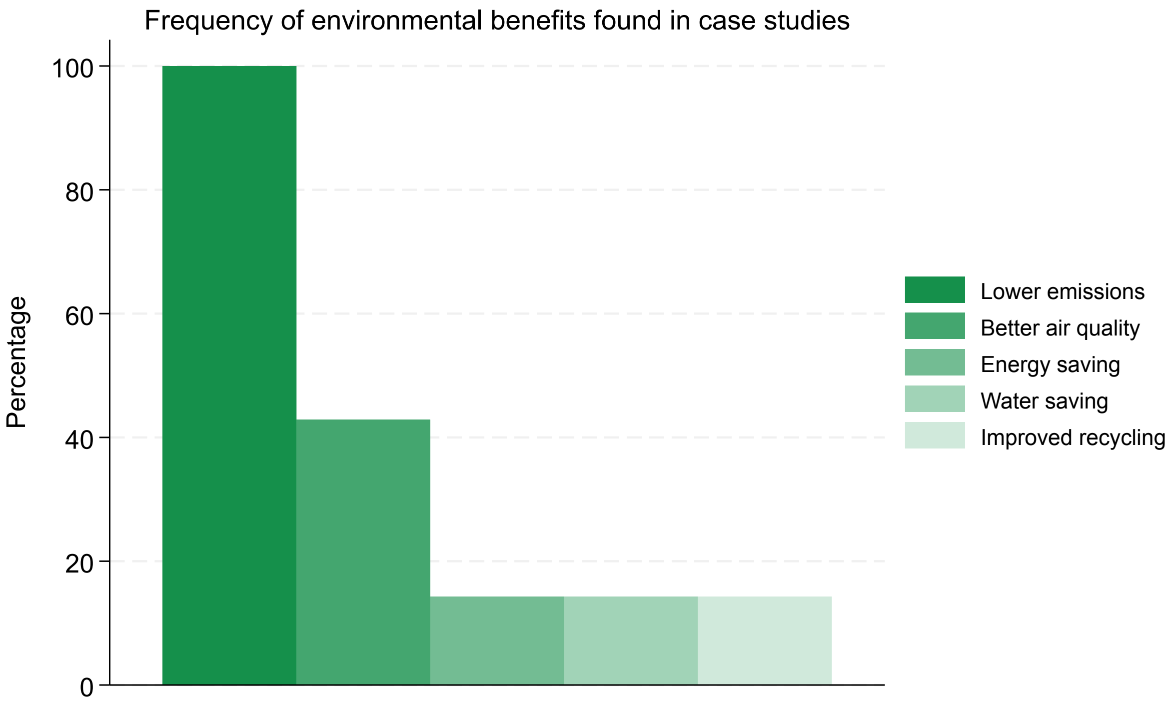


Panel B: Social Micromobility

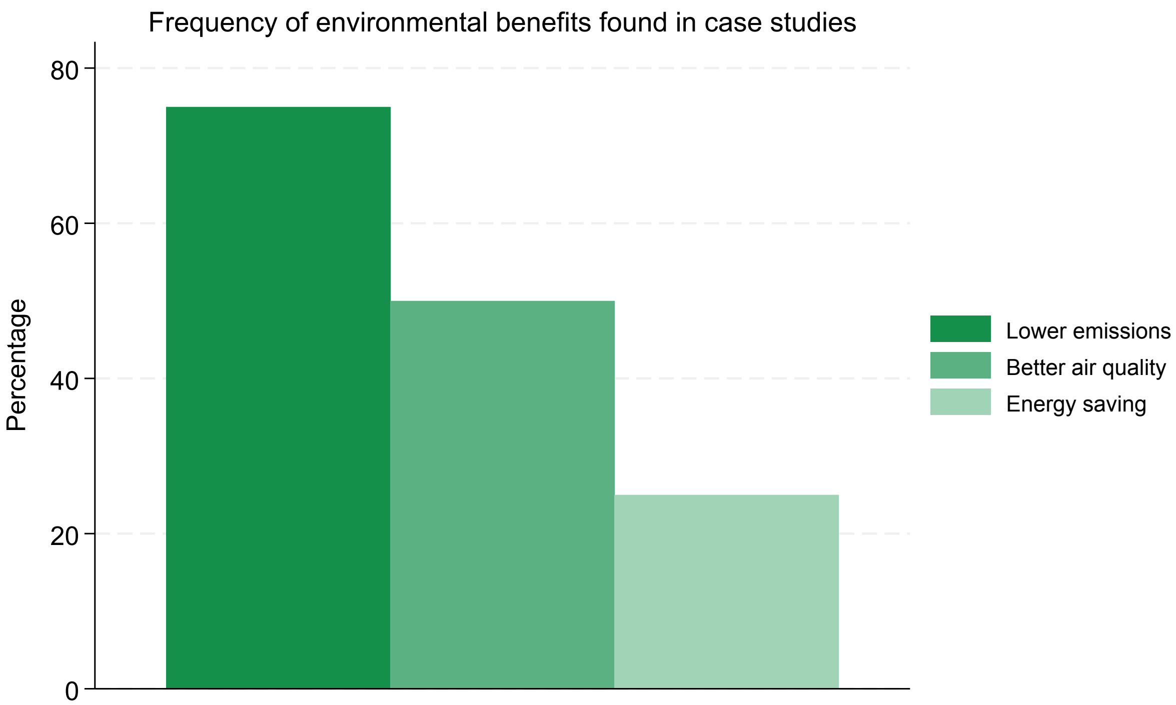


Appendix 6: Environmental Benefits by Category

Panel A: Logistics Micromobility



Panel B: Social Micromobility



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