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RESEARCH ARTICLE

Intermodal use of (e-)scooters with train in the Provence-Alpes-Côte d'Azur region: towards extended train stations areas?

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Abstract
Featuring rapid adoption rates in recent years, personal standing scooters, as a micromobility, represent a missing complement to the first and last mile of public transport. This paper examines intermodal trips involving private (e-)scooters and trains with the objective to investigate the influence of this intermodal combination on station catchment areas. The methodology is based on the analysis of existing scientific research and empirical evidences. The case study focuses on access data from 12 railway stations collected by SNCF Réseau in the Provence-Alpes-Côte d'Azur region in September and October 2020. Main findings of this secondary analysis, based on 53 passengers using this personal device, suggest an over-representation of male and younger users, with very frequent intermodal practices mainly dedicated to work or study, and a feeder distance between combined walking and cycling. There appears to be similarities between bike-and-ride and scoot-and-ride but also clear distinctions that characterize this emerging mode, among which the fact that scooter is almost always used both during access and egress stages. This article advocates that station areas should be better considered by redesigning the surrounding public spaces to better balance the space of each mode, in favour of alternatives to the car and sustainable cities.

Keywords E-scooter · Intermodality · Micromobility · Public transport · Urban transportation

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1 Introduction

Standing scooters are a dramatically growing new trend in urban mobility (Oeschger et al. 2020, p. 1). These are small, light, electric, single-user and cost-effective alternative transportation options for short distances (McKenzie 2019b; Abduljabbar et al. 2021, p. 1). Private e-scooters are increasingly spreading in France with a one-third increase in sales in 2020 (FP2M and SML 2021) and in Europe with an increase in use from 20 to 60% during the first lockdown (Bert et al. 2020). In addition, preliminary data from the OMNIL (2021, p. 35) mobility observatory suggest that light transportation modes have considerably increased in September and October 2020 in the Île-de-France region. Beyond its rapid adoption rate, this personal device interacts with other modes because it is relatively light and foldable (Tuncer et al. 2020, p. 1), providing high flexibility for the user (Zuniga-Garcia et al. 2020, p. 2), an essential value that explains a large part of the appeal of automobile (Héran 2015, p. 209).

The evolution of urban mobility is a key role in reducing the costs generated by a car-oriented society, resulting mainly in GHG emission, urban sprawl, different forms of pollution (air, noise), socio-spatial fragmentation, budget costs, traffic accidents and congestion (Héran 2001, p. 12). Although modal shift to public transport is one of the most energy-efficient ways to contribute to sustainable mobility, it has the disadvantage of being inflexible by following a fixed route (EEA 2020, p. 10).

Intermodality, i.e. using multiple means of travel to achieve a given trip (Polzin 2017), reduces the rigidity of public transport (Wiel 1998, p. 17) and is a key role improving the efficiency of the urban transport system (Oostendorp and Gebhardt 2018, p. 82) by extending the stations' service area (Amar 2016, p. 16).

In this context, Amar (2016, p. 222) describes the evolution towards a more connected and efficient mobility through the revaluation of proximity modes, articulated to other scales and forms of mobility. New mobility solutions are having a lasting impact on the twenty-first century mobility system (Cervero 2019, p. 137). Emerging feeder modes reinforce the attractiveness of public transport (Goletz et al. 2020, p. 116) and increase their service area, allowing more destinations to be reached within the same time budget (EEA 2020, p. 10). New mobility solutions forms, such as the combination of micromobility and public transport, are expected to become relevant in the future (Oostendorp and Gebhardt 2018, p. 77), especially in suburban areas where travel distances for accessing transit stops tend to be longer (Cervero et al. 2013, p. 84).

By providing on-demand mobility, e-scooters are touted as a solution to the missing "first and last-mile" (FLM) transit connection (Møller et al. 2020, p. 9). Therefore, micromobility could be a valuable complement to heavy-duty public transport networks by making it more efficient towards a post-carbon city (Schultz and Grisot 2019, p. 3). Thus, e-scooters, incorporated as an intermodal option (Abduljabbar et al. 2021, p. 1), have the potential to meet the challenges of public transport gaps (Gauquelin 2021). This emerging mode should be considered as a potential complement to the quality of the public transport system capable of promoting more virtuous and longer distance trips, competing with car in urban and peri-urban areas.

Micromobility options have a genuine capacity to be relevant as a segment of intermodal trips, increasing the catchment area of public transport and compete with car travel (CPB 2020, p. 63).

However, the changes produced by the arrival of e-scooters in the city remain nascent, unclear, and difficult to predict (Tuncer et al. 2020, p. 1). There is a lack of empirical studies on the integration of micro-vehicles and public transport, more specifically on e-scooter-rail intermodal transportation (Zuniga-Garcia et al. 2020, p. 2). Gaps are identified across quantitative support in this respect (Schlueter Langdon and Oehrlein 2021, p. 7), and trip purpose and demographics (Ensor et al. 2021, p. 9). It can be explained by the fact that these vehicles are new, methodology is not standardized and data are only scarcely available (Oeschger et al. 2020, p. 17).

This paper is based on the analysis of a survey conducted by the French rail network manager SNCF Réseau. The sample extracted from the questionnaire is composed of passengers who indicated using another mode to get to or from a train station. The method applied is based on geostatistical processing of the data collected by comparing standing scooters with the other modes mentioned, and by projecting spatial outputs. The aim of this paper is therefore to provide an overview of the literature published in relation to micromobility, especially standing scooters, and investigate a local survey on feeder modes to train stations. This paper identifies both a gap in the literature about this modal mix and a geographical disparity in the literature in favour of the US. To the authors' knowledge, no scientific article has examined in detail the socio-demographic profile and mobility practices of such intermodal travellers. This paper also presents evidence about this emerging trip chain, in the European context, highlighting some particular features such as the combined use of scooter in access and egress, and inequalities in usage in terms of gender and age distribution. The analysis of this survey thus contributes to a better understanding of the challenges involved in the use of micromobility in the context of first- and last-mile access to public transport. This work also makes recommendations to urban planners to integrate these riders' needs: a win-win objective being to capture the growth potential of this intermodal system, and attract a wider and more diversified public to the railways.

The remainder of the paper is organized as follows. In Sect. 2, we review existing literature based mainly on shared e-scooters, to highlight research gaps on combined scooters. Further to a description of SNCF Réseau's investigation protocol in Sect. 3, the present article reports the results on train transfers by scooter in the Provence-Alpes-Côte d'Azur (PACA) region in France, with a focus on one periurban station in Sect. 4. Results are discussed in Sect. 5, while Sect. 6 concludes and provides also an outlook for further research.

2 Related work

One of the appealing aspects of micromobility solutions is their role in enhancing connectivity to public transport (Abduljabbar et al. 2021, p. 4). The use of micromobility including bikes and personal mobility devices (PMD) as human (kick) or

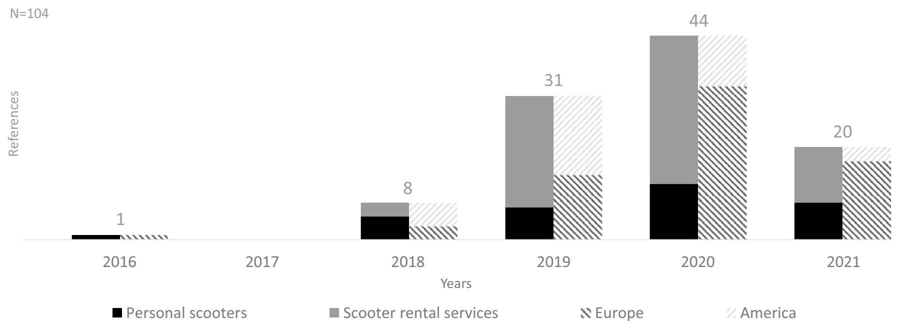


Fig. 1 Literature review overview: uses and users of personal and rented scooters in Europe and America. Sources: References, Source: authors, 2022

electric-powered (e-)scooters can significantly enlarge service area available within transit isochrones (Kostrzewska and Macikowski 2017, p. 4).

As a new type of vehicle with particular technical features—conveying a futuristic and sustainable representation of the city (Boffi 2019, p. 1)—e-scooters enable unique mobility practices by allowing riders to rapidly transform into pedestrians (Tuncer et al. 2020, p. 9). Kostrzewska and Macikowski (2017, p. 7) point out that scoot-and-ride[1] differs from bike-and-ride in the ease of boarding the linked mode on public transport: e-scooters appear to be an interesting "Hybrid, distinct transport mode" option (Kager et al. 2016, p. 1) when carried on dense or poorly equipped transit, even during peak hours. It is easily manoeuvrable, folded, and easy to carry, granting enhanced mobility and speed, especially when combined with urban transport (Tuncer et al. 2020, p. 1), although this depends on the type of public vehicle and the context.

The aim of this article is then to focus on the intermodal use of scooters, to capture the main characteristics of this practice which seems to be growing and which differs from cycling combined with public transport in some points.

2.1 Search parameters considered in the review of literature

Through a literature review based on previously conducted research on the uses and users of scooters, we will present the main results that emerge from the analysis of 104 scientific articles and reports collected on an international scale. Our intention is to cover all the publicly available data on this new object of study, including both academic literature and industry-driven research.

Very few scientific articles and reports examine exclusively the characteristics and impact of intermodality involving a standing scooter. Therefore, it was decided to devote this literature review to all white and grey literature on scooters and their combination with other modes of transport.

[1] Throughout this paper, the term "scoot-and-ride" will refer to the use of scooter in combination with transit.

Table 1 Share of studies on intermodal practices by scooter types

Filters	Studies reviewed	Addressing intermodality	Addressing intermodality (%)
Personal scooters	44	16	36
Scooter rental services	89	32	36
Europe	40	14	35
America	24	4	17

Sources: References, Source: authors, 2022

These papers have been systematically filtered to identify trends in the research, as shown in Fig. 1. The literature review is restricted to Europe and America, as few articles seem to exist on this subject in other continents, at least in English. It appears that studies about scooters are monopolizing the subject of electric scooters and have mainly focused on shared e-scooters soon after their emergence in 2017, especially during 2019 and 2020. While studies rate about e-scooters as Personal Electric Vehicles (PEV) seems to be increasing from 2021 onwards. This is in line with the growth in the number of publications expected by Abduljabbar, Liyanage, and Dia (2021, p. 2) who conducted a bibliometric analysis focused on micromobility, from English-language journal articles between 2000 and 2020.

Studies on the intermodal approach to e-scooters tend to focus on both personal and shared scooters, accounting for one third of the literature reviewed (Table 1). By contrast, this topic is more common in the European literature (36%) than in the American one (17%). Although the question of integration of standing scooters and transit is regularly included in scientific research and reports, it is only partially discussed and restricted to a few results which are outlined below.

To better understand the uses of scooters, we will first analyse the characteristics of all trips on scooters, and then we will examine the statistics gathered on intermodal trips.

2.2 Socio-demographic profile of scooter users

This part deals with the main aspects defining the user's profile, including age and gender that will be explored in Sect. 4.

2.2.1 Age

Field surveys based on the data analysis on scooters concur on the relative youth of users of scooters. Generally, the median age of scooter users ranges from 25 to 34 (Fig. 2). Accordingly, 6t-Bureau de recherche (2019a, p. 14) observes that 45% of shared e-scooter riders are under 25 in Paris (France), while 33% are under 24 in New Zealand (Fitt and Curl 2019, p. 4). In Calgary (Canada), Sedor and Carswell (2019) report that 70% are actually less than 30 while de Bortoli and Christoforou (2020, appendices) identify 46% as being under the 30-year mark in Paris.

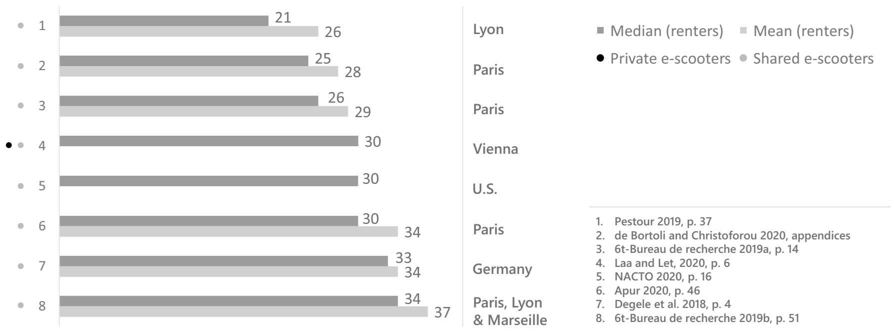


Fig. 2 Average age among e-scooter users. Sources: References, Source: authors, 2022

The same applies to personal scooters which are more popular with the younger population, with 41% of users between 15 and 25 in a ratio similar to that for public bikeshare in France (Richer 2021). A graduate thesis in Lyon stands out from the overall results by counting half of the users as being below 21 (Pestour 2019). Other authors suggest that the median age is closer to the 25–34, as illustrated by Laa and Leth (2020, p. 3) who counts 46% of both dockless and private scooter users in Vienna (Austria) in this age category.

In the US—especially in Arlington, Baltimore, Minneapolis, Portland, San Francisco and Santa Monica—more than half (50–73%) of shared e-scooter users are under 40 (NACTO 2020, p. 16).

Moreover, the 6t-Bureau de recherche (2019b, p. 65) research office determined the average age of users of the scooter-sharing system by frequency, revealing that the most casual users are likely to be older: regular users are 35 on a mean basis, occasional users are 37, whereas users having tried only once are 40.

Even though the under-30 age group seems to be the most popular choice for scooters, Degele et al. (2018, p. 4) note another significant peak of customers between 45 and 50 who tend to cover longer distance, suggesting then user clusters partly divided into Y and X+ generations.

The effects of crises also appear to make more young people shift to free-floating e-scooters, as the Apur (2020, p. 68) report shows with the public transport strikes in the Île-de-France region.

2.2.2 Gender

A second factor significantly influencing modal choice along with age is gender. Scooters face a gender gap, with male users taking up two-thirds to three-quarters of the reported modal share (Fig. 3).

In Oslo (Norway), the typical user of dockless e-scooter program is a man (Fearnley et al. 2020, p. 16). In Austin, 62% of shared e-scooters are men (Zuniga-Garcia et al. 2020, p. 16), while the NACTO (2020, p. 22) association of North American cities and transit agencies lists 66–80% male users from Austin, Baltimore, Minneapolis, San Francisco and Santa Monica.

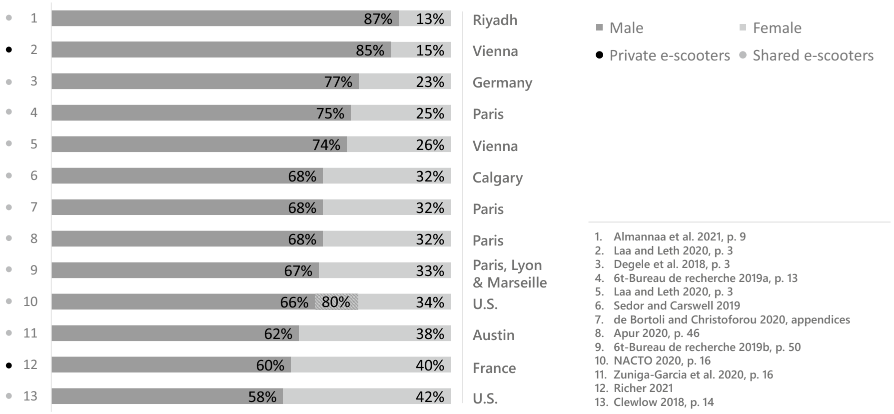


Fig. 3 E-scooter users rate by gender. Sources: References, Source: authors, 2022

The same figure (67%) is also found among *Lime* users in Paris, Lyon and Marseille, reaching 70% for visitors (6t-Bureau de recherche 2019b, p. 50). This masculine population for shared scooters is equally identified (68%) in the French capital, as much by Apur (2020, p. 46) as de Bortoli and Christoforou (2020, appendices).

The results with the most critic unbalance for e-scooter services estimate the male rate at 74% in Vienna (Laa and Leth 2020, p. 3), 75% for *Dott* users in Paris (6t-Bureau de recherche 2019a, p. 13), 77% in German metropolises (Degele et al. 2018, p. 3), and 87% in Riyadh (Saudi Arabia) (Almannaa et al. 2021, p. 9).

By considering the travel frequency by shared e-scooters, it turns out that men are more represented among *Lime* regular users (76%) than casual users (68%) and one-time users (58%) (6t-Bureau de recherche 2019b, p. 65). Even if this is less noticeable for *Dott* regular users (78%), with a 3% gap relative to overall (6t-Bureau de recherche 2019a, p. 25).

Gender inequalities seem to be strengthened when it involves personal devices: over 60% of scooter users in France are men (Richer 2021), Laa and Leth (2020, p. 5) reported 75% of male cycle path users by private scooters in Vienna, Sedor and Carswell (2019) surveyed both personal and shared scooters and obtained a 68% male share in Calgary.

However, the Île-de-France public transport strike drew a more feminized population among the new micromobility users, including shared e-scooters (Apur 2020, p. 68).

Surprisingly, despite this inequality in the access to scooters, women have a more positive image of this micromobility (72%) than men (67%) in the United States (Clewlow 2018, p. 15). These indications call for deepening the researches on gender use and representation of this new transport mode.

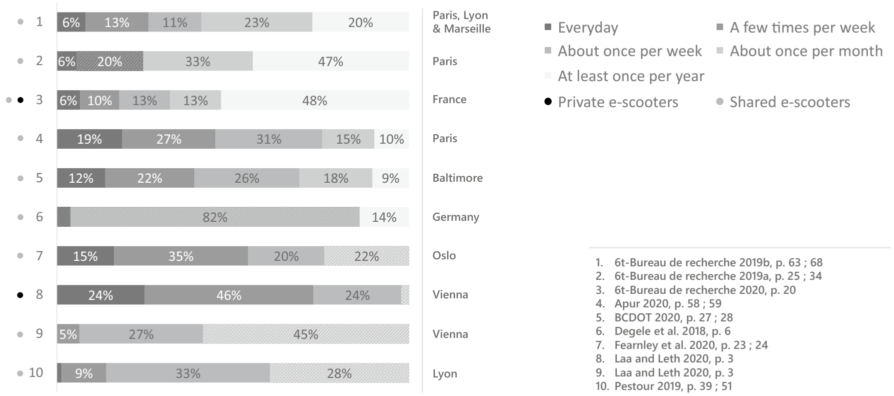


Fig. 4 Travel frequency by e-scooter. Sources: References, Source: authors, 2022

2.3 Mobility patterns of scooter trips

This section addresses the basic characteristics of scooter trips, i.e. frequency, purpose and distance.

2.3.1 Frequency

Shared e-scooters are mostly used casually, while private scooters seem to be used more frequently (Fig. 4).

In Paris, the use of e-scooters services at least once a week is the case for between 25 and 50% (6t-Bureau de recherche 2019a, b, 2020; Pestour 2019; Apur 2020) of riders. Similar rates are detected in Vienna with 32% of all respondents using the e-scooter sharing system at least once a week (Laa and Leth 2020, p. 3).

Data from City of Chicago (2020, p. 28) indicate that most e-scooter users were infrequent or occasional users. The opposite, usage rates for weekly or more reaches 60% in Baltimore (U.S.) (BCDOT 2019, p. 27) and 70% in Oslo in summer (Norway), although this drops to 42% heading into the autumn (Fearnley et al. 2020, p. 23).

More factors can influence travel frequency of shared e-scooters. The longer people have been subscribing, the more frequently they appear to use e-scooters, 62% of regular users beginning to access *Dott* at least 1 month prior to the survey period (6t-Bureau de recherche 2019a, p. 47).

Younger respondents between 17 and 39 report higher scooter and bike-share ridership: several times a week or every day for the 17–24 (49%) and the 25–39 (47%), compared to 25% for the 40–54 and 31% for the 55–64 age groups (BCDOT 2019, p. 27). Similarly, people who identify as Asian (57%), Black/African American (55%), or Hispanic/Latinx (55%) report being more frequent riders than those as White (30%) (BCDOT 2019, p. 27).

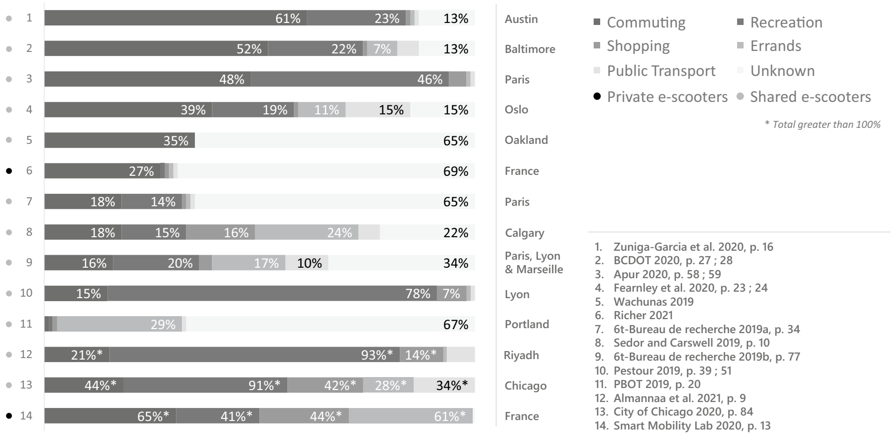


Fig. 5 Trip purpose by e-scooter. Sources: References, Source: authors, 2022

Unlike other modes, the use frequency of personal and shared e-scooters does not seem to be associated with the residential context, with little difference between the city centre, the inner and the outer suburbs (6t-Bureau de recherche 2020, p. 21).

Given the French legislation restricting the top speed of a scooter to 25 km/h, travel frequency is seen to have an effect on the perceived speed: frequent users report a driving speed above 20 km/h in comparison with 15–20 km/h speed's occasional users (Pestour 2019, p. 39).

The 6t-Bureau de recherche (2019b, p. 123) survey suggests that 72% of users are very much in favour of riding a rented e-scooter more often as long as the price is reduced.

In terms of use intensity, only one scientific publication focused on personal e-scooters and finds that 94% use it at least once a week (Laa and Leth 2020, p. 3). According to 6t-Bureau de recherche (2020, p. 22), 18% of e-scooter owners said they never use one, when frequency could also depend on the trip purpose: apart from commuting, scooters are used for shopping, leisure, culture, etc. at least once a week in 24% of situations.

2.3.2 Purpose

Commuting and leisure are the two main trip purposes for e-scooters services, whereas no extensive research on reasons for riding by personal scooters seems to have been driven (Fig. 5).

E-scooters services are used for different purposes (McKenzie 2019a, p. 19). Destinations related to work or study by shared e-scooters are the most cited: 16–18% (6t-Bureau de recherche 2019a, b, pp. 34, 68), and 48% (39% and 9%) (Apur 2020, p. 58) in Paris; 39% (9% and 30%) (Fearnley et al. 2020, p. 24) in Oslo; 35% (Wachunas 2019), 52% (BCDOT 2019, p. 28), and 61% (Zuniga-Garcia and Machemehl 2020, p. 16) in American metropolises.

A data-based analysis of bicycles and scooters distribution in Zaragoza (Spain) shows a regular occurrence during peak hours to the centre and the University in the morning and evening in the opposite direction (López-Escolano and Campos 2019, p. 11). The same phenomenon is present with students in St. George (U.S.) (The Spectrum 2019).

The next most mentioned activity is recreation and visiting family or friends by 20% (6t-Bureau de recherche 2019a, p. 34), and 46% in Paris (Apur 2020, p. 58), 78% in Lyon (Pestour 2019, p. 51), and 29% in Portland (PBOT 2018, p. 20). In Calgary, visiting represents 24% of the last shared e-bike and e-scooter trips (Sedor and Carswell 2019, p. 10).

When grouped with shopping, restaurant, and errands, the statistics seem more consistent between 30–50% in Europe and in the United States (twice 29%; 30%; 40%; 50%; 55%; and 85%). Moreover, a clear peak in usage is visible at the weekend and in the later hours of the day in Hamburg (Germany) and Louisville (U.S.), indicating a recreational and tourist usage (Civity Management Consultants 2019; Hosseinzadeh et al. 2021, p. 12).

Thus, data suggest that e-scooters are less being used as a first last-mile commute option, and more as a mode for running short-distance midday errands, travelling around a campus, and leisure in Indianapolis (U.S.) (Mathew et al. 2019, p. 48).

Besides the last trip made by shared e-scooter, the main reasons appear to be commuting, followed by errands: commuting trips have been achieved by shared e-scooters for 58% of users, most of the time for 19%, often for 15% and occasionally for 24% of them (6t-Bureau de recherche 2019b, p. 78).

In Baltimore, respondents were asked to rank the top three most common purposes with dockless bike or scooter trips: entertainment or socializing (50%), work or education (49%), shopping or errands (38%), business trips (37%) and connections to transit (22%) are the most highly cited in the list (BCDOT 2019, p. 28).

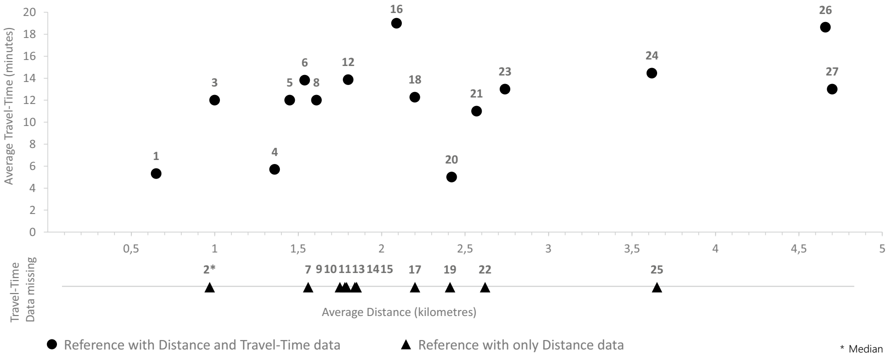
The intensive users explain that they mostly ride shared scooters to and from work and for business trips (6t-Bureau de recherche 2019b, p. 77).

Few studies could provide usage evidence on private scooters purposes. Richer (2021) analysed some forty Cerema-certified mobility enquiries between 2015 and 2019 and determined that 24–30% of trips by personal scooters are for work or education in France, which is a higher average than all trips (19%) and similar to private bikes and public bikeshare. In urban areas over 200,000 inhabitants in France, 3% of surveyed commuters state that they are interested in riding a personal standing scooter (6t-Bureau de recherche 2020, p. 22–23).

According to ITDP (2019, p. 19), a non-profit organization, e-scooters are popular among commuters since they save the need to change clothes or shower to get to work. We also remark that a rather stable amount of individuals (10%) ride to or from a public transport station, indicating that personal and shared e-scooters are used for intermodal trips (Fearnley et al. 2020, p. 24).

2.3.3 Distance

The scatter plot (Fig. 6) shows that private and shared e-scooters are best suited for short distances (Schellong et al. 2019, p. 3). E-scooter trips average between 1.5 and



Mean (median) distance:

1. **0.65** (0.55): Washington, D.C. (U.S.) (McKenzie 2019a, p. 6)
2. (0.97): Austin (Texas, U.S.) (Caspi et al. 2020, p. 13)
3. **1.00** [euclidean distance]: Oslo (Norway) (Fearnley et al. 2020, p. 17)
4. **1.36**: Paris and Lyon (France) (Coulombel et al. 2020, p. 28)
5. **1.45**: Austin (U.S.) (Bai and Jiao 2020, p. 270)
6. **1.54** (1.17): Washington, D.C. (U.S.) (Zou et al. 2020, p. 5)
7. **1.56** (1.00): France (Richer 2021)
8. **1.61**: U.S. (NACTO 2020, p. 10)
9. **1.75**: France (Fluctuo 2020a, p. 6)
10. **1.78**: Europe (Civity Management Consultants 2019)
11. **1.79** (1.46): Washington, D.C. (U.S.) (McKenzie 2019b, p. 5)
12. **1.80** (1.13): Indianapolis (U.S.) (Mathew et al. 2019, p. 44)
13. **1.84**: Germany (Statista Research Department 2020)
14. **1.85**: Portland (U.S.) (PBOT 2018, p. 11)
15. **1.85**: Calgary (Canada) (Sedor and Carswell 2019, p. 8)
16. **2.09**: Minneapolis (U.S.) (Bai and Jiao 2020, p. 271)
17. **2.20**: Paris (France) (Apur 2020, p. 27)
18. **2.20**: Lyon (France) (Pestour 2019, p. 54)
19. **2.41**: Chicago (U.S.) (City of Chicago 2020, p. 84)
20. **2.42**: St. George (U.S.) (The Spectrum 2019)
21. **2.57**: Baltimore (U.S.) (BCDOT 2019, p. 16)
22. **2.62**: Louisville (U.S.) (Stevens 2019)
23. **2.74**: U.S. (NACTO 2019, p. 11)
24. **3.62**: Paris (France) (de Bortoli and Christoforou 2020, appendicies)
25. **3.65** (4.00): Germany (Degele et al. 2018 p. 3)
26. **4.66** (2.75): Paris, Lyon and Marseille (France) (6t Bureau de Recherche, 2019b, p. 75)
27. **4.70** (3.00): Paris (France) (6t Bureau de Recherche 2019a, p. 33)

Fig. 6 Average distance for all trips by shared e-scooter. Source: References, Source: authors, 2022

3 km, lying at an intermediate position between the estimated range of combined walking and cycling: between 0.5 and 1 km for the pedestrian mode (El-Geneidy et al. 2010, p. 2) and about 3 km for the non-motorised bicycle (van Oort 2020). On short-distance trips (1–4 km), dockless e-scooters would provide a new alternative to the private automobile in car-park constrained environments (Smith and Schwieterman 2018, p. 9).

The median distances for shared e-scooter are less dispersed: from 0.6 (McKenzie 2019b, p. 6); 1 (Caspi et al. 2020, p. 13); 1.1 (Mathew et al. 2019, p. 44); 1.2 (Zou et al. 2020, p. 5); 1.5 (McKenzie 2019a, p. 5); 2.8 (6t-Bureau de recherche 2019b, p. 75); 3 (6t-Bureau de recherche 2019a, p. 33) to 4 km (Degele et al. 2018, p. 3). It should be noticed that the highest values result from declarative data, while the remaining values based on georeferenced data streams stabilize around 1.5–2.5 km.

In France, the median distance of private standing scooter trips is 1 km (1.6 on average) as opposed to 0.6 km for walking and 1.4 km for private and shared bikes (Richer 2021).

Data show that the distances travelled by e-scooter service are weather-dependent: trips between August and September averaged 1.6 km, while trips in January and February were closer to 1.1 km (BCDOT 2019, p. 14). It seems to be also influenced by the location inside the urban area: trips averaged both 1.9 km long in a Baltimore and Portland centre area, compared to an average of respectively 2.9 and 2.6 km near cities limits (BCDOT 2019; PBOT 2018, p. 11).

It has been seen that from the 85th percentile onwards, there is a lower propensity to make long journeys by this new device (less than 2.4 km) than by public bikes (2.7 km) and especially by personal bicycle (3.6 km), which demonstrates a less wide range of distances for private scooters (Richer 2021). The same is observed

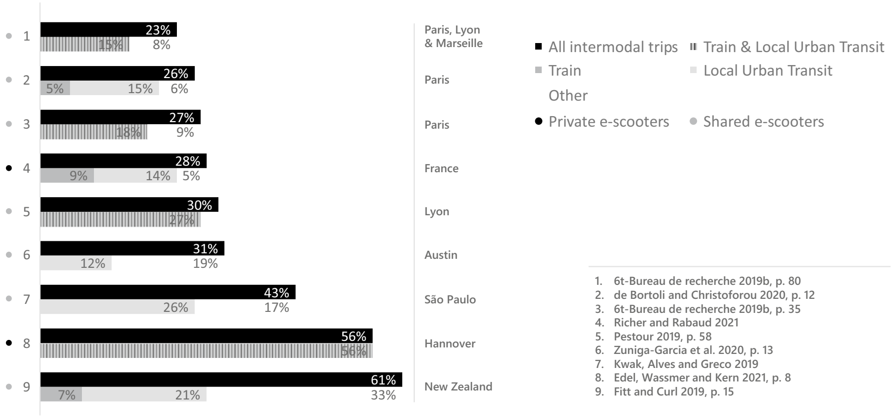


Fig. 7 Share and types of intermodal trips by e-scooter. Sources: References, Source: authors, 2022

for e-scooter services with the 75th percentile being less than 2.2 km (Mathew et al. 2019, p. 45), although pricing may be limiting the distances travelled over long distances.

Regarding the distance covered by intermodal shared e-scooter trips in Paris, Lyon and Marseille, 6t-Bureau de recherche (2019b, p. 79) estimates that these daily trips and all daily routes are shorter than the average time–distance: these rides lasted 16.5 min or an approximate distance of 4 km.

2.4 Scooters combined with transit

Various studies have identified the characteristics of scooter-and-ride practises. This part takes a closer look at the role of intermodality in the last scooter trips. Figure 7 shows a trend of around one third of scooter used for access or egress trip chains. There is also a clear distinction in the type of combination depending on the area.

In France, trips combining a scooter with another mode account for 23% (6t-Bureau de recherche 2019b, p. 80), 26% (de Bortoli and Christoforou 2020, p. 12); 27% (6t-Bureau de recherche 2019a, p. 35); 30% (Pestour 2019, p. 58) of total shared scooter trips; and 28% for the personal device (Richer 2021). In Hannover (Germany), five of the nine commuters using a personal e-scooter linked it to public transport (Edel et al. 2021, p. 8). In Europe, intermodal trips including a scooter are mainly driven by public transport, accounting for around 70%.

By contrast, Austin, São Paulo and New Zealand have rates mainly marked by their complementarity with private cars: respectively at 31% (Zuniga-Garcia and Machemehl 2020, p. 13); 43% (Kwak et al. 2019); and 61% (Fitt and Curl 2019, p. 15).

Therefore, between a quarter and a fifth of standing scooter trips in France are combined with public transport, notably the metro and train. A multiple choice questionnaire shows that 43% of standing scooter riders associate this vehicle with the metro, 40% with the bus, 22% with the train, and 17% with the tram in Oslo

(Fearnley et al. 2020, p. 25). For unmotorized scooters in Stuttgart, 25% of interviewees connect it with the tram and the bus; and 17% with the train (Zirn et al. 2018, p. 4). In Paris, 74% of shared e-scooters, bicycles, and mopeds users have already linked one of these modes to the metro, 33% to the bus, 29% to the suburban trains (RER) and 20% to the tramway (Apur 2020, p. 60).

Beyond the last ride, a large proportion of users sometimes or often use scooters to reach a public transport station. In the United States, one-third of users usually connect a free-floating e-scooter with public transport (NACTO 2019, p. 9). This share is twice in Paris, where 70% of *Lime* users have made at least one intermodal trip in the previous month (Lime 2019, p. 5) and 60% of *Voi* users sometimes connect e-scooters with public transport (Møller et al. 2020, p. 12). Each month in the period from March to November 2021, between 43 and 50% of privately owned standing scooter and solowheel users in France switch between modes during a same trip (Mobiprox 2021).

3 Methods

The literature review on the use of scooters, for all forms of journeys, revealed several descriptions depending on the type of scooter and the geographical areas. With regard to personal scooters, the vast majority of users are young men who use it at least once a week, particularly to go to work or school. The distance covered using this micromobility device is estimated to be around 1.5 km, although this is influenced by trip purpose and by urban surrounding. These findings provide a baseline for this evidence-based research, which attempts to better understand the type of use and profile of public transport passengers using a private scooter in France.

3.1 Objective

This paper aims to achieve the following objectives with a secondary analysis of a survey data, property of SNCF Réseau, French national public rail network manager.

1. Identify and quantify transit passengers' basic travel characteristics and mode shares for rail station access and egress trips;
2. Understand the comparative advantages of intermodal practices related to the standing scooter, including what links and differentiates it from the bicycle and the car;
3. Locate the train station accessibility by scooter where micromobility-friendly development recommendations can be made.

3.2 Survey protocol

This questionnaire was carried out as part of the studies prior to the public utility enquiry for the transport project "Ligne Nouvelle Provence Côte d'Azur" (LNPCA). This project aims to create three metropolitan express networks in the conurbations

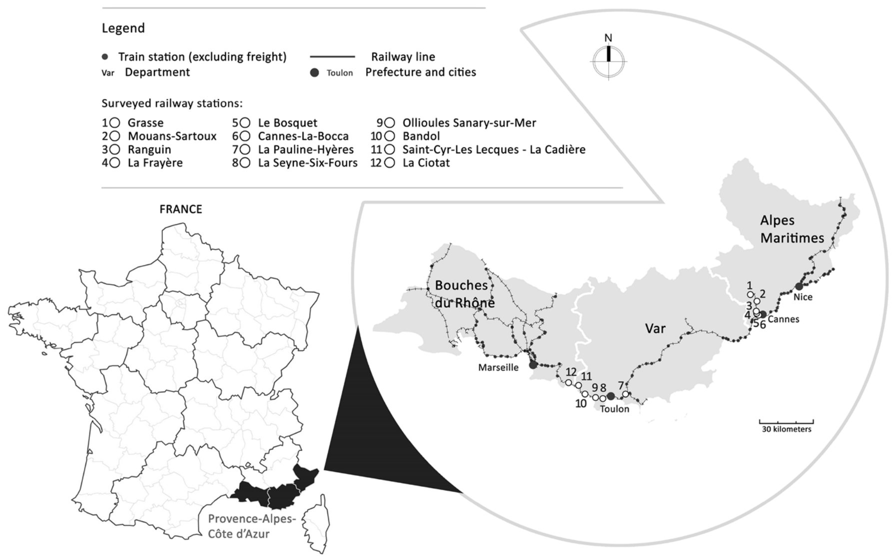


Fig. 8 The study perimeter of the twelve railway stations surveyed in the Provence-Alpes-Côte d'Azur region (PACA). Sources: Geo.data.gouv.fr, Source: authors, 2022

of Aix-Marseille, Toulon and the Côte d'Azur, to improve rail links between the three metropolises (SNCF Réseau n.d.).

The face-to-face questionnaires were conducted by interviewing individuals going to the station, filtering out train passengers. It was conducted a Tuesday or a Thursday over a period from late September to early October 2020, excluding school holidays. These dates are part of a context linked to the COVID-19 health crisis and correspond to the period of free movement after the end of the first generalized lockdown on 11 May 2020, and shortly before the implementation of the second national lockdown on 29 October 2020.

This station-based survey collected information on the age and gender of passengers, travel frequency and purpose, the municipality (or even the street) of trip origin, the destination station, transfer modes as well as the effects produced by the pandemic.

Twelve railway stations in Provence Alpes Côte d'Azur region were surveyed to investigate the access and egress characteristics of train passengers. Namely, the stations of: Grasse (1), Mouans-Sartoux (2), Ranguin (3), La Frayère (4), Le Bosquet (5), and Cannes-La-Bocca (6) in the Alpes-Maritimes department; La Pauline-Hyères (7), La Seyne-Six-Fours (8), Ollioules—Sanary-sur-Mer (9), Bandol (10), and Saint-Cyr-Les Lecques—La Cadière (11) in the Var department; and La Ciotat (12) in the Bouches-du-Rhône department (Fig. 8).

3.3 Description of the study area

The twelve locations studied have similarities in that none benefit or operate free-floating scooter service, assuming that all the scooters observed in the survey are

Table 2 Description of the survey site for each railway station

Station patronage (2019)*	Station number	Railway station	Proportion of electric scooters	Scooter rental scheme	Nearby cycle facilities**	Modal share: Scoot-and-ride	Modal share: Bike-and-ride
340,736	1	Grasse	?	No	Parking and paths	0,30%	0,30%
165,696	2	Mouans-Sartoux	100%	No	Parking and paths	2,80%	4,50%
76,307	3	Ranguin	60%	No	Paths	0%	0%
84,814	4	La Frayère	60%	No	No	1,10%	1,70%
85,092	5	Le Bosquet	?	No	No	3,60%	1,50%
212,472	6	Cannes-la-Bocca	100%	No	Parking	3,60%	3,60%
119,168	7	La Pauline-Hyères	90%	No	Paths	4,50%	5,60%
320,849	8	La Seyne-Six-Fours	90%	No	No	3,90%	6,30%
359,553	9	Ollioules Sanary-sur-Mer	?	No	No	2,90%	5,90%
324,916	10	Bandol	?	No	No	0,80%	1,70%
339,760	11	Saint-Cyr-Les Lecques - La Cadière	100%	No	No	2,60%	3,40%
539,722	12	La Ciotat	100%	No	Parking	1,10%	4,60%

Sources: *SNCF.com/explore/dataset/frequentation-gares (2019), **OpenStreetMap (2021), Source: authors, 2022

owned by the user or borrowed for a long period of time. Similarly, the type of scooter identified varies according to the stations studied, although the trend is for electric scooters to predominate (Table 2).

It is also relevant to note that the stations are not all integrated into the same urban context and do not all have the same size, capacity or quality of rail service. In addition, it can be assumed that the railway station areas are relatively poorly designed for cyclists and pedestrians, even for the busiest stations even though regional trains have facilities to accommodate bicycles and other micromobility for free.

The data analysis considers these twelve sites before focusing on a single case study to illustrate our arguments. In view of this, the Mouans-Sartoux station (2) attracted our attention for several aspects that ensure a comprehensive diagnosis:

- The station is located in the commune of Mouans-Sartoux in the Alpes-Maritimes department, with 10,000 inhabitants in 2018 and a population density of 733 per km^2 compared to 979 in Bandol, with 8000 inhabitants (Insee 2021). It is located about 10 km from Grasse and Cannes.
- This train station, part of the Grasse–Cannes–La Bocca railway axis, registered 120,000 passengers in 2016 before rising to 160,000 users in 2019 (SNCF 2018).
- As part of the reopening of the railway line in 2004, four stops were put into service, including the one at Mouans-Sartoux. The PACA Region and the Pôle Azur Provence Agglomeration Community have restored the original station with a waiting room, ticket offices and information facilities (Nice Premium 2011).
- The surroundings of the station are supplied with dedicated routes, car park facilities and one public bicycle storage, giving a total of 34 available spaces including the 10 "*boxcyclettes*" (OpenStreetMap 2021). The terminal is also bordered by a bus line to Grasse, around 290 free car parking spaces, dedicated carpooling spots and a park-and-ride facility to be opened in 2021 (Olivier 2021; OpenStreetMap 2021).

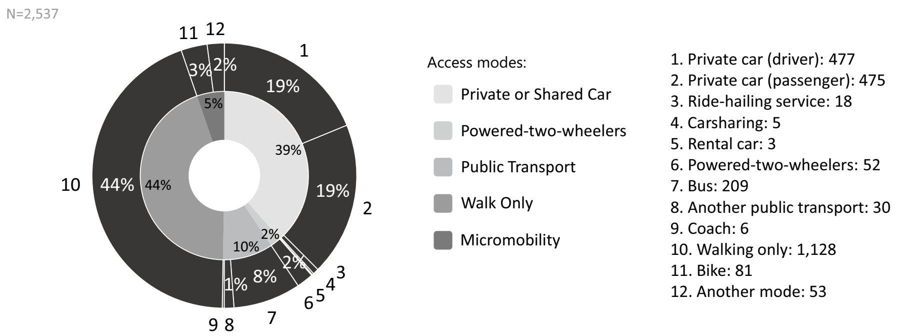


Fig. 9 Modal share and number of respondents by access mode. Source: authors, 2022

- Micromobility's modal share for access is relatively in line with the general average of the survey, standing at 2.80% for the standing vehicle and 4.50% for the bicycle (all types).
- The station has the benefit of capturing only surveyed passengers with electric scooters, allowing for a more in-depth insight into this emerging mode (Table 2).

It is relevant to note that Mouans-Sartoux city was evaluated by 90 of its inhabitants in the context of the French Cycling Barometer in 2019. The territory then recorded a positive score of 3.69/6—against an average of 2.75/6 for cities with less than 20,000 inhabitants and 2.57/6 for the 16 ranked cities of the department—thanks in particular to the comfort, safety, urban design and the public efforts made by the municipality. Between the last two editions of 2017 and 2019, the cycling situation has improved for 70% of respondents (FUB 2019).

3.4 Sample description

The study interviewed a total of 2537 passengers. To the question, "How did you get from your place of departure to this station" 53 of them replied that they had accessed the station using "another mode" = such as "scooter, skateboard, hoverboard, etc.". It is this sub-category of the 53 passengers that will be analysed in this article.

Among the travellers accessing one of the surveyed stations, 44% walked, 39% used a private or shared car, 10% travelled by public transport, 5% by micromobility (bike, scooter, skateboard, hoverboard, etc.), and 2% by powered-two-wheelers (motorbike, motorcycle, etc.) (Fig. 9).

It should be noted that observations made in parallel with the administration of the survey show that almost all the passengers interviewed who stated that they had accessed a station "with another mode (scooter, skateboard, hoverboard, etc.)" had indeed used a scooter. However, the standing scooter riders investigated were not categorized by type of scooter, i.e. whether it was a mechanical or electric scooter. There is no match in the entries between the observations made across electric and push and the results for each individual. In the following, we consider that these

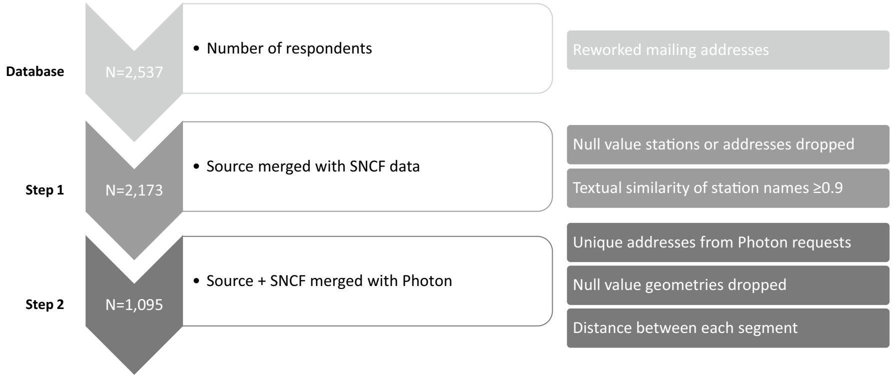


Fig. 10 Geocoding methodology for addresses. Source: authors, 2022

travellers constitute the sub-sample of travellers accessing a station by scooter. Thus, it can be considered that 2.09% of the surveyed travelling to one of the railway stations used a standing scooter, which is higher than those observed in the previous literature review.

3.5 Geographical analysis method

A spatial analysis of the data collected in the case study supplements the statistical results to confront scooter trips and other access modes with the urban environment. The departure and destination stations were requested in the questionnaire, together with the street and municipality of origin. However, the precise location of the destination of the trip was not collected during the survey.

To map the origin and destination flows, we geocoded the stages of each respondent's journey according to the mode to access the train station. The geocoding procedure depends on a multistep approach (Fig. 10). First, to standardize the names of the stations and obtain their geolocation, we extracted the SNCF database of stations with their geolocation. We merged the database with the SNCF Open Data using a Python code which applies a textual filter on the headings of the origin and destination stations (1). Missing names in the survey results were compared manually by querying the SNCF API to obtain more conclusive results and to correct some names. The spatial data are taken from *OpenStreetMap* (OSM)[2] running *Photon*[3] to carry out reproducible and open access work. We request with the *Photon* tool to generate single addresses that were georeferenced and allocated to each row (2).

In more detail, the first step was to improve the quality of the stations and street mailing addresses previously reworked by the owner of the database, with a Python code (using a "*SequenceMatcher*"). This program has resulted in the harmonization

[2] ©OpenStreetMap contributors (cf. https://www.openstreetmap.org/copyright) / OpenStreetMap: https://www.openstreetmap.org#map=19/43.62020/6.97455.

[3] Photon, Apache Licence, Version 2.0, GitHub: https://github.com/komoot/photon.

of station names to get better matches, and the implementation of a textual similarity index between the registered stations and the Open Data list[4] (with a limit set at 0.9, on a scale from 0 to 1.0).

The second part of the process enabled latitude and longitude coordinates to be assigned to the locations, while minimizing the approximations of the titles. To match the OSM database, the Python code queried *Photon* which provided exact or similar addresses with geographical coordinates. Then, we obtained unique addresses identified and matched with survey data (with a textual similarity above or equal to 0.9) to combine names and spatial coordinates. This approach made it possible to calculate the straight line and travel distances (taking the shortest route on roads) for both access[5] and train trips.[6]

The determination of the geographical coordinates of the places of origin (address number, street and municipality), the departure and arrival stations and the municipalities of destination guarantee GIS-based analysis on *QGIS*.[7]

Travel time, which was not recorded in the questionnaire, was also estimated to compare the efficiency of this modal combination with private car. It is important to note that this predicted time only takes into account the movement itself, excluding the additional time required for preparation, congestion, parking, or waiting time before reaching the station. This bias affects all modal chains, albeit non-uniformly, which allows for a reasonable comparison of trip duration across mode combinations.

In sum, the following statistical analysis is based on the 2537 responses to the questionnaire, while the spatial analysis of the data is based on 1095 location-based journeys.

4 Results

In this section, we will focus on the main findings of the station survey regarding the profile and practices of scooter users in combination with train, i.e. 2.09% of passengers surveyed. It should be pointed out that this share varies significantly depending on the twelve stations studied and that it would seem that the higher the modal share of bike-and-ride, the higher the share of scoot-and-ride (Table 2).

4.1 Socio-demographic characteristics of scoot-and-ride travelers

Individuals were interviewed about their age and gender, which could then be categorized by transfer mode.

Other things being equal, there is an over-representation of 18–34 among passengers accessing a station by scooter (Fig. 11). Compared to all modes, the majority

[4] SNCF Open Data: https://ressources.data.sncf.com/explore/.

[5] ©OpenRouteService.org by HeiGIT (cf. https://openrouteservice.org/terms-of-service/).

[6] SNCF route planner: https://www.sncf.com/fr.

[7] QGIS: https://www.qgis.org/en/site/.

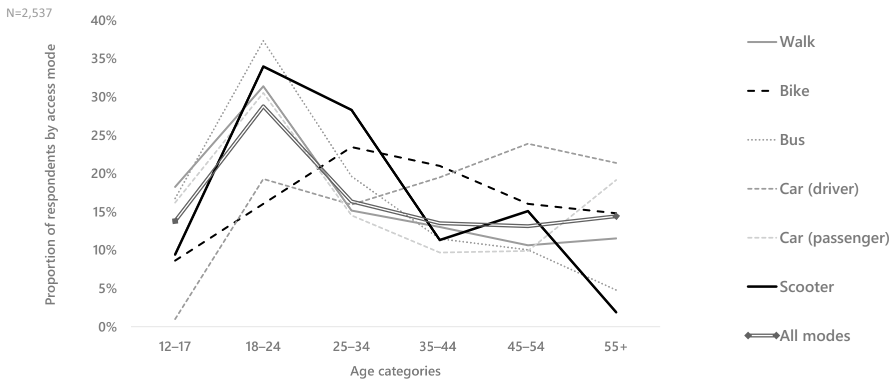


Fig. 11 Age by feeder mode. Source: authors, 2022

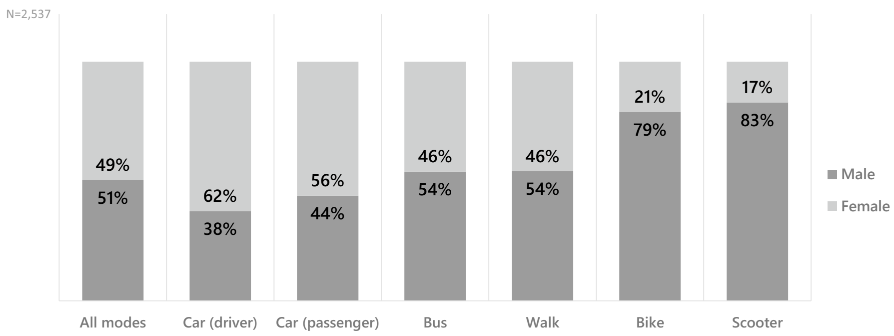


Fig. 12 Gender distribution by feeder mode. Source: authors, 2022

age category of 18–24 is estimated at 29% as against 34% for intermodal scooter riders. These social disparities are more significant for the next category of 25–34 representing 16% of all passengers as opposed to 28% for scooter riders. Conversely, the 12–17 and over-55 age groups are less important in the distribution of intermodal scooter use by age: the youngest age group accounts for only 9% compared to 14%, and the other age range for 2% compared to 14% on average. We can also point out that a less pronounced increase of scoot-and-ride users stands out: the 45–54 age group at 15% versus 13%. We can also see that the age-related characteristics of combined scooter users differ significantly from passengers surveyed accessing a station by bicycle. In relation to the age classes targeted by scooter, the modal share of intermodal cycling is more concentrated among the over-35s, and particularly among adults 35–44 (21%), 45–54 (16%) and the over-55s (15%).

The socio-demographic features of intermodal trips by scooter are reflected in significant gender inequalities. Although the sample achieved a balance of 51% men and 49% women for all access modes, 83% of the scooter users were men and only 17% were women (Fig. 12). These gender disparities are almost unchanged for

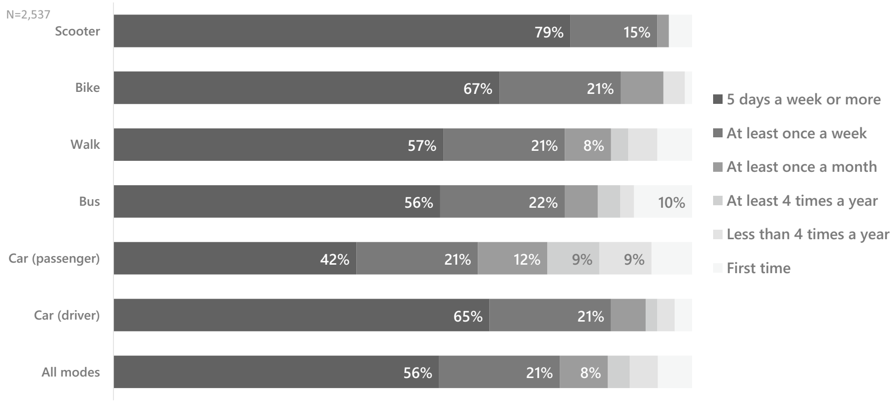


Fig. 13 Travel frequency. Source: authors, 2022

cycling (79% men), while women are over-represented among car drivers (62%). Only walking (54% men), the bus (54% men) and car passengers (56% women) are the least discriminating feeder modes to access one of the surveyed stations.

4.2 Mobility behaviour by combining train and scooter

Passengers were also surveyed on their mobility behaviour, i.e. travel frequency and purpose, as well as the type of transit access then egress mode along the intermodal trip.

Personal scooter is a combined mode used much more frequently than all other modes revealing a specific use of this micromobility, as shown in Fig. 13. 79% of surveyed use a scooter as a feeder at least five days a week, whereas only half (56%) do so on average. Intermodal and daily trips by scooter differ from bicycle (67%) and car as a driver (65%), and more clearly from walking (57%), bus (56%), and car as a passenger (42%). In aggregate, almost all (94%) of the respondents use their scooters at least once a week to reach a station, compared to three quarters (77%) for all modes. The shares decrease to 88% for cycling, 86% for driving, 78% for walking and bus, and 63% for driving as a passenger.

The frequency of train use has remained broadly the same since the start of the COVID-19 health crisis, for 63% of passengers and 58% of scooter users. However, 31% of new passengers and 28% of standing e-scooter users had not previously used the train before the pandemic, while 6% (overall) and 4% (scooter travellers) of them are using the train for the first time. It should be noted that 9% of scooter passengers say that they have increased their train use since the health crisis.

As regards trip purpose, 81% of the rail passengers accessing a station by scooter commuted, including 55% to work and 26% to study. This figure should be seen in the context of all modes with the train being distributed between working (37%), studying (31%) and leisure (20%). Commuting share by scooter is similar to purposes observed for cycling (80%) and car driving (82%), but with a higher proportion of students by scooter (Fig. 14). In contrast, the share of trips made by scooter

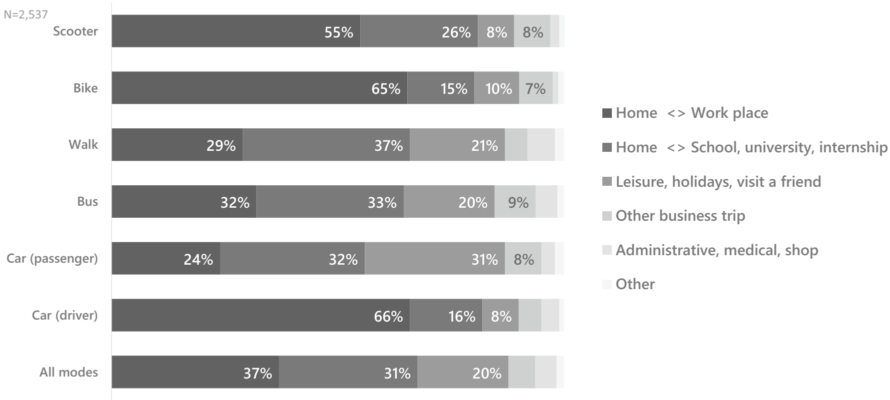
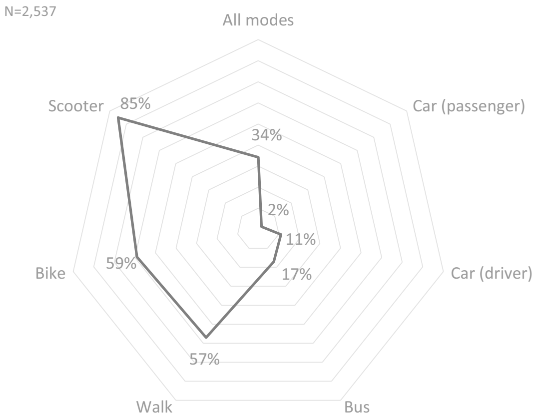


Fig. 14 Trip purpose by feeder mode. Source: authors, 2022

Fig. 15 The proportion of passengers using the same mode for transit access and egress. Source: authors, 2022



and train for leisure purposes decreases to 8%, as do car drivers (8%) and cyclists (10%).

To get an overview of intermodal trips, the survey sought to measure the proportion of passengers using the same mode for transit access and egress. Results clearly show that a very large majority (85%) of rail passengers use a scooter both before and after their train ride, as opposed to only 34% of all respondents. Figure 15 illustrates that several transfer modes are in fact not often used at both ends of the rail trip, such as car passengers (2%) and drivers (11%) or bus users (17%). The values for cycling (59%) and walking (57%) tend to be close to those for the standing scooter.

4.3 Distances covered to reach stations

The feeder trip distances were estimated for 46 of the 53 respondents accessing one of the twelve stations by scooter, according to the location of their residence. The

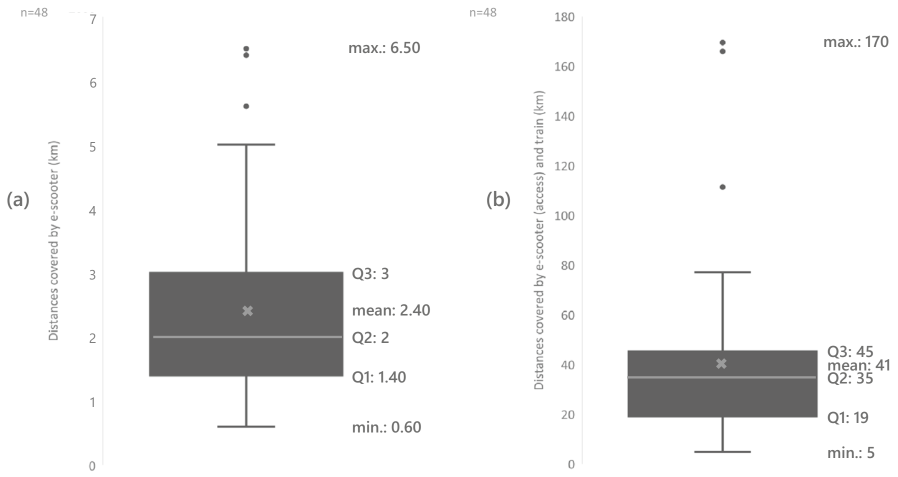


Fig. 16 Distances travelled by combined e-scooter and train passengers. **a** The average distance (in kilometres) covered to reach a station by e-scooter. **b** The average distance (in kilometres) covered for access and train segments. Source: authors, 2022

average distance is 2.4 km, as shown in Fig. 16a. The results show that for every 100 intermodal users by scooter, 75 trips are longer than 1.4 km, 50 than 2 km, and 25 than 3 km. Based on the predicted travel times by bicycle based on the *OpenRouteService* route planner, access trips take approximately 10.6 min. This figure is coherent with the widely used value of 10 min for the walkable radius around stations (Bertolini and Spit 1998).

These distances travelled by scooter are higher than the average feeder trip, regardless of mode, which is 1.70 km (0.87 km when considering the median).

The segment of the intermodal chain by train and scooter covers an average of 40.5 km, as shown in Fig. 16b. The median access and train route is 35 km.

Thus, the scooter seems to provide only a 6% coverage of the distance trip (without considering the egress segment from the station), whereas these first kilometres correspond to a quarter of the time spent on these trips.

The study aims to compare the benefits of standing scooters combined with the train, as opposed to an entirely car-oriented use, so as to determine the modal shift potential of this practice from private car. The data analysis examines the attractiveness of the scooter and train combination by measuring travel time against a trip that would have been made by car (Fig. 17).

The estimated times by scooter and train to the destination station appear to be 9.8 min longer on average. This means that intermodal trips generally last more than 45.1 min, versus 35.3 min for a planned trip by car, regardless of parking and urban congestion times for the latter.

In the 46 scoot-and-ride trips surveyed, the average duration of the trips is 22% longer than in a perfect scenario by car. However, it appears that this negative balance is prevalent among scoot-and-ride trips exceeding 20 km (Fig. 18). Among the nine trips that are characterized by a positive balance, no potential time savings

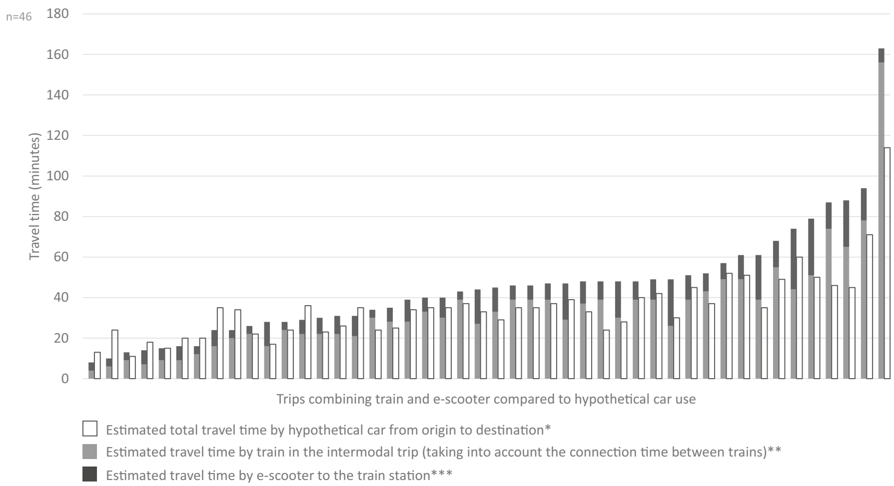


Fig. 17 Estimated travel time by e-scooter and train relative to the assumed time by car. Sources: *OpenStreetMap (2021), **SNCF (2021), ***OpenRouteService (2021), Source: authors, 2022

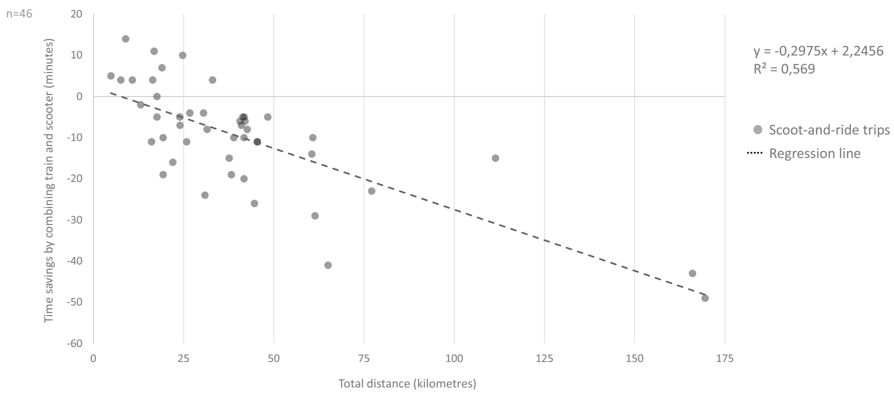


Fig. 18 Linear regression of door-to-door time saving by train with e-scooter on theoretical use of car. Source: authors, 2022

could be identified beyond the 33 km threshold. On the contrary, the most significant differences in favour of the car (i.e. between − 40 and − 50 min) are mainly observed above the median distance (41.7; 44.6; 61.4; 65; 166 km). Within the scope of the urban area accessible by regional train (TER), 23 of the 46 intermodal trips surveyed do not exceed 33 km. It transpires that 10 of them compete with the car, even in an unconstrained environment. Taking into account these 23 journeys, i.e. half of the sample, the average time balance is in favour of the e-scooter and TER mix, saving 3.22% of time compared to private car. It should be noted that this graph showing the comparative saved times according to two modal choices cannot be generalised. As the results of the regression are significantly dependent on the

Fig. 19 Map of the first segments of the intermodal chain with e-scooter or bicycle to Mouans-Sartoux station. Source: authors, 2022

speed of the trains, it requires the integration of future lines such as the existing and future high-speed train network (TGV) which could compete strongly with the use of the car over longer distances.

4.4 Focus on the Mouans-Sartoux station

Once the characteristics of the intermodal trips and the users are established, it is meaningful to analyse a station in more detail in order to better understand the effects of these mobility practices on the radius of a station area. To this end, we will consider Mouans-Sartoux station (2), which is located in a small and dense town of 10,000 inhabitants.

By plotting the origin locations of passengers who have used a scooter or a bicycle to reach the train station, hypothetical routes have been mapped out (Fig. 19) between the two places based on the shortest route (excluding traffic areas restricted).

It appears that the median distances covered by the e-scooter are 1.5 km and 3.6 km for the bicycle. Between these micromobilities we find the private car for passengers with a range of 3.2 km. Lastly, walking reaches a 700-m median around the station.

The spatial analysis of Mouans-Sartoux station investigates the urban environment around passengers who have chosen to use a scooter or a traditional, folding

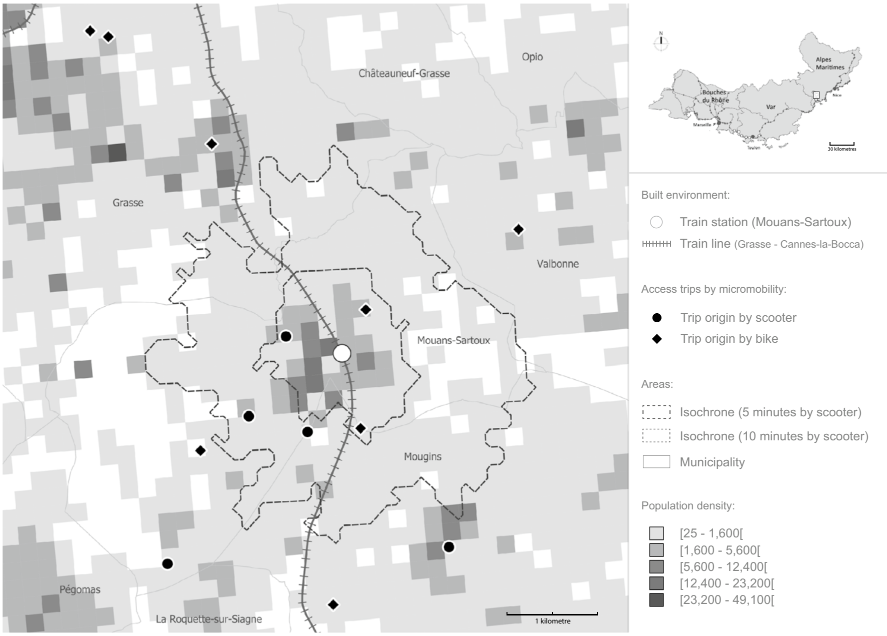


Fig. 20 Population distribution around Mouans-Sartoux station. Sources: Insee (2019), authors, 2022

or electric bike to get to catch their train. By measuring the density of inhabitants for each 200 × 200 m grid,[8] we infer that scooter users are more likely to start from a relatively dense place in relation to the average population distribution of the commune, whereas cyclists are more likely to come from less dense areas (Fig. 20).

5 Discussion

The main results obtained from the analysis of this survey, collected in twelve stations in the Provence-Alpes-Côte d'Azur region, show that the use of scooters in combination with the train is not marginal, despite its novelty in the modal range of options. Modal share corresponds to that of motorbikes and is almost equal to bicycles. This indicator which amounts to 2.09% is much higher than the 0.8% and 1.25% recorded by Gioria (2016, p. 14) and Enov (2021, p. 18) revealing the rise of this transfer mode, particularly with regard to the e-scooter. Following the COVID-19 health crisis, the growing standing scooter modal share in association with the train resonates with the significant increase in e-scooter sales recorded in France (FP2M and SML 2021). More broadly, this could be explained by the resilience in walking and cycling (Héran 2020).

[8] Insee: https://www.insee.fr/fr.

The upward trend in these statistics could be explained by the development of the electric scooters, as shown by the high proportion (approximately 90%) of this motorized device through this survey. The importance of the electric motor in the combined scooter differs from the bicycle which remains predominantly traditional, as the above-mentioned report demonstrates, given a ratio of 0.20 for the intermodal e-bike compared to 0.58 for the e-scooter (Enov 2021, p. 17).

It can be deduced that the prevalence of this type of scooter that at least partly supports the trips' range, reaching more than 2 km. It can be associated with 3 km station radius by driving defined in French territorial engineering literature (Hasiak and Bodard 2018, p. 3). Regardless of the mode, this distance exceeds the average distance made to reach one of the surveyed stations, including when active modes are omitted. Similarly, it was seen that scooter achieves large areas over 40 km, as a result of its combination with the train. These results echo studies conducted by Rabaud and Richer (2019, p. 7) who evaluate the effective distance by scooter to be roughly 23 km in France, as well as by Edel, Wassmer, and Kern (2021, p. 8) who note that 44% cover more than 20 km in Hannover (Germany). The greater distance covered by bike to reach the rail station is found in several studies such as BiTiBi (2017, p. 20; 28)'s study which estimates the access trip to be 4 km, for a total of 35 km in Belgium and Liverpool.

It has been seen that a quarter of the time spent in the intermodal trip (off egress) depends on the first mile stage by scooter, supporting the portion identified by Krygsman, Dijst, and Arentze (2004, p. 268). The average access time by scooter is about 10 min, while Enov (2021, p. 20) measured 15 min for all modes considered in three major railway stations in the country. Although this intermodal practice seems to overcome both the short range of the scooter and the fixed route nature of the train, time required for these trips appears to be not competitive with a monomodal use of the private car in regional city fringes (considering the absence of parking time and urban congestion). This differs from the Schlueter Langdon and Oehrlein (2021, p. 9)'s model illustrating that the integration of micromobility with public transport is faster than the car. A possible explanation for this might be that the methodological approach in this paper is not sufficiently complex, and the case study is located in a sparsely populated area beyond the city limits. The variations based on urban forms have been taken into account by Ensor, Maxwell, and Bruce (2021, p. 69) who predict a 1% reduction in car use in New Zealand's fringe areas, compared to 3% in the major city inners, in the scenario of substantial availability of shared and owned micromobility. These calculations need to be qualified in terms of time and congestion conditions, as indicated by McKenzie (2019b, p. 9)'s research which shows that ride-hailing is faster than scooter services for the majority of the day, apart from during weekday commuting hours.

In contrast to the car, scooter origin points were mostly observed in relatively dense areas in Mouans-Sartoux, despite the absence of cycle routes. This result may suggest that the use of scooters in dense neighbourhoods may be explained by parking and traffic constraints that encourage the use of alternatives to access the station. This hypothesis is in line with Smith and Schwieterman (2018, p. 9)'s findings that most shared e-scooters are time-competitive with the car, between 0.8 and 3.2 km, in Chicago's parking-constrained environments.

Another significant aspect of this “Hybrid Urban Mobility tool” (Kostrzewska and Macikowski 2017, p. 7) is the way this mode is used: the scooter on board the train is used on a daily basis and for work or study purposes. These characteristics can reflect the convenience provided by the scooter in combination with rail transport. The proportion of regular scooter users on the train largely exceeds the average share of daily train passengers. This outcome matches the report on French metropolitan railway stations that found twice as many frequent passengers by micromobility (Enov 2021, p. 18). The high frequency of scooter use, like cycling and driving, appears to be related to commuting. Conversely, it is interesting that few scooter users take the train for leisure or social purposes, sharply contrasting with shared e-scooters. This can be seen in the context of the 6t-Bureau de recherche (2020, p. 40) report stating that 45% of respondents would not use a scooter for shopping purposes due to theft, versus only 15% are reluctant to use this mode for commute trips.

A last distinctive feature of the scooter appears among the properties examined: unlike bicycles, nearly all passengers by scooter use this mode for both access and egress. This individual strategy can be found in the fifth category of micro-vehicle and public transport integration, outlined by Oeschger, Carroll, and Caulfield (2020, p. 3). This indicator shows that scooter has an advantage when combined, as it can be carried on trains more easily than bicycles, especially during peak periods. Standing scooter offers the advantage of reaching a wider range of destinations once the traveller have left the train. This advantage is not met in shared scooter use, with 44% of riders switching to a different mode for their return trip (6t-Bureau de recherche 2019b, p. 80).

Having discussed trip patterns, this paper addresses socio-demographic characteristics of passengers using scooters. The main type of user profile is a young man, between 18 and 34. These outcomes show a complementarity with the distribution of cycling passengers depending on age, over-represented from 35 years onwards. A question emerges with regard to the youthfulness of scooter users: is this an age-related effect or rather a generation-based effect, suggesting a gradual increase in the ageing proportion of standing scooter users with the train? Results suggest a more pronounced gender differences associated with the private scooter, as evidenced by Laa and Leth (2020, p. 3)’s online survey. This investigation reveals a travel pattern which tends to exclude a part of the public. While these findings partly jeopardize sustainable mobility goals, the scooter may be able to turn the tide. According to Héran (2020)., mention should be made of cities such Copenhagen or Strasbourg (France) which achieved gender parity by bicycle by means of a safer environment (Schepman 2014). One of the first barriers to micromobility for women is risk aversion, especially due to the volume and speed of traffic (Garrard et al. 2018, p. 57). Still, scooter users are the ones who feel most unsafe when riding, rating themselves at 6.3/10, according to a French study undertaken by Smart Mobility Lab (2020, p. 25). Broach (2016, p. 118) shows that women were around 38% less likely to cycle and that availability of low-traffic routes may be particularly important to them. In addition to this, Clewlow (2018, p. 14) argues that e-scooter could be a catalyst for attracting more women since the electric assistance makes it possible to bridge the distance for which they seem to be more sensitive while the standing position is more suitable for some types of clothing. The scooter as an intermodal device can be more gender inclusive as demonstrated by the second generational peak of users (45–54) identified in the study, reminiscent of clustering customers observed by Degele et al. (2018, p. 4) on dockless e-scooters in Germany. These two issues represent a challenge for the scooter insofar as the population is ageing and evidences that women behave more virtuously for the environment than men, except for mobility (Pech and Witkowski 2021, p. 26).

Facing with the challenges of scoot-and-ride to contribute fully to the sustainable mobility system, several recommendations intended for planners and transport operators are highlighted in this study.

To ensure a significant modal shift from car drivers to micromobility, it seems therefore necessary both to promote the use of these individual light modes and to curb the development of the car (Bruno et al. 2021, p. 530) within several-kilometre "bubbles" (Canepa 2007, p. 31). We did not observe scoot-and-ride competing directly with bike-and-ride—unveiling a similar evolution for each station—or walking on greater distances. These two small modes have the potential to substitute park-and-ride practises by sharing common features: frequency, purpose and even age for passengers. Especially since replacing "kiss and ride" by a micromobility ride means cutting the distance travelled by car by twice, for the passenger and the driver, since the driver often has to make a round trip or extend his journey by detouring to the station (Litman 2021, p. 50).

While the first proposal is the development and maintenance of cycle paths adapted to all types of micromobility (bike, scooter, skateboard, etc.), such a measure would not be effective on its own if the supply of services dedicated to the car remains abundant, notably car park. The interest of determining the average range of the scooter combined with the train is then to define the catchment area where residents could adopt this mobility solution. For land use planning stakeholders, this geographic area has become a key territorial challenge to enhance rail services use (Hasiak and Bodard 2018, p. 1). The urban design approach should be considered as one of the solutions to promote a lower carbon access to stations, as the modal shift from car to rail is significantly influenced by the connection quality to the station (Stránský 2019, p. 38). In addition to protected cycle paths separated from car traffic, volume and speed moderation and a reduction in car parking (Richer 2021), the rail operator could work on the station, platform and train conception to make access for scooters and bikes easier, since 23% of scoot-and-riders or bike-and-riders express a desire to transfer without barriers (Enov 2021, p. 35). An alternative to reducing the capacity of car parks in station areas is to manage access by allowing free parking only for commuters—who have no other access to the station than by car—to prevent them from renouncing using the train.

Focusing on the case study of Mouans-Sartoux, it was seen that the municipality is making efforts to develop cycling in the railway station area, but is also favouring the car use around. The most striking initiative is the opening of the Château de Mouans-Sartoux car park in 2021, providing 245 new free spaces to ensure train and car intermodality (Ecomnews n.d.: Olivier 2021). As is widely admitted, urban decision makers and transit agencies should invest in cycling-and-ride rather than park-and-ride facilities, for reason of space and cost-effectiveness and environment (Pucher and Buehler 2009, p. 79). Chan and Farber (2020, p. 2175) suggest that availability of car park, together with measures encouraging active transportation, may generate conflicts and deter passengers from using micromobility for access. Given the park-and-ride facility opened in August 2021, one recommendation for the Mouans-Sartoux station area would be to transform the other spaces dedicated to car parking into public spaces, on which there will be protected cycle routes favouring a greater diversity of micromobility users.

These planning recommendations would increase competitiveness of micromobility integrated with efficient train lines with respect to car travel, within extended catchment areas in less dense areas, as CPB (2020, p. 63) points out.

6 Conclusion

In this study, the secondary analysis of a survey conducted in twelve French train stations, between the first and second lockdown measures due to the COVID-19 health crisis, examines in more detail the usage patterns and socio-demographic characteristics of the scooter integrated in an intermodal trip. A sample of 53 passengers accessing one of the surveyed stations by scooter was analysed.

The results suggest that the use of this light vehicle contributes to enlarging service area within transit isochrones, covering a 2-km distance (11 min) at the walking and cycling interface. This means that the coverage of the scooter is 5.5 times as wide as walking. Regarding the riders, young adult men who take their scooter onboard the train both for access and egress frequently, to study or work, are overrepresented. 83% of surveyed scoot-and-ride passengers are male and 62% are between 18 and 34 years old. 79% of respondents by scooter access to the train station with at least five times a week, 81% of them were going to work or study when questioned, and a third of these commuters are students. During the same trip, the scooter is both used as an access and an egress mode for 85% of riders. It has been seen that the combination of the two modes takes place in dense areas and could be time-competitive with the car.

The main findings of this paper revisit the conventional scale of station areas based on a physical and mental boundary of 0.8 km by inviting to integrate the first- and last mile connections to public transport. Indeed, the scope of the Transit-Oriented Development (TOD) urban model in most countries corresponds to a “pedestrian pocket” around a transit stop (Calthorpe 1993) with a radius between 0.4 and 0.8 km by walk or bike. Referring to the founding principles of TOD, the synergy created by associating the use of scooters or bicycles with transit extends beyond the walkable “primary area”: riders reach the “secondary area” (Calthorpe 1993, p. 87) related to TOD which appears to cover up to 1.6 km, connecting low-density housing (Ibraeva et al. 2020, p. 112). Thus, this emerging mode represents an opportunity to strengthen the TOD model by supporting public transit and creating a pedestrian and cycling-friendly urban environment to reduce the vehicular traffic congestion. By “bursting” the TOD radii Canepa (2007, p. 34) and thereby increasing potential transit ridership, this intermodal perspective amounts to redesigning the TOD concept by integrating cycling modes, through the “Bicycle-based TOD” (B-TOD).

This implies the need for car restrictions and alternative incentives, as recommended in the case study, to encourage modal shift to rail and less energy consuming intermodal practices. To achieve this, it is essential for urban decision-makers to further redesign public spaces around stations by reducing the space occupied by car park and traffic, and by developing cycle routes. Looking at the potential virtues of this synergy, it appears that local and regional authorities could benefit from their success in achieving sustainable and socially fair development goals. Extending the railway station areas by promoting micromobility could reflect the emerging concept of the "15-minute city" (Duany and Steuteville 2021), where the combination of walking, cycling, scootering and public transport (Sadik-Kahn 2021) would ensure that most commonly-accessed services and activities can be reached within a 15-min walk or cycling ride (Moreno and Hjelm 2021).

The contributions of this work can be extended to gain a deeper understanding of intermodality associating standing scooter with rail. First, the current survey lacked the precise location of trip destination, precluding a detailed comparative analysis of the first- and last-mile by scooter. Additionally, future empirical studies should consider several indicators not addressed in relation to the scooter and public transport combination: such as distinguishing mechanical from electric scooters, users' revenues and socio-professional categories, routes used to reach their destination, modes substituted, reasons for choice mode, propensity to adopt this micro-vehicle, perception and acceptance. Future works examining the combination of scooters with urban public transport may also provide interesting results in comparison to the findings in this paper.

Several questions arise and take the form of future challenges. With a modal share of 2.09% for station access by scooter, taking this folding mode onboard trains does not seem to be an issue. However, to what extent can scooter-and-ride practices develop to a stage where their presence on trains disturbs passengers on board? Alongside this, at what point can the design of transit vehicle types becomes a limiting element in the development of scoot-and-ride? To anticipate this challenge, regional trains should integrate facilities for folded standing scooters, in the same way as bicycles. But railway stations should also provide secure parking spaces for private micromobility, especially for first- or last-mile riders, or as an alternative if the trend of scoot-and-ride practice strongly develops.

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