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► **To cite this version:**

Dylan Moïnse. Exploring the Relationship Between Perceived Bikeability and Gender-Inclusive Micromobility Usage: A Study Across 53 French Cities. 2023. halshs-04266904

**HAL Id: halshs-04266904**

**<https://shs.hal.science/halshs-04266904v1>**

Preprint submitted on 31 Oct 2023

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# Exploring the Relationship Between Perceived Bikeability and Gender-Inclusive Micromobility Usage: A Study Across 53 French Cities

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## Abstract

As the utilization of micromobility continues to experience growth and diversification, while simultaneously gaining recognition as an environmentally-friendly mode of transportation, it remains predominantly male-dominated. Recent scientific literature has emphasized the significance of strategies encompassing the entire population, revealing a strong correlation between the gender gap in cycling likelihood and the cycling levels within an area. This indirect relationship necessitates identifying the factors that promote gender-inclusive bicycle usage. Focusing on the French context, the key objectives of this empirical research are (i) measuring gender inequalities in the use of bike and emerging micromobility at the municipal level, (ii) assessing the influence of built environment and urban design on the gendered modal share of cyclists, and (iii) comparing and clustering the investigated French cities with the development of an index that takes into account gender equity, the modal share of cycling, and the perceived bikeability. By drawing from two distinct databases based on the use of micromobility and the subjective bikeability of cities and by conducting quantitative observations, this original study sheds light on the significant connection between gender-balanced cycling distribution, cycling modal share, cycling infrastructure presence and perceived bikeability. This paper concludes that encouraging women to embrace cycling is not solely dependent on achieving a critical mass of cyclists or building cycling lanes. Instead, it emphasizes the need for the development of a comprehensive 'bicycle system' that takes into account all aspects of bikeability. This innovative outcome leads to the categorization of examined cities based on the development of a gender-inclusive with cycling quality index. This exploration underscores the vital role of urban planning and offers recommendations for stakeholders regarding future policy initiatives.

*Keywords:* Bicycle, Bikeability, E-scooter, Gender, Inclusive Mobility, Micromobility

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## 1. Introduction

### 1.1. A Visible Gender Gap in Cycling

In France, environmental beliefs and lifestyle choices vary by gender. Women generally show more eco-friendly preferences across various social and geographic groups. However, when it comes to mobility, they seem less likely to adopt sustainable practices like reducing car use or opting to cycle (Pech and Witkowski 2021, p. 26). Research has noted this gender difference in cycling habits. It also highlights challenges in achieving sustainable mobility, as the only European sector where greenhouse gas emissions have increased over the last three decades, with a 33.5% rise between 1990 and 2019 (European Environment Agency 2022, p. 17), and which is embraced unequally depending on gender.

Although women make more of their daily journeys by car, they still have a lower carbon footprint than men as their journeys are generally 12% to 17% shorter, and they favor walking and public transport (Shaw et al. 2020, p. 10). These numerous motorized journeys of less than five kilometers by women, mainly due to the very heavy mental burden of managing family activities, represent an interesting potential for modal shift to cycling, provided that existing barriers are identified and deconstructed. This ambition aligns with

Goal 11.2 of the 2030 Agenda, adopted in 2015 with a set of 17 Sustainable Development Goals (SDGs), which specifically mandates that sustainable transportation systems must be designated as gender-inclusive (United Nations 2015, p. 21).

This gender gap in cycling has been observed in a myriad of studies, especially in many Western countries (Handy and Xing 2011; Codina et al. 2022, pp. 9, 7), and sharply differs from the typically higher presence of women in walking and public transportation (Pollard and Wagnild 2017, p. 8). In practice, a geographical distinction exists in the gender split of bicycle, with parity achieved by a handful of northern European countries such as the Netherlands, Denmark and Germany, which have gradually developed a bicycle culture (Nelson and Allen 1997; Pucher and Buehler 2008, p. 79). Japan also stands out as an exception with a gendered approach to cycling, much more embraced by women due to cultural norms (Lagadic 2022, p. 5). Thus, in countries and urban areas characterized by low bicycle utilization rates, scientific literature consistently concurs that men tend to cycle more than women, as observed not only in Barcelona (Codina et al. 2022, p. 7), in New Zealand (Shaw et al. 2020, p. 6), but also in the United States (Garrard, Handy, and Dill 2012, p. 217). However, the observation of these gender disparities in bicycle usage cannot simply be

ascribed to cultural differences between Nordic European and Latin countries, as argued against by Héran (2015, p. 19). According to Sayagh (2018, p. 17), these gender inequalities are more the result of characteristics associated with social norms related to mobility and public spaces, disproportionately impacting women.

Alongside the gender gap in cycling, a variety of electric micromobility options have recently emerged, both personal and shared, which seem to perpetuate or even reinforce inequalities in usage at the expense of women. Even if women have a more positive image of new micromobility in the United States (Clewlow 2018, p. 15), recent literature on these new mobility solutions shows that gender inequalities are more pronounced than for bicycles, whether for private e-scooter in Vienna (Laa and Leth 2020, p. 5) or e-scooters used when combined with train in the Provence-Alpes-Côte d'Azur French region (Moïnse et al. 2022, p. 19), with 9 out of 10 users being male.

### 1.2. *Cycling Modal Share as a Vehicle for Inequality Reduction*

To address the gender gap in cycling, an increasing body of research suggests that promoting cycling among women can be optimized both through strategies targeting the broader cycling population and women specifically (Garrard, Crawford, and Hakman 2006, p. 63). An international comparative analysis conducted by Goel et al. (2022, p. 70) highlights a significant correlation between gender-neutral cycling usage and the level of cycling across cities and countries, revealing that in countries where the cycling rate is below 7%, females are on average 50-60% less likely to cycle than males. This research has led to a clustering of surveyed countries, on one hand, regions where cycling is less popular and includes a minority of female (clusters 1 to 3), and on the other hand, geographies marked by developed and gender-balanced (clusters 4 to 5) bicycle use, including Finland, Germany, Japan, the Netherlands, and Switzerland (Goel et al. 2022, p. 75). This approach, which examines women's participation in the context of bicycle democratization, serves as an indicator of a cycling-friendly culture and environment (Garrard, Crawford, and Hakman 2006, p. 63).

However, a body of studies report contrasting findings, indicating that there are no statistically significant associations between gender and the propensity of commuters to cycle in a given area. This is evident in the case of Barcelona (Avila-Palencia et al. 2017, p. 9) or in England and Wales, where the adoption of cycling for commuting has increased without a significant enhancement in gender diversity (Aldred, Woodcock, and Goodman 2016, p. 39). This strand of research suggests that simply boosting cycling rates is insufficient to encourage women to adopt this mode of transportation. Instead, it advocates for the establishment of a cycling culture within specific contexts (Aldred and Jungnickel 2014, p. 2). To achieve this, these authors recommend considering the specific needs of underrepresented social groups, such as potential female cyclists, with a primary focus on addressing safety concerns and care-based mobility practices, which are the two

main barriers identified in the literature on gender and cycling (Ravensbergen, Buliung, and Laliberté 2019, p. 9).

### 1.3. *The Influence of Urban Environment*

While ongoing research explores the connection between walkability and gender-specific usage, a growing body of literature focusing on the urban environment in relation to gender inequality in cycling is emerging (Garrard 2021). Studies suggest that investing in a more equitable distribution of cycling infrastructure can contribute to mitigating demographic disparities in cycling (Rachele et al. 2015, p. 11). According to Pucher and Buehler (2012, pp. 2, 10), the success of countries characterized by gender-balanced bicycle usage can be attributed to the implementation of substantial pro-cycling policies that advocate for commuting cycling as a safe, appealing, and competitive mode of transportation. In a comparative study of 18 American cities, Nelson and Allen (1997, p. 79) identified a positive correlation between the density of bicycle pathways per resident and the proportion of commuters who cycle. This positive association has also been explored by Cordier (2021, p. 110), who conducted a statistical analysis correlating the modal share of cycling in seven French cities — Lyon, Villeurbanne, Lille, Roubaix, Tourcoing, Paris, and Saint-Nazaire — with the allocation of space for cycling. This study revealed that an additional 1% of cycling space in one of these cities leads to an increase of 0.56% in the cycling modal share, highlighting the benefits of expanding cycling infrastructure (Cordier 2021, p. 110).

The strong correlation between the development of cycling infrastructure and the increased adoption of cycling among women is predominantly explained by varying risk perceptions (Héran 2015; Schepman 2014, p. 187), as supported by an extensive body of literature on the subject. Consequently, safety concerns point to indirect effects of bicycle facilities on cycling participation, driven by their impact on perceptions of cycling safety (Emond, Tang, and Handy 2009, p. 22). Both male and female cyclists encounter similar challenges related to road safety, whether in Queensland, Australia (Heesch, Sahlqvist, and Garrard 2012, p. 10), or in Columbus in the United States (Akar, Fischer, and Namgung 2013, p. 355).

Nonetheless, the majority of articles investigating gender-related risk consistently conclude that female cyclists perceive safety concerns as more substantial barriers to cycling than males (Ravensbergen, Buliung, and Laliberté 2019, p. 4). Among the forty studies analyzed by Aldred, Elliott, et al. (2017, pp. 35, 49), more than half provide evidence of a stronger preference among women for separation from motorized traffic. Women who cycle appear to be more sensitive to the central safety concern emphasized by the provision of dedicated bike lanes separated from motorized traffic, as demonstrated by the results of the 2010 Women Cycling Survey in the United States (Sibley 2010, p. 11) and particularly in Baltimore (Abasahl, Kelarestaghi, and Ermagun 2018, p. 80). In fact, women exhibit a higher level of discomfort than men when cycling in mixed traffic, along with an elevated perception of risk and a decreased likelihood

of experiencing a bicycle crash, as observed in Italy (Prati et al. 2019, p. 4), Toronto in Canada (Mitra and Nash 2019, p. 7), and Minnesota in the United States (Krizek, Johnson, and Tilahun 2005, p. 36). The introduction of dedicated cycling infrastructure leads to a 4% to 6% increase in women's participation in cycling, especially on routes where more than 80% can be ridden on a protected cycling lane, in New York City in the United States (AitBihiOuali and Klingens 2022, p. 8). This divergence in risk aversion significantly influences women's choice of cycling mode (Garrard, Rose, and S. K. Lo 2008; Akar, Fischer, and Namgung 2013, pp. 57, 352), particularly within marginalized social groups such as racialized women (Lubitow, Tompkins, and Feldman 2019, p. 1189).

In addition to the increased safety concerns voiced by female cyclists, the literature highlights a second factor linked to care mobility, which is grounded in the greater household responsibilities typically assigned to women (Emond, Tang, and Handy 2009, p. 22). The 'traditional sexual division of labor' (Prati 2018, p. 2) is often cited as an explanation for women's reduced participation and their tendency to be more cautious than men when it comes to matters of health and safety (Steinbach et al. 2011, p. 21).

#### 1.4. Research Aim

In the context of the existing scientific literature on gender and cycling, this article aims to investigate the relationships between cycling modal share, bicycle-friendly environments, and women's participation in cycling using an empirical and comparative approach. In accordance with the recommendations outlined by Goel et al. (2022, p. 78), this study seeks to examine the multifaceted factors that underlie these three variables, including their connections with safety, which is inherently linked to the urban environment. However, this research strives to move beyond the oversimplified interpretation of the geographical presence of bike lanes as a comprehensive explanation for gender-related social dynamics. To achieve this, the framework adopted in this study centers on the concept of 'bikeability,' with a deliberate focus on understanding how cyclists perceive the bike-friendliness of their surroundings. This approach is taken at a time when the primary obstacles to women's cycling participation stem from factors of an individual level.

In the same way as walkability with walking, bikeability refers to the degree to which an area is conducive to safe, convenient, and enjoyable cycling transportation. It encompasses various factors that affect the ease, connectivity, and safety of cycling, making it a practical mobility for both commuting and recreational purposes. Bikeability represents an assessment of the cycling level of service in terms of the ability and experienced convenience and comfort to access diverse destinations (Lowry et al. 2012, p. 43). Neglecting subjective bikeability may exaggerate the influence of other factors (Gan et al. 2021, p. 173). This indicator is complex to define and measure objectively, therefore this concept is usually using perceived components such as accessibility,

safety, comfort, and attractiveness (Gan et al. 2021, p. 173). Bikeability can be measured by focusing on particular cycling paths, neighborhood streets, road networks (Hardinghaus et al. 2021; Lowry et al. 2012; Krenn, Oja, and Titze 2015; McNeil 2011; Wysling and Purves 2022; Schmid-Querg, Keler, and Grigoropoulos 2021, pp. 5, 44, 454, 55, 5, 6) or at a regional scale (Winters et al. 2016; Gu et al. 2018; Nielsen and Skov-Petersen 2018, pp. 4, 68, 38).

This research aims to address the following question: Are there significant relationships between gender-specific bicycle usage, the level of cycling, and perceived bikeability? To delve into this inquiry, this statistical exploration adheres to a predefined set of objectives:

1. Firstly, it seeks to quantify gender disparities in bicycle usage, as well as in emerging micromobility, utilizing a substantial sample within a specific geographical area;
2. Once gender-specific usage patterns are identified, the study will investigate whether the 'safety in numbers' influences gendered micromobility usage;
3. Following this initial analysis, an examination of perceived bikeability will be conducted as a factor that, in turn, elucidates the uneven gender distribution in micromobility usage;
4. By adopting a comparative approach, this research also seeks to characterize and rank the examined areas;
5. A final objective is to define an indicator capable of capturing the main interactions observed between the surveyed variables and gendered micromobility usage.

To address these objectives, this research will first describe the adopted methodology, involving a secondary analysis of public surveys, along with a quantitative user observation survey conducted within a case study. Subsequently, the core findings will be presented using a linear regression model, highlighting the associations between the gendered distribution of micromobility and, on one hand, the modal share of cycling, and on the other hand, perceived bikeability. The outcomes will then lead to the clustering of the analyzed areas and their ranking based on an indicator that considers the presence of women among cyclists, the widespread adoption of cycling, and the urban environment's quality. This article concludes by discussing these results, delineating certain limitations, the implications of this research, and suggesting avenues for future studies.

## 2. Materials and Methods

### 2.1. Case Study

The current study adopts the French context as its analytical framework to explore the interplay between the urban environment and gender-specific bicycle usage. The selection of this geographical setting is primarily justified by its recent commitment to promoting cycling. In recent years, France has attracted substantial attention for its burgeoning enthusiasm in encouraging cycling, particularly in the post-COVID era.

High-profile initiatives such as the transformation of iconic streets, like Paris's Rue de Rivoli (Buehler and Pucher 2021, p. 398) in 2020, serve as a compelling case in point. Furthermore, the choice of such an extensive geographical scope is driven by the desire to conduct a comparative approach across a broad spectrum of urban contexts. France's geographic diversity, encompassing cities of various sizes and contrasting climatic conditions, provides an excellent backdrop for such examination. Moreover, the insights derived from a case study in France can hold international relevance, as the lessons unearthed in the French context may find resonance in diverse settings. Lastly, the French terrain offers detailed demographic and mobility-related data, facilitating the collection and analysis of requisite information for a comprehensive exploration of gender disparities in urban bicycle usage.

In France, 24% of trips are made exclusively on foot, and 3% by bicycle. However, the use of bicycles has been increasing significantly in recent years, with a 13% increase in cycling in 2022 and a 52% increase between 2019 and 2022, mainly due to the rise of *vélotaf* (bike commuting) (Le Point 2023). While private cars dominate the daily transportation system, the adoption of bicycles is rapidly growing, with 19% of the French population reporting regular use, marking a 4% increase (IPSOS 2023, p. 4). Despite being introduced relatively recently, the modal share of privately owned e-scooters, when used in conjunction with trains, is comparable to that of bicycles in France, accounting for 2% of all train trips (Moinse et al. 2022; Gioria 2016; Enov 2021, p. 25). The substantial increase in the combination of micromobility and train travel following the COVID-19 health crisis aligns with the significant growth in e-scooter sales recorded in France (FP2M and SML 2021).

The French context provides an interesting research setting for this topic, as it is gradually witnessing the emergence of a set of pro-cycling policies at the national level. Recently, the introduction of the *Plan Vélo et Marche 2023-2027* (2023-2027 Cycling and Walking Plan) represents a significant milestone in this regard. This government-led strategy seeks to develop a 'cycling culture' (Ministère de la Transition Écologique et de la Cohésion des Territoires 2023), by annually providing cycling training to 850,000 children and by expanding cycling infrastructure. The target is to reach 100,000 kilometers of secure cycling facilities, referred to as *véloroutes* (car-free cycling paths) by 2030, a substantial increase from the current 57,000 kilometers. Simultaneously, the newly enacted 2019 *Loi d'Orientation des Mobilités* (Mobility Orientation Law, LOM), which aims for carbon neutrality by 2050, reinforces the deployment of 100,000 secure bicycle parking spaces around train stations, as well as the expansion of dedicated bicycle spaces on trains and buses.

In addition to a nationwide sampling across France, this study focuses on a more detailed level of observation by examining the Hauts-de-France region. Located in the northern part of France, the Hauts-de-France region emerged as an

administrative entity resulting from the territorial reform enacted in 2015<sup>1</sup>. By the year 2020, the region's population had stabilized at 5,997,700, representing 9.2% of the total national population, and boasting a relatively high population density of 189 inhabitants per square kilometer.

At the regional level, cycling emerges as the main commuting mode for 2.2% of all journeys, with variations ranging from 1.1% in the Oise department to 2.7% in the Nord department. This regional distribution is notably influenced by the urban scale of cities, with 'major urban centers' registering a cycling modal share of 3%, compared to 2% in 'intermediate urban centers' and 'small towns', and less than 1% in 'suburban areas' and 'rural villages' (Insee 2023). On average, 26.41% of individuals identifying cycling as their primary personal mode of transportation in Hauts-de-France are women, while women constitute the majority at 56.23% for walking. Gender-based disparities in bicycle usage are evident among the various departments within the region, with rates ranging from 25% in the Aisne department to 37% in the Nord department (Vélo & Territoires 2023). Regarding bike-friendliness, the Hauts-de-France region receives a bikeability of 2.84 out of 6, positioning it in the 9th place among the 14 regions (Caduc 2022, p. 24).

## 2.2. Datasets

The current study relies on the 2019 population census, a key dataset generated by the *Institut National de la Statistique et des Études Économiques* (National Institute of Statistics and Economic Studies, Insee), conducted every five years. Specifically, the data is derived from the 'Professional Mobilities' (MOBPro) file, which focuses on daily commuting patterns (Insee 2023). Households had the option to respond individually, either online or by completing paper questionnaires distributed via postal mail. This database provides representative information on home-to-work commutes, drawing from a sample of employed individuals over 15 living in Metropolitan France, as well as in the *Départements et Régions d'Outre-mer et Collectivités d'Outre-mer* (overseas departments, regions, and collectivities, DROM-COM), excluding Mayotte.

The census questions that define the MOBPro dataset pertain to variables associated with workplace locations at the municipal level (Q20) and the primary mode of transportation (Q22). Each individual is anonymously described according to the characteristics of their commutes, sociodemographic patterns, residential and workplace locations at the municipal level, sector of activity, housing type and mobility equipment. By incorporating the weighting factor for each individual, sample sizes ranging from 200 to 500 can be used with confidence for representative purposes (Insee 2023). Consequently, it is advisable to exercise caution when making comparisons among smaller geographical territories. Additionally, it is worth noting

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<sup>1</sup>Law No. 2015-29 of January 16, 2015, addressing regional boundaries and regional and departmental elections

that since 2015, the questionnaire has made a clear distinction between bicycles and motorized two-wheel vehicles (Razemon 2013), with the modification of Q22 that distinctly includes 'bicycles (including electrically assisted bikes)'.

The 2019 MOBPro database, covering a total of 7,932,895 individuals, encompasses several filtered variables, notably individual weight ('IPONDI'), the most frequently used primary mode of transportation for commuting ('TRANS'), place of residence ('COMMUNE'), and gender ('SEXE'). The first inclusion criterion, implemented through a series of Python codes, centers around the primary mode of transportation linked to cycling ('TRANS=3'), with the exclusion of other mobility forms, as conducted by Raux, Lamatkhonova, and Grassot (2021, p. 7). This excludes intermodal journeys where cycling serves as a secondary mode due to the statistical treatment applied<sup>2</sup> (Cerema 2020, p. 32). The survey yielded a subsample of 204,663 individuals, composed of 126,732 male cyclists and 77,931 female cyclists. Descriptive statistics reveal that merely 1.5% of women reported cycling for commuting, in contrast to 3.7% of men.

The second exclusion stage from the MOBPro database involved consolidating commuters within similar municipalities, as undertaken by Papaix, Dupont-Kieffer, and Palmier (2022, p. 259). Responses that were grouped and did not surpass the significance threshold of 200 cycling individuals were excluded, in order to maintain a greater diversity of cities. Following the application of this secondary filter, among the 10,520 cities featuring at least one cyclist in the database, 144 French cities are represented, including 128,492 cyclists, of which 76,773 are male and 51,719 are female. Among the 144 selected cities, 65 are main cities, while 79 are peripheral or center municipalities comprised within an intermunicipal entity.

The second database used to collect area-related attributes related to cycling environments is the biannual questionnaire from the 2021 *Baromètre des Villes Cyclables* (Bicycle-Friendly Cities Barometer), produced by the French *Fédération des Usagers de la Bicyclette* (Bicycle Users Federation, FUB). Deployed since 2017, this third edition assesses the bike-friendliness of cities across France by gathering feedback from cyclists and evaluating various aspects of urban cycling infrastructure, policies, and the overall cycling experience in urban areas (FUB 2021). This barometer aims to capture the overall sentiment of users in France and to create a ranking of cities based on their perceived bikeability. Today, this barometer holds a position of reference for local authorities, associations, users, and researchers. This research opted to incorporate users' perceived bikeability, recognizing

<sup>2</sup>In the majority of travel surveys in France, the hierarchy of transportation modes is typically established based on the primary mode used for intermodal journeys. The *Enquêtes Mobilité Certifiées Cerema* align with the convention set by the *Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement* (Center for Studies and Expertise on Risks, Environment, Mobility, and Urban Planning, Cerema), giving priority to urban collective modes of transport (Cerema 2020, p. 32).

that safety is a matter of both actual and subjective experienced by cyclists (Garrard, Rose, and S. K. Lo 2008, p. 57). Ma and Dill (2017, p. 303) evidenced a mismatch between objective and perceived environment regarding bikeability, notably for utilitarian bicycle use, that may due to gender tolerance for risk and measurement error in GIS-based (Geographical Information Systems) and perception-based measures.

The questionnaire was administered online and invited both cyclists and non-users to rate their experiences and provide opinions on cycling conditions. Ratings were given on a scale ranging from 1 (very unsatisfactory) to 6 (very satisfactory), across multiple categories. The various ratings assigned by each respondent result in an overall score for a city and, leading to a ranking of cities based on their perceived bike-friendliness by users. This open access questionnaire includes 26 questions related to respondents' bicycle travel experiences, organized into five distinct themes: (i) *general perception*, (ii) *safety*, (iii) *comfort*, (iv) *city's efforts*, and (v) *bike services and parking*. Based on this aggregated score, cities are classified on a scale from A+ (>4.6/6) to G (<2.3/6), ranging from 'excellent cycling conditions' to 'very unfavorable cycling conditions' (FUB 2021). According to these five main themes, the average score obtained for each city is 2.98/6 (Vermeulen and Kaouane 2022, p. 17).

The first thematic category, labeled as general perception (i), delves into a range of questions related to the pleasantness of cycling (Q14), the seamlessness of the cycling network (Q15), potential conflicts between cyclists and pedestrians (Q16), interactions with motorized vehicles (Q17), the density and speed of traffic (Q18), and the democratization of cycling usage (Q19). The second section on safety (ii) focuses on the feeling of safety while cycling (Q20), on major roads (Q21) and residential streets (Q22), while joining the neighboring cities (Q23), and crossing intersections (Q24), as well as the inclusivity for children and the elderly (Q25). The third aspect is devoted to comfort (iii) examining the quality levels associated with cycling routes (Q26), their maintenance (Q27), the presence of road signage (Q28), the provision of temporary roads during construction (Q29), and the availability of dedicated one-way cycling lanes (Q30). The fourth theme on municipal efforts (iv) scrutinizes the initiatives undertaken by the city to promote cycling (Q31), the city's communication efforts (Q32), the extent to which cyclists are integrated into discussions on mobility and urban development projects (Q33), as well as issues related to obstructive car parking (Q34). The last category revolving around services and parking (v) concentrates on the bicycle parking facilities in general (Q35), and more precisely at public transport stations (Q36), the accessibility of bicycle rental services for short-term and long-term usage (Q37), the availability of bicycle stores and repair shops (Q38), and the prevalence of bicycle theft incidents (Q39).

The survey was conducted from September 14th to November 30th, 2021, and received 277,384 responses, with 250,228 from cyclists (Vermeulen and Kaouane 2022, p. 7). It is worth noting

that only municipalities with a minimum of 50 cyclist responses were included in the rankings. As a result, this edition's ranking features a total of 1,625 French municipalities, categorized as follows: 38 major cities, 218 medium-sized cities, 353 small towns, 292 villages, 719 suburban municipalities, and 5 islands. Among the cycling respondents in the 2021 barometer, 54% identified as male, and 46% as female, without considering those who did not specify their gender. This marks a four-point increase in favor of women compared to 2019 (Vermeulen and Kaouane 2022, p. 10). By conducting an attribute join of the 144 cities with more than 200 cyclists who responded to the MOBPro database and the cities ranked in the *Baromètre des Villes Cyclistes* with at least 100 individual ratings, we identified 64 French cities for sampling. We then chose to retain only the central municipalities of the metropolitan areas within the sample, resulting in a final total of 53 cities. Therefore, the list of these 53 cities, organized by their respective regions, is as follows:

- Auvergne-Rhône-Alpes Region: Annecy, Chambéry, Clermont-Ferrand, Grenoble, Lyon, Saint-Étienne, and Valence;
- Bourgogne-Franche-Comté Region: Besançon, and Dijon;
- Bretagne Region: Brest, Lorient, Rennes, and Saint-Nazaire;
- Centre-Val de Loire Region: Orléans and Tours;
- Grand Est Region: Metz, Mulhouse, Nancy, Reims, Strasbourg, and Troyes;
- Hauts-de-France Region: Amiens, Arras, Beauvais, Douai, Dunkerque, Lille, and Valenciennes;
- Île-de-France Region: Paris;
- Normandy Region: Caen, Le Havre, and Rouen;
- Nouvelle-Aquitaine Region: Angoulême, Bayonne, Bordeaux, La Rochelle, Limoges, and Poitiers;
- Occitanie Region: Montpellier, Nîmes, Perpignan, and Toulouse;
- Pays de la Loire Region: Le Mans and Nantes;
- Provence-Alpes-Côte d'Azur Region: Aix-en-Provence, Avignon, Marseille, Nice, and Toulon;
- Réunion (Overseas Region): Saint-Denis, Saint-Paul, and Saint-Pierre.

Thanks to these two databases, we were able to characterize the 53 French cities in terms of their cycling modal share, gender distribution of cycling users, and the bike-friendliness ratings assigned to them. These variables have been enriched with data from OpenStreetMap (2023), extracted on August 21, 2023, providing access to geographical information regarding cycling infrastructure in a given city. Additionally, we have incorporated data from the *Base nationale des aménagements cyclables* (National Bicycle Infrastructure Database) created by

Vélo & Territoires (2023) and from Insee (2021)'s municipal density grid.

### 2.3. Application of Quantitative Observations

In addition to the secondary analysis of mentioned databases, this empirical research relies on the implementation of a methodology designed to capture the demographic profiles of bike and micromobility users within our specific case study, centered around the Hauts-de-France region. Given the complexity of accessing data related to emerging light mobility, such as e-scooters, and the desire to obtain a representative sample, the chosen data collection method is quantitative observation, situated at the intersection of qualitative ethnographic observation and on-site counting. As the literature suggests a connection between the presence of bike infrastructure and the gendered distribution of cycling, and recognizing the compatibility of new micromobility with public transportation (Moine et al. 2022, p. 20), we chose to focus our quantitative observation on train stations. In doing so, we aim to respect the diversity of territorial systems, both urban and suburban, present in the studied region. The interest in conducting a supplementary observation is therefore to collect a large sample of users who are using, not just bicycles, but also micromobility devices that are more difficult to identify in the context of questionnaires.

Quantitative observation involves the systematic collection of field data, employing a method meticulously tailored to a predetermined subject. This approach is constructed based on a categorization derived from an expansive set of open-ended questions (Peneff 1995, p. 134). It firmly resides within the domain of quantitative observation, enhanced by the utilization of videography techniques (Filion 2011, pp. 38, 43). This methodology is distinguished by its objective nature, guided by the principle of quantifying social phenomena. Videographic recording redefines the process of direct observation by clearly separating the initial observation phase from the coding phase, thereby mitigating specific challenges associated with fieldwork conditions (Cochoy and Calvignac 2013, p. 100). It serves as a data collection instrument that enables fine, non-participatory, and overt observation, aiming for greater systematicity in the study through the amalgamation of statistical information and visual recording (Paugam 2012; Filion 2011, p. 42). Drawing from the methodology of quantitative observation, this contribution is fundamentally inspired by previous research on the gender distribution of cycling, which was primarily grounded in field observations (Raibaud 2020) and on trips combining public transport and bike use (Sherwin et al. 2011; La Paix Puello and Geurs 2015, pp. 192, 27).

This investigation was conducted on the platforms of the surveyed railway lines with the dual objective of capturing both the access and egress trips (Enov 2021, p. 13). In total, quantitative observation was carried out at nine train stations in the Hauts-de-France region, with careful consideration given to the existing station classification in the former Picardie region (CETE Nord Picardie and DREAL Picardie 2011, pp. 2–4). Our

## HAUTS-DE-FRANCE REGION

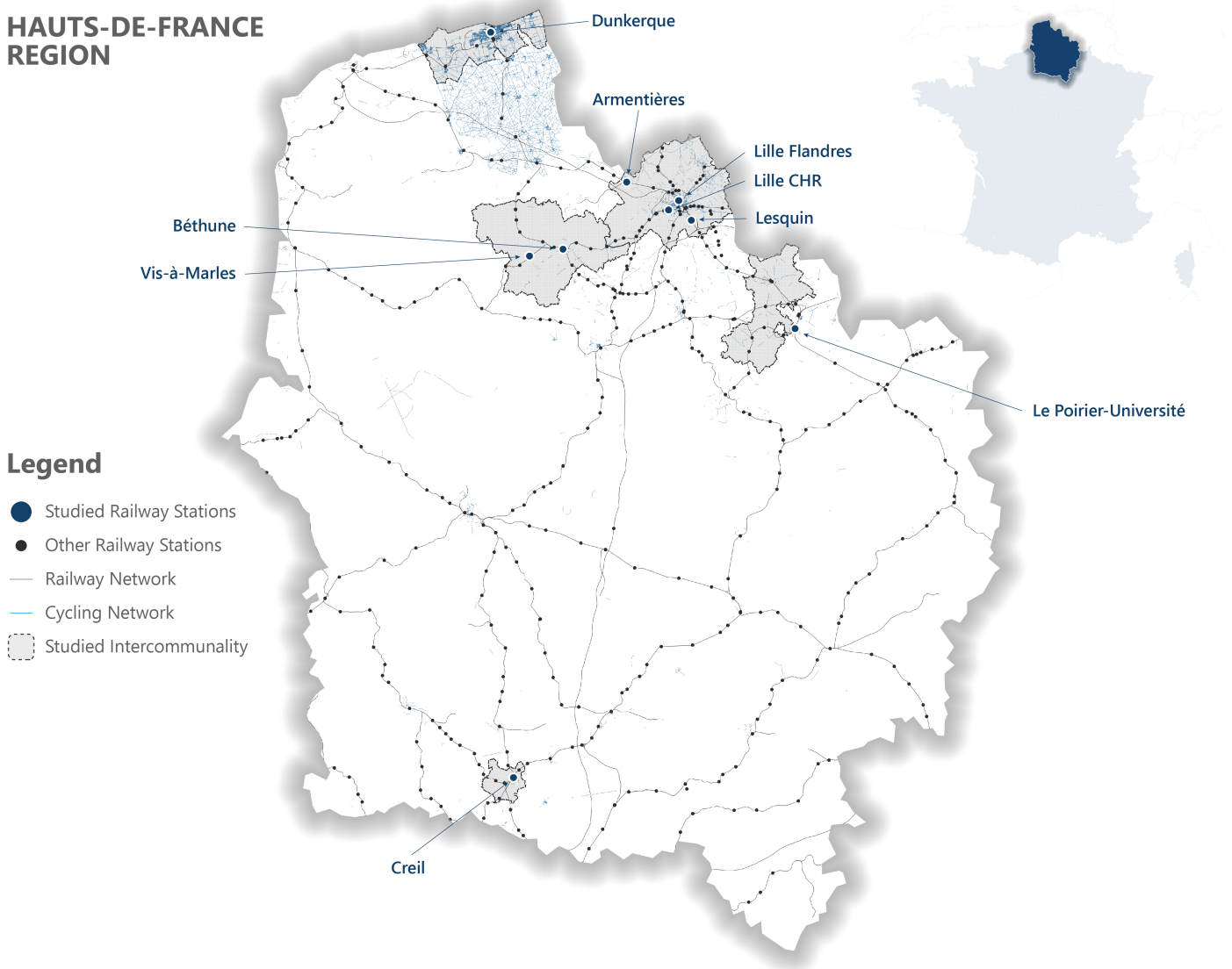


Figure 1: Location Map of the Hauts-de-France Region Case Study

Data Source: OpenStreetMap (2023)  
Realization: Author, 2023

research was centered around a selection of key stations (fig. 1), including the 'gares de p les r gionaux' (major regional hubs) such as Lille Flandres (21,992,946 passengers in 2022), Dunkerque (2,116,944), B thune (1,601,485), and Arment res (850,773), as well as the Creil (5,224,702) 'gare   rayonnement francilien' (stations oriented towards Paris), and the 'gares de rabattement sur les p les r gionaux' (feeder stations to regional hubs) like Lille CHR (312,323), Lesquin (141,025), Le Poirier-Universit  (84,268), and Vis- -Marles (17,063) (SNCF 2023).

The survey was conducted during peak hours at train stations on Tuesdays and Thursdays between the months of March and June 2022 (fig. 2). The methodological protocol involved the establishment of a coding system to characterize each

observed passenger using three variables<sup>3</sup>: values related to the observed transit (such as regional train, TER, or high-speed train, TGV) and last-mile mode of transportation (such as pedestrian, bicycle, folding bike, e-scooter, etc.), age

<sup>3</sup>It is worth noting that the observation grid, constructed from sociodemographic variables including age and gender categorization, presents limitations in direct observation. Researchers must exercise awareness and take precautions to address these limitations (Chevalier and Stenger 2018, p. 106). Furthermore, conducting research necessitates a process of 'social self-analysis' (Scarfo Ghellab 2015, p. 1), fostering reflexivity on the researcher's position within specific geographical and social contexts in relation to their personal experiences and perspectives. Subsequently, the reading and interpretation of collected data remain inherently subjective, necessitating data processing phases that include third-party verification to lend objectivity to the ethnographic perspective. In addition to these sociodemographic variables, the construction of temporal and spatial categories linked to sequencing, which entails creating a reality observed and imposed by the observer (Filion 2011, p. 39), was integrated.





Figure 2: Quantitative Observation Session on One of the Platforms at Lille Flandres Station

Photography: Author, 7 April 2022

categories, and visible gender (female, male, or undefined). The formulation of these categories was anticipated during the fieldwork and validated through an initial experimental phase ( $N = 4,924$ ). The data collection phase resulted in the accumulation of 90 hours of observation and over 33 hours of videographic recording using a portable camera<sup>4</sup>. The overall sample encompassed observations of 15,435 described passengers, along with the identification of 1,035 passengers utilizing various forms of micromobility.

The execution of the research method required the creation of a request for survey authorization, submitted to the national *SNCF Gares & Connexions* railway stations manager. Following approval, the protocol underwent further refinement through discussions, leading to the development of regulatory documents referred to *Inspections communes préalables* (ICP)<sup>5</sup>. Concurrently, a process to ensure compliance with the General Data Protection Regulation (GDPR) was initiated, in

<sup>4</sup>The equipment utilized was the *HERO10* action camera from *GoPro*. This portable device, affixed to a tripod, facilitated immersion on train platforms while delivering ultra-high-definition images at 4K resolution.

<sup>5</sup>In accordance with Article V of Decree No. 2008-244 dated March 7, 2008, *Inspections communes préalables* is a document designed to predefine

partnership with the Data Protection Officers (DPO) at Gustave Eiffel University<sup>6</sup>.

#### 2.4. Statistical Analysis

The secondary analysis involves two mobilized databases: the 2019 *MOBPro* database (Insee 2023) and the 2021 *Baromètre des Villes Cyclables* (FUB 2021), along with the quantitative observation conducted in our case study. This analysis employs descriptive statistics and a linear regression model. To achieve this, we utilize both Pearson and Spearman correlations with their P-values of significance in our statistical analysis, aiming to enhance our comprehension of the relationships and consider potential data nuances. Pearson and Spearman correlations are two widely employed techniques, used in this study for assessing the association between the gender distribution in cycling (the dependent variable) and various factors such as modal share of cycling, subjective bikeability, cycling infrastructure rate, and population density in each of the studied municipalities (independent variables). This study draws inspiration from prior academic research that employed these correlations to examine the relationships between the sociodemographic characteristics of a population and the urban environment, as conducted by Goel et al. (2022, p. 64) who investigated the connections between bicycle usage based on gender and age, and the modal share of cycling across 17 countries.

The Pearson correlation, in particular, is well-suited for detecting linear relationships between variables and relies on the covariance of the datasets, and is computed using the following formula 1 (K. Pearson et al. 1930):

$$\rho_{Pearson} = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^n (Y_i - \bar{Y})^2}} \quad (1)$$

where:

- $\rho_{Pearson}$  is the Pearson correlation coefficient;
- $X_i$  is the data points from the variable X;
- $Y_i$  is the data points from the variable Y;
- $\bar{X}$  is the mean of the variable X;
- $\bar{Y}$  is the mean of the variable Y.

Conversely, the Spearman correlation is better suited to uncover non-linear and monotonic relationships, while being

the scope of intervention of an external company during the execution of an operation, as well as to define the facilities and equipment provided to the establishment (Légifrance 2008). In the context of this survey, two joint ICPs were created at the scale of the former Nord-Pas-de-Calais and Picardie regions, involving collaboration between station managers and the researchers. These documents specified the platforms included in the observation and the placement of cameras, all while respecting passenger flows.

<sup>6</sup>Given that this data collection method involves video recording, it entails the processing of personal and sensitive data, which is subject to the legal framework for the protection of personal data, known as the General Data Protection Regulation (GDPR), as per Regulation (EU) 2016/679 of the European Parliament and of the Council dated April 27, 2016 (CNIL 2018).

less sensitive to extreme values in comparison to the former correlation. This is achieved by considering the difference between ranking within the database, and follows the [formula 2](#) (Spearman 1904):

$$\rho_{\text{Spearman}} = 1 - \frac{6 \sum_{i=1}^n d_i^2}{n(n^2 - 1)} \quad (2)$$

where:

$\rho_{\text{Spearman}}$  is the Spearman correlation coefficient;

$d_i$  is the difference between the values of ranks X and Y;

The Pearson correlation coefficient quantifies both the strength and direction of the linear association between two continuous variables. These measures operate within a scale of -1 to +1: a value of -1 signifies a perfect negative correlation (where one variable increases, the other decreases linearly), a value of +1 represents a perfect positive correlation (where one variable increases, the other also increases linearly), and a value of 0 denotes the absence of any linear correlation between the two variables.

### 3. Findings

#### 3.1. Exploration of Gendered Cycling Modal Share

The focal point of this exploration lies in the measurement of gender distribution in micromobility usage in France. Unsurprisingly, the secondary analysis of the *MOBPro Census* sheds light on a significant gender imbalance concerning commuting by bicycle. A scrutiny of the female participants in this national mobility survey reveals that they account for only 38.08% of cycling commuters in the country ([fig. 3](#)), whereas they constitute 51.60% of the French population.

Utilizing the quantitative observation conducted in the Hauts-de-France region, it is crucial to emphasize the pronounced gender gap in the intermodal use of micromobility. Female users account for slightly more than a quarter of the examined sample, underscoring this disparity. Furthermore, substantial variations emerge when considering different micromobility modes, with personal bicycles and e-scooters showing the most distinct gender inequalities, whereas a more balanced gender distribution is evident in the case of folding bikes and kick standing scooters ([fig. 3](#)).

Mirroring previous research, these descriptive statistics are consistent with the limited body of scientific literature concerning the relationship between bicycle usage and gender in France ([Gaudron-Arlon 2022](#), p. 1). In France, across all age groups, men engage in cycling nearly three times as frequently as women, while women tend to walk more than men ([Rossignol et al. 2023](#), p. 2). In the context of gender-specific private and shared bicycle usage, an analysis from [Adam \(2018\)](#) on manual counts conducted by the *Métropole de Lyon* emphasizes the substantial predominance of male cyclists, constituting 59% of the total. The 6t-Bureau de recherche

([2018](#), p. 27)'s report focusing on the profile of free-floating bicycle users in Paris corroborates these findings, with 68% being male. The development of a user typology for the *Vélo'v* bike-sharing system in Lyon, as conducted by [Vogel et al. \(2014, p. 289\)](#), unveils an unequal gender distribution that fluctuates among the four identified categories: 'Use of Heart' and 'Assiduous Users' are notably male-dominated, whereas 'Multimodal' and 'Sporadic Users' display a more even gender distribution.

A similar pattern emerges in the context of the recent rise of micromobility. When examining personal e-scooters, this trend becomes apparent, with men representing 60% of users in France, as evidenced by the consolidation of data from approximately forty certified mobility surveys conducted by [Richer \(2021\)](#). Moreover, the prevalence of male ridership, ranging from 68% to 75%, remains consistently high on dockless shared e-scooters. This holds true not only in Paris ([Apur 2020](#); 6t-Bureau de recherche [2019a](#); [Bortoli and Christoforou 2020](#), 46, 14, appendices) but also in the metropolitan areas of Paris, Lyon, and Marseille (6t-Bureau de recherche [2019b](#), p. 50). Similarly to the bike usage, it has been studied that the most frequent users of shared e-scooters are predominantly men (68%) compared to occasional users (58%) in these three French metropolitan areas (6t-Bureau de recherche [2019b](#), p. 65).

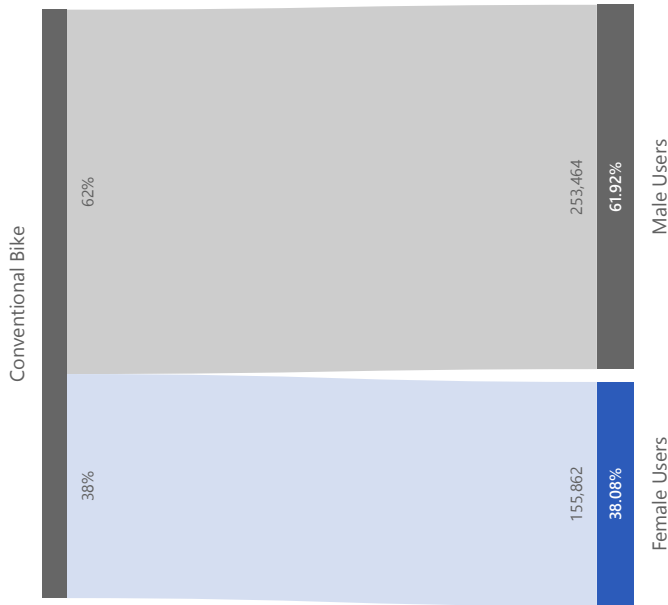
#### 3.2. The Indirect Role of Critical Mass

To juxtapose the existing literature with this investigation, which relies on the analysis of public surveys and the quantitative observation of micromobility users, the statistical evaluation attempts to elucidate the connections between the rate of female participation and the cycling modal share across 53 French cities. The calculation of a linear regression model underscores the relative strong and positive correlation between the percentage of women cycling and bicycle usage in a city center, with a coefficient of determination (denoted  $\rho_{\text{Pearson}}$ ) of 0.73 ( $P < 0.001$ ). This concept of 'safety in numbers' involves recognizing that as the number of cyclists increases in public spaces, motorists are more likely to view them as a legitimate group of road users. Consequently, motorists become more attentive to cyclists, as explained by [Oosteren and Schneider \(2021, p. 83\)](#) as the relationship between the number of cyclists and the number of casualties among cyclists involved in car accident is inverse ([Jacobsen 2003](#), p. 208).

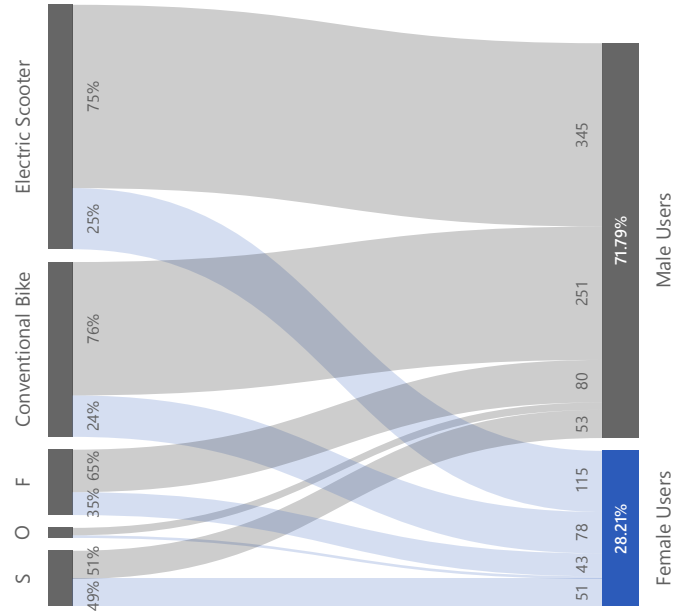
In the realm of cities renowned for their cycling-friendliness in France, particularly regarding the share of commuters who opt for bicycles, it is worth highlighting a more equitable gender distribution. Notably, Grenoble and Strasbourg, where urban cycling rates approach 17%, report a nearly balanced gender representation in this mode of transportation, standing at approximately 45% and 49%, respectively ([fig. 4](#)). Likewise, La Rochelle and Bordeaux achieve gender parity closely aligned with the local population (51%) while boasting bicycle modal shares of around 12% and 14%, respectively.

Conversely, some larger urban centers exhibit a low bicycle

### 2019 MOBPro Database on Commuting Unimodal Bicycle Use



### Quantitative Observation of Intermodal Passengers Using Micromobility



#### Legend

- F Folding Bike
- O Other Micromobility Devices
- S Human-Powered (Kick) Scooter

Figure 3: Distribution of Cyclists by Gender and Type of Micromobility in France

Data Source: MOBPro Census (Insee 2023) and Author’s Study  
 Realization: Author, 2023

modal share, below the national average of 3.5%, and a low representation of female cyclists. Among the most unequal cities, notable examples include Toulon (20%), Saint-Paul (22%), Saint-Pierre (24%), Brest (25%), Saint-Denis from La Réunion (25%), Aix-en-Provence (26%), Limoges (26%), Beauvais (28%), Saint-Étienne (28%), and Arras (28%) where the bicycle modal share ranges between 1% and 3% (fig. 4). Nevertheless, it is crucial to contextualize these observations by considering specific counterexamples that seem to deviate from the established pattern. Cities like Avignon (50%), Poitiers (45%), Valenciennes (42%), and Bayonne (37%) stand out as exceptions, as gender disparities appear less pronounced despite a modest modal share of cycling in the city center, ranging from 3% to 7%.

However, the positive correlation between the modal share and female participation in cycling appears less consistent when considering the intermodal use of micromobility in the Hauts-de-France case study. The linear regression model yields a coefficient of 0.35 ( $P < 0.05$ ) when analyzing data from the nine surveyed train stations. At the Lille Flandres central station and the Lille CHR suburban station, where the bicycle modal share is 6.1%, intermodal travelers include fewer than a third of female cyclists (32%). A similar gender distribution

is observed at Armentières station (33%) in an area traversed by 4% of cyclists. The trend remains evident at the Béthune (22%), Lesquin (14%), Creil (13%), and Dunkerque (12%) stations, where the bicycle modal share ranges from 1% to 3%. When differentiating between types of micromobility, a moderate relationship is observed ( $\rho_{Pearson} = 0.55$ ,  $P < 0.05$ ) for the intermodal use of conventional bicycles, and a weakly relationship exists for personal e-scooters combined with public transportation networks ( $\rho_{Pearson} = 0.33$ ,  $P < 0.05$ ). In contrast, this relationship is not substantiated for folding bicycles ( $\rho_{Pearson} = 0.04$ ,  $P > 0.05$ ) and even contradicts the findings for kick scooters ( $\rho_{Pearson} = -0.41$ ,  $P > 0.05$ ).

To the author’s knowledge, this outcome has not yet been statistically demonstrated in the French context, except for Strasbourg where cycling comprises more than 7% of the modal share and women make up for 48% of cyclists (Certu 2013, p. 42). Some insights by Héran (2015) and Schepman (2014, p. 187) suggested that a substantial presence of cyclists in a city tends to lead to a more balanced bicycle usage, citing examples such as Strasbourg and Copenhagen. This finding is in line with the international comparison conducted by Garrard, Crawford, and Hakman (2006, p. 63) who highlighted that countries with high cycling rates for both commuting and recreation tend to

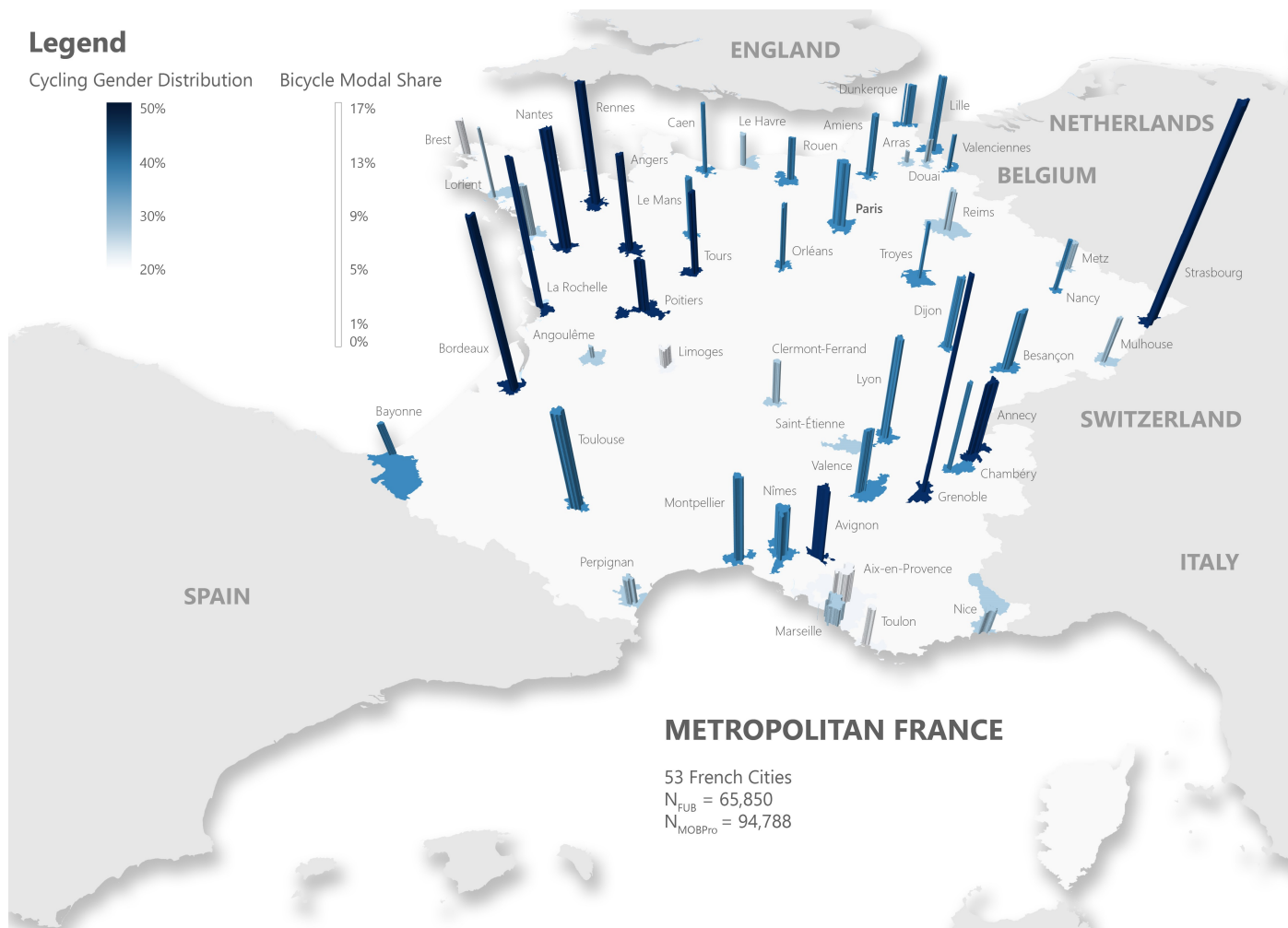


Figure 4: Cross-Mapping of Modal and Gendered Share of Cycling in France  
 Data Sources: *MOBPro Census* (Insee 2023), *Atlas Vélo Régional (Vélo & Territoires 2023)* and Authors' Study  
 Realization: Author, 2023

Table 1: Descriptive Statistics of the Linear Regression Model

Independent Variables	$\rho_{Pearson}^{Bicycle}$	$P_{Pearson}^{Bicycle}$	$\rho_{Spearman}^{Bicycle}$	$P_{Spearman}^{Bicycle}$	$SD^{Bicycle}$
Bicycle Modal Share	0.729	<0.001	0.807	<0.001	0.037
Proportion of Cycling Infrastructure	0.647	<0.001	0.670	<0.001	0.071
Bikeability Score	0.619	<0.001	0.618	<0.001	0.499
Theme 4: <i>City's Efforts</i>	0.618	<0.001	0.619	<0.001	0.645
Theme 1: <i>General Perception</i>	0.603	<0.001	0.613	<0.001	0.523
Theme 3: <i>Comfort</i>	0.598	<0.001	0.609	<0.001	0.545
Theme 2: <i>Safety</i>	0.596	<0.001	0.604	<0.001	0.539
Theme 5: <i>Services and Parking</i>	0.490	<0.001	0.438	<0.001	0.379
Proportion of Cycling and 30km/h Areas	0.347	<0.05	0.398	<0.001	0.218
Population Density	0.281	<0.05	0.396	<0.01	3,020.555

Data Sources: *Baromètre des Villes Cyclables* (FUB 2021), *OpenStreetMap* (OpenStreetMap 2023) and Author's Study  
 Realization: Author, 2023

experience reduced gender differences in cycling. Similarly, in an analysis spanning 17 countries across six continents, Goel et al. (2022, p. 70) identified a high association between the gender gap in cycling propensity and the level of cycling. Within cities and countries where cycling rates fall below 7%,

women exhibit an average 56% lower likelihood of cycling compared to men, as shown by Goel et al. (2022, p. 70).

This second statistical analysis endeavors to establish a substantial connection between the percentage of cyclists and women's inclination towards embracing cycling from a

geographical viewpoint. Nonetheless, this strong correlation does not provide insights into the causal relationships between these two variables. Specifically, it remains unclear whether it is the critical mass that fosters greater gender diversity among cyclists, the higher involvement of women in cycling that augments this modal share, or a combination of both factors operating interactively. It is within the context of this renewed inquiry and the scientific positioning concerning the role of the urban environment that this study sought to evaluate the perceived quality of cycling within a territory by its users.

### 3.3. Addressing the Gender Gap through the Lens of Bikeability

In order to assess the existing correlations between the urban environment and the gender-based distribution of micromobility in France, this linear regression model was enhanced by incorporating new independent variables encompassing the concept of perceived bikeability and urban environment (table 1). The analysis of gender-specific cycling patterns encompassed (i) the bikeability score, comprising dimensions related to *general perception, safety, comfort, city's efforts, and services and parking*; (ii) population density; (iii) the proportion of dedicated cycling infrastructure; and (iv) the consideration of cycling and 30 km/h areas. This regression-based modeling underscores a relative significant association between the presence of females in cycling and the perception of bikeability within the city ( $\rho_{Pearson}=0.62$ ,  $P<0.001$ ), which exhibits a great robustness as the relationship observed with the overall modal share of cycling ( $\rho_{Pearson}=0.73$ ,  $P<0.001$ ).

An additional noteworthy connection enhances the comprehensiveness of these findings, as demonstrated by the association observed with the prevalence of cycling paths within a municipality ( $\rho_{Pearson}=0.65$ ,  $P<0.001$ ). Conversely, the correlation between the rate of cycling infrastructure, including areas restricted to 30 km/h, and the gender-based distribution of cycling is relatively modest and is not statistically significant ( $\rho_{Pearson}=0.35$ ,  $P<0.05$ ), mirroring the situation with population density, which exhibits no discernible relationship ( $\rho_{Pearson}=0.28$ ,  $P<0.05$ ). The results confirm the connections between the frequency of cycling, the level of bikeability, and the presence of high-quality cycling infrastructure, as well as their collective relation with gender equity (Codina et al. 2022, p. 8).

The identification of a notably significant correlation between the perceived bikeability score among cyclists in France and the gender-specific cycling rate within the chosen municipalities remains robust, both for central cities incorporated within *Metropolises, Urban Communities and Agglomeration Communities* intermunicipalities<sup>7</sup>. Hence, assuming all other factors remain constant, it appears that achieving a

<sup>7</sup>These three types of intermunicipalities are related to the French administrative structure and governance, known as *Établissements Publics de Coopération Intercommunale* (EPCI) with fiscal autonomy. These administrative entities, designed to bring together multiple municipalities, are

higher modal share of cycling may be attainable when a city's bikeability score surpasses 4.3 (fig. 5). Among the three cities that achieve gender parity, La Rochelle and Bordeaux score 4.13 and 3.42, respectively, while Avignon records a score of 3.13, closely aligning with the average score of the 53 cities, which stands at 3.08. In a broader context, the seven cities — Bordeaux, Avignon, La Rochelle, Strasbourg, Annecy, Grenoble, and Tours — with a female representation rate exceeding 45% exhibit an average score of 3.74. Conversely, the ten municipalities where cycling is predominantly male-dominated, with a share of at least 70%, exhibit an average score of 2.63.

Taking into account the quantitative observation of intermodal users opting for micromobility solutions, this statistical analysis aligns with the regression curve derived from gender-specific cycling patterns in relation to bikeability, especially when considering personal e-scooters used in conjunction with train. As a result, users at Le Poirier Université station are predominantly male (5.26% of women) and face a low bikeability score of 2.24 (fig. 5). This trend is mirrored at Lesquin (15.79%), Armentières (17.24%), and Creil (18.52%) stations, where bikeability ratings range from 2.26 to 2.77. In contrast, gendered disparities are less pronounced at Lille Flandres (28.35%), Béthune (31.43%), and Lille CHR (31.58%) stations, where the perceived bikeability corresponds to scores between 2.8 and 3.08. However, Dunkerque station presents a noteworthy exception, characterized by relatively high bikeability yet marked by a male-dominated micromobility usage (28.57%). This phenomenon could be partially attributed to the presence of a unique regional express high-speed train (TERGV) network<sup>8</sup> established in 2000, and to the impacts of free public transportation since 2018 (Héran 2020). In comparison to the exclusive use of bicycles, a second noteworthy trend is the reduced representation of women among intermodal micromobility users within the same city. This observation underscores that a bikeability score of 4.3 alone would not be adequate to attain gender parity among train users who opt for micromobility solutions.

Once the link between bikeability and the gendered patterns of bicycle and micromobility use in intermodal transport was established, the statistical analysis underwent further refinement to discern the factors exerting the most substantial influence on this connection. The objective of this examination is to offer a qualitative perspective on bikeability in the context of the gender analysis undertaken in this study. By

primarily categorized based on the population size of the area. Consequently, following the 2010 French Territorial Collectivities Reform, the classification of EPCI with fiscal autonomy (*EPCI à fiscalité propre*) includes the *Communautés de Communes* (CC, min. 15,000 inhabitants), the *Communautés d'Agglomération* (CA, min. 50,000 inhabitants), the *Communautés Urbaines* (CU, min. 250,000 inhabitants), and the *Métropoles* (min. 400,000 inhabitants).

<sup>8</sup>TERGVs are high-speed trains operating on the *LGV Nord* but managed by the regional authorities and accessible with a regional train ticket, without the need for reservations or assigned seating. Consequently, the boarding policies applied to these TERGVs mirror those of French high-speed trains. There are no designated spaces for transporting bicycles, and they are only permitted onboard if disassembled.

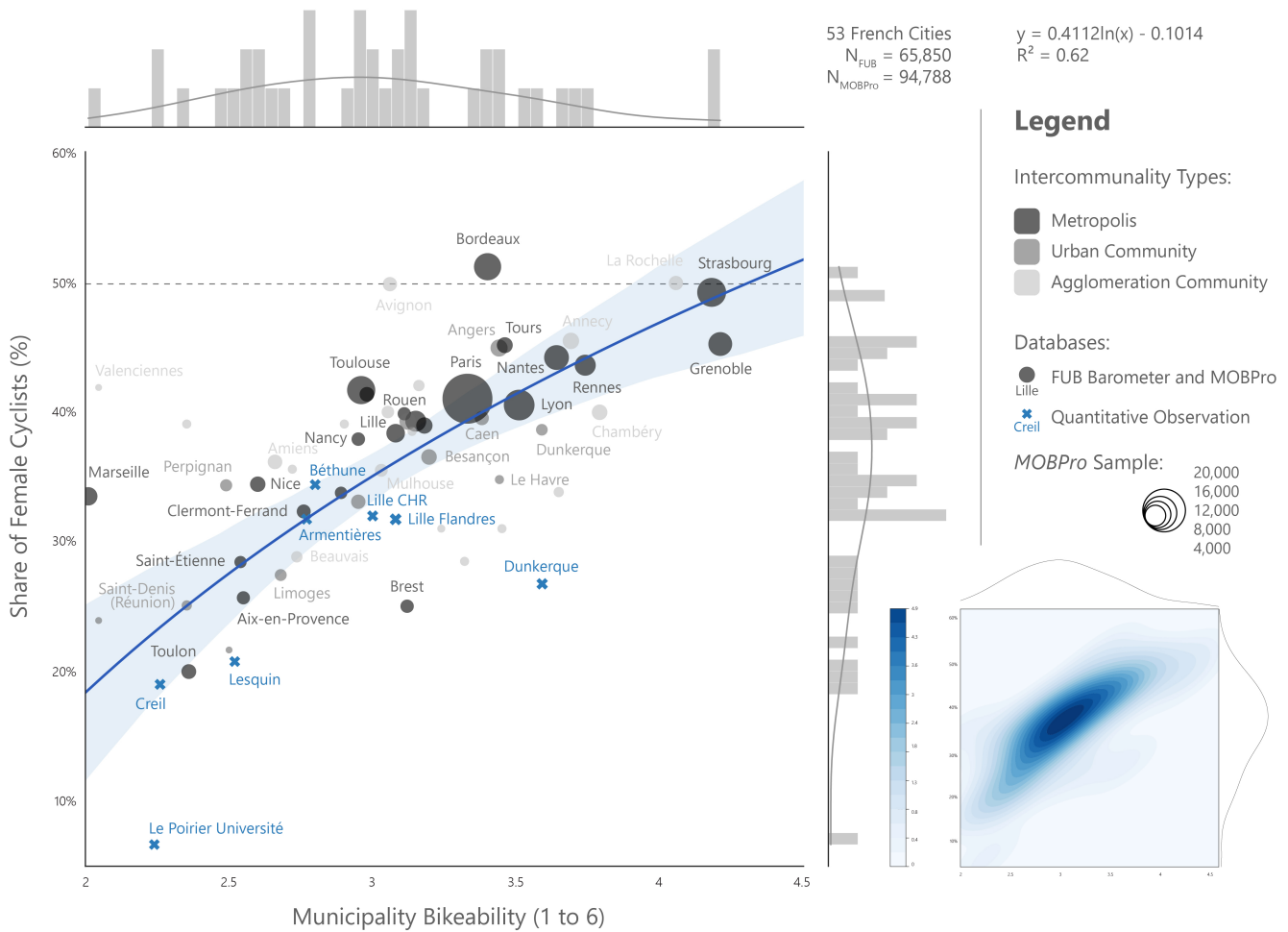


Figure 5: Linear Regression Model between the Proportion of Female Cyclists and the Perceived Bikeability of Main French Municipalities  
 Data Sources: *Baromètre des Villes Cyclables* (FUB 2021), *MOBPro Census* (Insee 2023) and Author's Study  
 Realization: Author, 2023

reexamining the five themes outlined in the FUB (2021) through the online questionnaire, it became feasible to evaluate how each key element was rated by users, consistently taking into account the intersection of bikeability and the gender representation rate in cycling within the city. In relation to these mentioned themes, successive linear regression models reveal a relatively significant correlation, encompassing facets such as the *City's Efforts* ( $\rho_{Pearson}=0.62$ ,  $P<0.001$ ), *General Perception* ( $\rho_{Pearson}=0.60$ ,  $P<0.001$ ), *Safety* ( $\rho_{Pearson}=0.60$ ,  $P<0.001$ ), *Comfort* ( $\rho_{Pearson}=0.60$ ,  $P<0.001$ ), and, to a lesser degree, *Services and Parking* ( $\rho_{Pearson}=0.49$ ,  $P<0.001$ ).

When scrutinizing the specifics of each question, the statistical analysis unveils a relative significant correlation across the board, with a coefficient of determination exceeding 0.5 for more than half of the inquiries (fig. 6). Notably, the factors exerting substantial influence predominantly pertain to:

- The widespread adoption of bicycles (Q19,  $\rho_{Pearson}=0.66$ );
- The sense of safety experienced during cycling (Q20,  $\rho_{Pearson}=0.60$ );

- Confidence in safety on residential streets (Q22,  $\rho_{Pearson}=0.60$ );
- Advocacy and promotion of cycling by the city (Q32,  $\rho_{Pearson}=0.60$ );
- The playful and enjoyable aspect of cycling in the city (Q14,  $\rho_{Pearson}=0.59$ );
- The capacity to navigate swiftly and directly through the bike network (Q15,  $\rho_{Pearson}=0.58$ );
- The experience of safety when crossing intersections (Q24,  $\rho_{Pearson}=0.57$ );
- Engaging cyclists in mobility and development project discussions (Q33,  $\rho_{Pearson}=0.57$ );
- Municipal efforts aimed at bolstering bicycle development (Q31,  $\rho_{Pearson}=0.57$ );
- The quality of the cycling network (Q26,  $\rho_{Pearson}=0.56$ );
- Confidence in safety on main roads (Q21,  $\rho_{Pearson}=0.56$ ).

Dependent Variable: Gendered Distribution of Cyclists  
Model: Ordinary Least Squares (OLS)

$$R^2 = \rho_{\text{Pearson}} / \rho_{\text{Spearman}}$$

\*: P-value <0.001  
±: P-value <0.01

Number of Observations: 53 French Cities

$N_{\text{FUB}} = 65,850$   
 $N_{\text{MOBPro}} = 94,788$

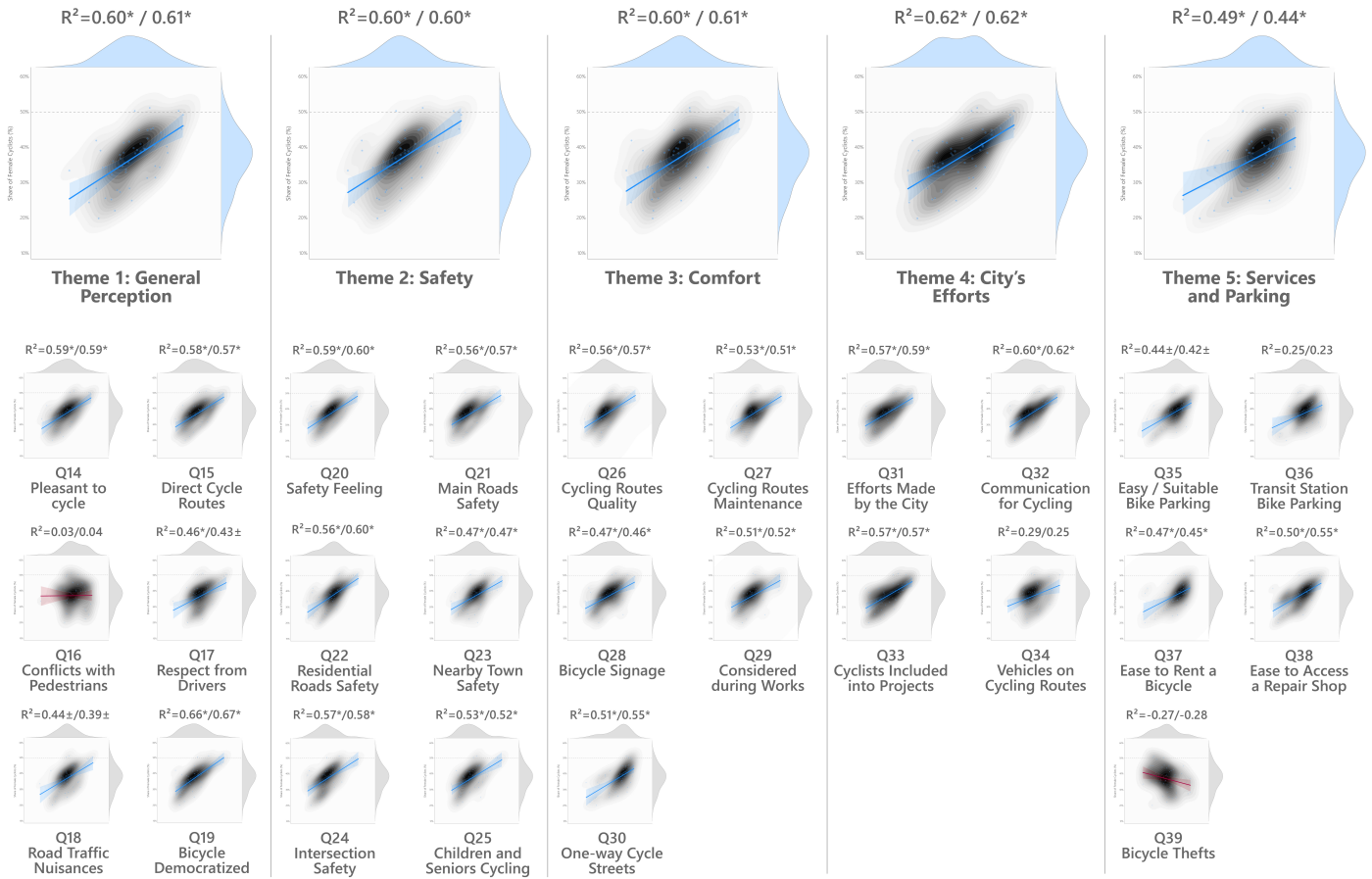


Figure 6: Linear Regression Model between the Gendered Distribution of Cycling and the Themes and Questions used to Aggregate the Perceived Bikeability Score by Municipality

Data Sources: *Baromètre des Villes Cyclables* (FUB 2021), *MOBPro Census* (Insee 2023) and Author's Study  
Realization: Author, 2023

Notably, only two questions do not contribute to the relationship between bike-friendliness and the gender distribution in cycling: those related to conflicts with pedestrians (Q16,  $\rho_{\text{Pearson}}=0.03$ ) and the frequency of bike thefts (Q39,  $\rho_{\text{Pearson}}=-0.27$ ).

Therefore, it becomes that a multitude of factors play a crucial role in bolstering the significance of bikeability as a key explanatory variable for a more inclusive cycling modal share in France. The critical mass of cyclists emerges as a pivotal sub-variable in this equation, along with considerations of bicycle safety, facilitating a continuous and direct network throughout residential areas and one-way streets that play a vital role in ensuring an enjoyable cycling experience. Additionally, city-initiated cycling policies hold equal importance alongside effective communication and city planning strategies that incorporate cyclist feedback and participation. However, it is crucial to recognize the importance of factors that improve bikeability in municipalities. These include implementing safety measures on main roads, intersections, and roundabouts; creating secure infrastructure for vulnerable populations; maintaining the cycling network; and ensuring easy access to

bicycle repair facilities.

The main contributions of this research resonate with the extensive scientific literature providing insight into the relationship between the urban environment and inclusive mobility, particularly in terms of gender gap, with a specific focus on promoting walking. Several studies affirm that higher walkability scores can play a crucial role in reducing gender-based disparities in physical activity. A study comparing 69 cities across the United States found a direct correlation between walkability and gender balanced use, accompanied by an increase in physical activity levels for pedestrians (Althoff et al. 2017, p. 3). At the local level, it was observed that streets characterized by high walkability in Utah, in the United States, boasted twice the proportion of female users compared to those with limited walking infrastructure (Jensen et al. 2017, p. 86). An investigation, conducted in Chennai, India, revealed that a substantial proportion of females reported insufficient walking and cycling facilities, safety and nuisances concerns due to traffic levels (Adlakha and Parra 2020, p. 4). These findings are further supported in the research works in Southern California of W.-T. Lo (2017) and A. W. -.

Lo and Houston (2018, pp. 171, 48), which highlight the greater influence of walkability scores on women when compared to men.

### 3.4. Classification of Cities Under Comparison

Using quantitative analysis of datasets provided by FUB (2021) and Insee (2023), this research aims to categorize the 53 French cities based on their bikeability scores and the degree of feminization in cycling. To achieve this, the study employed bivariate analysis to evaluate the positive correlation observed geographically. Four categories emerge from this statistical analysis: (i) gender-balanced and bike-friendly, (ii) bike-friendly but gender-unequal, (iii) gender-balanced but bike-unfriendly, and (iv) gender-unequal and bike-unfriendly cities (fig. 7).

By using evenly distributed intervals, the map provides a visual representation of a concentration of cities characterized by a balanced gender distribution in cycling modal share and a high perceived level of bikeability (i). These cities are primarily located in western Metropolitan France, excluding Brittany. Notable examples include Bordeaux, Nantes, Rennes, Tours, Angers, Poitiers, as well as cities in the eastern part of the country, such as Strasbourg, Grenoble, Annecy, Chambéry, and Lyon (fig. 7). In contrast, cities receiving lower ratings for both variables (iv) are predominantly situated in southern Metropolitan France, encompassing places like Toulon, Marseille, Aix-en-Provence, Saint-Étienne, Limoges, and Clermont-Ferrand. Additionally, cities in the Department of Réunion, such as Saint-Pierre, Saint-Paul, and Saint-Denis, fall into this category.

Furthermore, several regions that offer favorable conditions for cycling but face challenges in achieving a balanced gender distribution (ii) are primarily located in the northern and western regions of Metropolitan France, including cities like Dunkirk, Le Havre, Arras, Douai, and Reims, as well as Lorient, Brest and further, Saint-Nazaire. On the other hand, certain cities demonstrate a balanced gender distribution in cycling usage but still maintain relatively low levels of bikeability (iii). This is exemplified by cities such as Valenciennes, Amiens, Angoulême, Nîmes, and Nice.

Based on the three variables examined throughout the article, namely gender distribution in cycling, the modal share of cycling, and a municipality's bikeability rating, this research's final objective is to introduce an indicator that encompasses bikeability and bike usage, with a particular focus on gender-balanced cycling. The interest of such an index is to serve as a useful tool for evaluating the interplay among these three aspects within the context of French cities. This indicator, referred to as  $I_{gcb}$  (0 to 1), is a composite of three indices: one based on the distribution of female cyclists, denoted as  $I_g$ ; a second index assessing bike development (with an ideal value set at 25%), labeled as  $I_c$ ; and a third index derived from user-assigned bikeability ratings, identified as  $I_b$ . For this purpose, the determination of the general indicator employs various variables, one related to the gendered distribution of

cycling (denoted  $G_{fc}$ ), another related to the modal share of cycling in the city (denoted  $C_{ms}$ ), and another related to the perceived bikeability score (denoted  $B_s$ ) (formula 3):

$$\begin{aligned} I_g &= \frac{\text{Min}(G_{fc}, 50\%)}{50\%} \\ I_c &= \frac{\text{Min}(C_{ms}, 25\%)}{25\%} \\ I_b &= \frac{B_s}{6} \\ I_{gcb} &= I_g * I_c * I_b \end{aligned} \quad (3)$$

where:

$I_g$  is the gendered share of cycling;

$I_c$  is the cycling modal share;

$I_b$  is the bikeability score of the municipality;

$I_{gcb}$  is gender equity in connection with cycling and bikeability.

The development of this gender equity indicator, coupled with considerations of cycling democratization and perceived bike-friendliness within the areas, offers a more comprehensive understanding of the profile of the studied cities. With an average score of 0.098 and a median of 0.067, the 53 cities are still far from achieving a level of mobility that can be deemed both sustainable and inclusive, both in terms of urban planning, services, and demographics. Notably, the four cities that outshine the rest in the ranking are Strasbourg ( $I_{gcb}=0.47$ ), Grenoble ( $I_{gcb}=0.44$ ), La Rochelle ( $I_{gcb}=0.34$ ), and Bordeaux ( $I_{gcb}=0.32$ ) (see fig. 7).

Among the cities included in the study, 47 record scores below 0.2, while those at the lower end of the ranking include Saint-Pierre ( $I_{gcb}=0.011$ ), Angoulême ( $I_{gcb}=0.012$ ), Arras ( $I_{gcb}=0.012$ ), Saint-Denis ( $I_{gcb}=0.013$ ), Limoges ( $I_{gcb}=0.015$ ), Marseille ( $I_{gcb}=0.015$ ), and Saint-Étienne ( $I_{gcb}=0.015$ ) (see fig. 7). In this ranking, it is noteworthy to mention the standings of major French metropolises. Specifically, Rennes holds the 5th position ( $I_{gcb}=0.22$ ), the 6th for Nantes ( $I_{gcb}=0.213$ ), the 8th for Lyon ( $I_{gcb}=0.167$ ), the 12th for Toulouse ( $I_{gcb}=0.144$ ), the 14th for Montpellier ( $I_{gcb}=0.131$ ), the 19th for Lille ( $I_{gcb}=0.1$ ), the 20th for Paris ( $I_{gcb}=0.099$ ) and the 30th for Rouen ( $I_{gcb}=0.061$ ).

## 4. Discussion

### 4.1. Implications of the research

While a strong correlation exists between inclusive micromobility usage and the cycling level within a city, validating findings in the existing scientific literature (Goel et al. 2022; Garrard, Crawford, and Hakman 2006, pp. 70, 63), it is important to note that this association is inseparable from the bike-friendliness of the area (Garrard 2021).



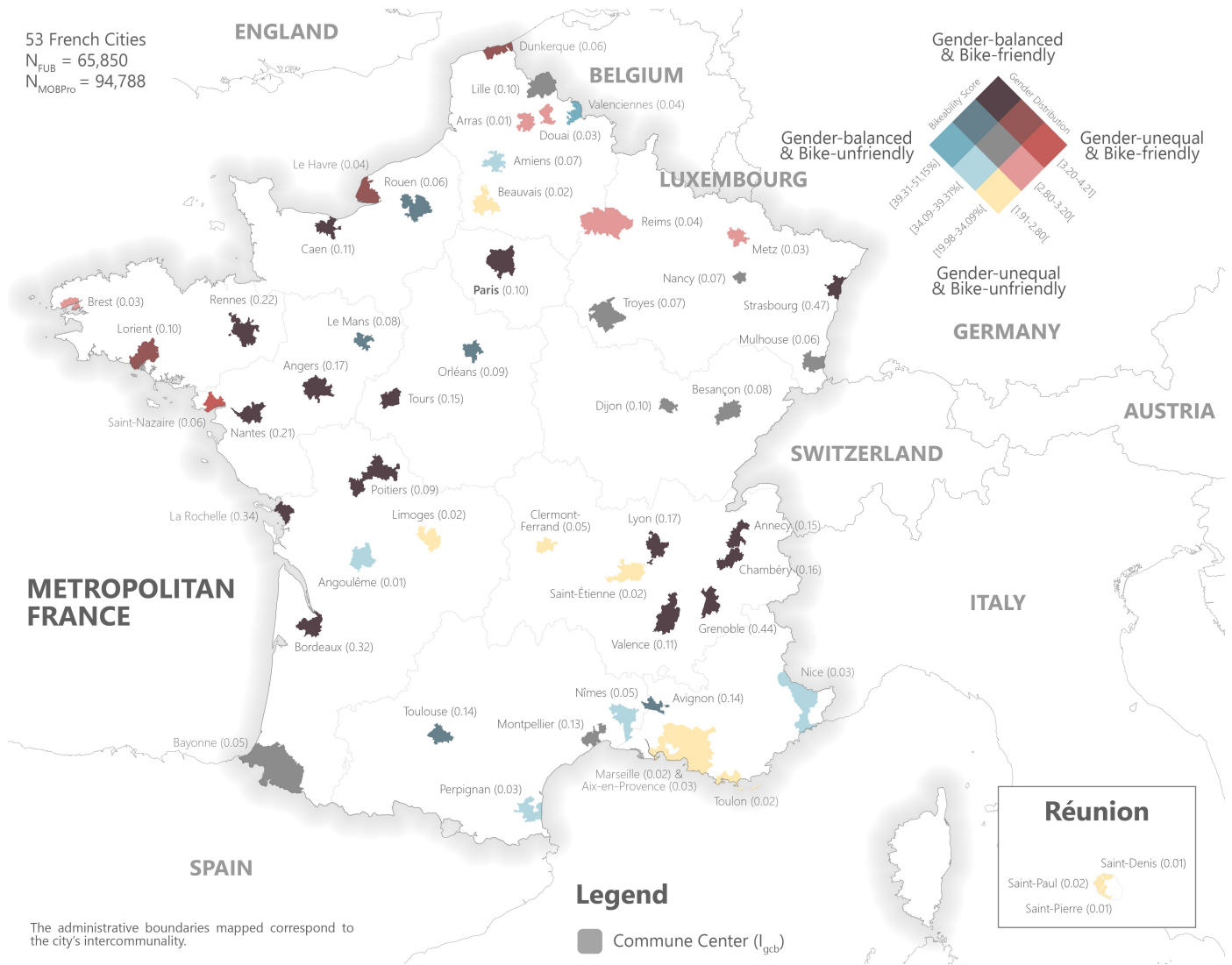


Figure 7: Bivariate Map of the 53 French Cities according to Gender Distribution, Cycling Use and Perceived Bikeability  
 Data Sources: *Baromètre des Villes Cyclables* (FUB 2021) and *MOBPro Census* (Insee 2023)  
 Realization: Author, 2023

The noteworthy interactions observed between gender and individual factors, such as the critical mass of cyclists, as well as initiatives promoting cycling and the development of continuous, well-connected, and secure cycling infrastructures in the French case study, align with the research conducted by Garrard, Handy, and Dill (2012, p. 513). This research highlights that countries like the Netherlands, Denmark, and Germany, which have actively promoted commuting and leisure cycling, achieve gender parity by focusing on a secure and democratized system as the cornerstone of their cycling policies (Nelson and Allen 1997, p. 79). Nonetheless, these results are challenged by certain studies that emphasize the persistence of cultural norms, even in the presence of a 'female-friendly' cycling environment, taking some time for 'early-adopters' women to popularize its usage (Aldred and Jungnickel 2014; Aldred, Woodcock, and Goodman 2016, pp. 8, 40).

The *Baromètre des Villes Cyclables* database indicates that women tend to have higher concerns and lower levels of experience when it comes to cycling, as safety is rated on average at 2.75 points compared to 2.84 points for male cyclists (Vermeulen and Kaouane 2022; Caduc 2022, pp. 25, 37). The findings outlined in this contribution shed light on the pivotal role of risk aversion, to which women cyclists tend to experience more acutely, potentially deterring them from embracing cycling. This is underscored by a systematic literature review on feminist geographies, which identifies risk aversion as the primary hurdle to women's cycling participation (Ravensbergen, Buliung, and Laliberté 2019, p. 4). The impact of both real and perceived safety (Garrard, Rose, and S. K. Lo 2008, p. 57) can be attributed to a heightened sense of caution socialized through traditional gender roles, where women are often associated with roles as care providers and nurturers (Prati et al. 2019, p. 5). Consequently, enhancing the safety of

cycling infrastructure not only fosters greater bicycle adoption across the entire population but also legitimizes and normalizes cycling as a mode of transportation in urban environments (Aldred, Woodcock, and Goodman 2016, p. 40). These guiding principles encompass the notion of the 'bicycle system' (Héran 2015; Héran 2001, p. 169) as a framework for understanding users' needs and as a comprehensive system, similar to the 'automobile system' (Hall 1988) and the automobile territories (Dupuy 1999, p. 13).

The key factors emphasized by women include a sense of insecurity, with 57% expressing this concern compared to 46% of men, as well as the lack of cycling infrastructure, with 57% of women noting this issue compared to 53% of men, according to the *Baromètre des Villes Cyclables* (Vermeulen and Kaouane 2022, p. 26). The most frequently mentioned factors, which vary by gender, include the absence of dedicated cycling lanes and poor road conditions (Van Dyck et al. 2013, p. 61), leading to a significant exposure to motor vehicle traffic (Krizek, Johnson, and Tilahun 2005; Mitra and Nash 2019, pp. 36, 9), in line with these analysis results. The expressed additional safety concerns translate into a preference for increased separation from motorized traffic, as highlighted in the systematically reviewed scientific literature by Aldred, Elliott, et al. (2017, pp. 35, 49). A study carried out in Lille, France, using focus groups, showed that the female cycling participants agreed on the use of one-way cycle tracks and bicycle lanes on traffic-calmed streets, whereas over a third of them expressed discomfort or even avoided bicycle lanes on busy streets, bus corridors open to cyclists, and contra-flow cycle lanes on traffic-calmed streets (Copenhagenize France and d'Aubigny 2021, p. 20). The interviews conducted as part of Eskenazi (2022, p. 261)'s doctoral research in Hamburg corroborate that most surveyed women express a preference for segregated infrastructure along sidewalks. However, as their cycling proficiency advances, the demand for entirely separated, traffic-free infrastructure diminishes (Eskenazi 2022, p. 261). This has also been demonstrated among female cyclists with over 3 years of experience in Lille, France (Copenhagenize France and d'Aubigny 2021, p. 16).

The inclination toward a protected cycling network applies not only to women (Garrard, Rose, and S. K. Lo 2008, p. 57) but to all cyclists, with a particular focus on underrepresented demographic groups, such as racial minorities (Lubitow, Tompkins, and Feldman 2019, p. 1189), children, and the elderly (Pucher and Buehler 2008, p. 504), given the prevalence of the MAMIL<sup>9</sup> user's profile (Aldred, Woodcock, and Goodman 2016; Beck and L. Pearson 2023, p. 41). The greater sensitivity of women in advocating for an inclusive cycling infrastructure for all demographic groups of users could be explained by gendered divisions in domestic responsibilities and caregiving roles on women's travel patterns (Vermeulen and Kaouane 2022, p. 49). This perspective is further supported

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<sup>9</sup>'MAMIL' is an acronym that stands for 'Middle-Aged Man In Lycra', used to describe middle-aged men who are avid cyclists. This term is often used to refer to particular cyclists who are passionate about cycling sport.

by the *Baromètre des Villes Cyclables*, where 87% of female respondents expressed concerns about the safety of cycling for children and the elderly (FUB 2021).

These observations manifest similarly concerning the rise of e-micromobility. The outcomes of this study suggest that the utilization of shared e-scooters exacerbates the same gender-related issue as cycling but to a greater extent (Younes, Noland, and Andrews 2023, p. 7). According to the existing literature on this topic, safety stands out as the primary obstacle to adopting these new mobility solutions, especially in the context of e-scooters, where women more frequently express concerns about personal risk (Parnell, Merriman, and Plant 2023, p. 10). Even though safety perception is one of the main factors to consider, women's cycling behavior is also influenced by household responsibilities and various social and environmental factors (Emond, Tang, and Handy 2009, p. 22).

This study delves into environmental factors, such as urban density and design, as essential considerations. While the link between women's cycling preferences and density was not confirmed in the French case study, there is a clear correlation between cycling infrastructure directly related to traffic safety, comfort, and the attractiveness of the cycling network. Studies have shown that cycling trips are positively correlated with elements shaping the urban environment and related to proximity and active mobility (Nelson and Allen 1997; Buehler and Pucher 2012, p. 80). Specifically, this aligns with the '3Ds' framework — *Density, Diversity, and Design* — pioneered by Cervero and Kockelman (1997). This model has gradually expanded into '5D' by integrating Destination accessibility and *Distance to Transit* (Ewing and Cervero 2010, p. 267), then into '6D' with the inclusion of *Demand Management* (Tal and Cohen-Blankshtain 2011, p. 395), and most recently into '7D' by considering *Demographics*, including gender issues (De Gruyter et al. 2020, p. 641). These dimensions integrating social inclusivity resonate with the concepts and planning strategies of the Transit-Oriented Development (Calthorpe 1993, pp. 43–87) and the 15-Minute City (Moreno 2020; Duany and Steuteville 2021, p. 126). The goal is to advocate for an urban planning approach that fully embraces proximity- and transit-focused, with feminist and inclusive urbanism (Bruntlett 2022; Lanza and Carboni 2023; Lanza, Pucci, and Carboni 2023, p. 7). In this context, exploring the gender gap through an environmental lens involves considering an inclusive 15-Minute City that seamlessly integrates an equitable Transit-Oriented Development (e-TOD), as advocated by Hersey, Spotts, and Pollack (2015, p. 7). This approach aligns with the notion of TOD-based 15-Minute Cities, as put forth by Wolański (2023, p. 11). In this perspective, rethinking urban planning that promotes alternative mobility, through walking and cycling (15-Min City) as well as by promoting transit use (TOD), tends to incorporate aspects related to walkability and bikeability, which must go hand in hand with better inclusion of populations based on gender.

## 4.2. Limitations

This statistical research intentionally employs a 'macro-social' framework (Desjeux 2004, p. 6) to gain deeper insights into the factors contributing to the gendered usage of bicycles across a vast region. This encompassing perspective enables us to discern patterns, aligning with statistical trends and social dimensions, such as gender dynamics. However, it is important to note that this paper does not seek to disregard the influences of factors at meso- and micro-social scales, which illuminate this societal phenomenon through a 'nanosociological' lens, considering interactions within private and public spheres, the assimilation of social values, and the role of the subconscious mind (Desjeux 2004, p. 7).

This work encounters an initial limitation in its exclusive focus on urban planning actions, which cannot fully explain this phenomenon. The Master's thesis by Gaudron-Arlon (2022, p. 4) challenges cycling policies that primarily prioritize the development of cycling infrastructure as the sole means to achieve greater diversity among cyclists, highlighting the inadequacy of this approach. Through an examination of the French city of Lyon, this publication reveals that certain obstacles faced by women in cycling persist despite the development of cycling infrastructure (Gaudron-Arlon 2022, p. 37), designated 'gender-neutral bike lanes' by the Lyon Metropolis authority (Otter 2022; Lesieur 2022). As a result, addressing the gender gap requires a multifaceted approach, encompassing the eight domains outlined in the Gender Equality Index: work, money, knowledge, time, power, health, (direct and indirect) violence, and intersecting inequalities (Prati 2018, p. 6). Furthermore, additional factors, such as trip-chain complexity (Heesch, Sahlqvist, and Garrard 2012, è), workplace appearance and a lack of confidence in bike maintenance, also contribute to the gender gap (Pucher and Buehler 2012, p. 226).

It is crucial to acknowledge another significant limitation when interpreting the results and their implications: the need for caution in assuming that reducing gender disparities in cycling automatically translates into achieving gender equality (Sayagh 2022; Abord de Chatillon, Ortar, and Sayagh 2021, pp. 155, 41). Cycling behaviors are intricately linked to the concept of 'motility' as a capital<sup>10</sup>, which encompasses the framework of actual mobility opportunities influenced by gendered predispositions, resulting in distinct possibilities (Abord de Chatillon, Ortar, and Sayagh 2021, p. 45). Beyond the exploration of urban planning in conjunction with mobility, feminist epistemology provides a complementary perspective, shedding light on 'intellectual sexism' that prevails in research valuing scientific objectivity and that decontextualizes gender studies.

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<sup>10</sup>'Mobility' is a notion borrowed from biology that means capable of moving. Conceptualized by Kaufmann, Bergman, and Joye (2004, p. 750), 'motility encompasses interdependent elements relating to access to different forms and degrees of mobility, competence to recognize and make use of access, and appropriation of a particular choice, including the option of non-action.'

The focus extends beyond regarding gender solely as an indicator and recognizes it as a power relation stemming from social and political construction, underscoring the importance of avoiding generalizations based on stereotypical characteristics attributed to women. In Lausanne, in Switzerland, Pelgrims (2023) demonstrates how cycling practices are shaped by aesthetic, bodily, and affective interactions between gendered bodies, cycling equipment, and the materialities of bicycles, highlighting the significance of bodily micro-practices through mobile video ethnographies. While gendered norms regarding cycling are socialized from an early age (Sayagh 2018, pp. 12–16), the consideration of gender should also be placed in a broader context through an intersectional approach<sup>11</sup>, which involves examining specific forms of discrimination related to income and ethnicity in conjunction with gender. This approach aims to reveal distinctive patterns, as exemplified in Peltier (2023, pp. 134–137)'s thesis on Romanian women identified as Roma. The presence of cycling infrastructure also tends to disproportionately benefit privileged social groups at the expense of less advantaged populations. This relationship highlights the substantial impact of non-infrastructure-related barriers among disadvantaged and racially marginalized communities (Braun 2021, p. 13).

## 5. Conclusions

By revealing the existence of a gender gap in micromobility usage in France, this article unveils a statistically significant association among the modal share of cycling, perceived bikeability, and the proportion of female cyclists within the 53 French cities under examination. This positive correlation remains consistent for both traditional cycling and emerging micromobility options, such as e-scooters, as well as for both single-mode and intermodal journeys when integrated with train travel. The conflicting perspectives in the literature regarding the democratization of cycling and its potential impact on achieving gender equity imply that bikeability and temporality are two pivotal factors to take into account. Perceived bike-friendliness can be seen as the missing link in the hypothesized cause-and-effect chain: an improvement in bikeability would normalize and boost cycling use, thereby legitimizing ongoing efforts to enhance bikeability. Concurrently, women may progressively embrace cycling over time due to spatial democratization and the widespread presence of cycling in public spaces. This survey demonstrates the presence of a positive association between perceived bikeability and the gender-balanced usage of the bike in French city centers, suggesting that a high score of perceived bikeability tends to be accompanied by an equivalent proportion of women and men cycling. The study also

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<sup>11</sup>'Intersectionality' refers to a method that takes into account the complex interplay of various social identities and forms of discrimination that individuals may experience simultaneously. This perspective leads to describe how different dimensions of identity, such as race, gender, sexuality, class, or disabilities, intersect and interact.

highlighted the presence of this positive correlation in the case of emerging micromobility, particularly for the personal e-scooter. Nevertheless, bikeability alone may not be sufficient to attract as many women as men for intermodal travel involving cycling modes.

This study underscores that achieving gender parity in cycling goes beyond mere considerations of 'safety in numbers' or the presence of cycling lanes from an urban planning perspective. Instead, the key driver lies in the perceived bike-friendliness experienced by cyclists. In other words, it primarily involves enhancing the 'bicycle system' (Héran 2015; Héran 2001, p. 169) through a multitude of urban factors. These factors encompass the normalization of cycling, the establishment of a secure environment facilitated by continuous, high-quality, and direct cycling infrastructure and the reduction of automobile traffic in residential streets and boulevards, the promotion of comfort and enjoyment in cycling, and proactive engagement by public authorities, characterized by transparent advocacy for cycling and grounded in principles of participatory democracy. As a result, the equation for achieving a more equitable gender distribution in cycling encompasses not only the proportion of cycling infrastructure, but also variables related to the city's proactive efforts, the overall perception, comfort levels, safety, and the availability of supporting services and parking facilities. These elements can set in motion a virtuous cycle, driving widespread cycling adoption, including among women. Conversely, factors related to 30 km/h zones and population density do not align with the hypothesis that they contribute to a more equitable adoption of cycling.

The last two objectives of this research were to classify geographical contexts based on their perceived bikeability and the proportion of female cyclists through a bivariate analysis, and to use an indicator capturing the gendered usage of cycling in relation to the modal share of cycling and bikeability ratings. This cartographic observation highlighted the major French cities with favorable indicators of inclusive bikeability, namely Strasbourg, Grenoble, La Rochelle, and Bordeaux. Conversely, this typology revealed the least cyclist-friendly and gender-inclusive cities, primarily Saint-Pierre, Angoulême, Arras, Saint-Denis, Limoges, Marseille, and Saint-Étienne. The establishment of this revised ranking serves as guidance for stakeholders and local authorities to develop urban and inclusive strategies aimed at enhancing cycling practices in cities.

To conclude, this innovative article emphasizes the significance of promoting both objective and perceived bikeability as a pivotal tool in bridging the gender gap. Its ultimate goal is to foster the development of an urban planning approach, referring to an inclusive 'Micromobility-Oriented Development' (MOD). Female participation in cycling emerges as a noteworthy indicator of a bicycle-friendly culture and environment, with these elements mutually reinforcing each other (Garrard, Crawford, and Hakman 2006, p. 64). However, delving into the topic of women in cycling goes beyond closing the gender gap in urban mobility, it also initiates a broader conversation about

gender inequalities (Sammito 2023) and the societal imperative of social inclusivity. This paper serves as a guidance for stakeholders and public authorities to effectively implement inclusive urban planning initiatives that uphold principles of gender equity.

Based on these findings, the article recommends that future research should undertake a more comprehensive exploration of the intersection between gender and cycling. This necessitates adopting a systemic approach that takes into account all sociodemographic factors influencing micromobility usage, including income, race, gender, sexuality, and disabilities. Additionally, the quantitative investigation presented in this paper should gain a deeper understanding by being complemented by feminist geographies of cycling research (Ravensbergen, Buliung, and Laliberté 2019, p. 9). From a geographical standpoint, future research should aim to incorporate GIS-based bikeability measurements, built environment, urban forms, and the perceived bikeability. Expanding the geographical scope would also be valuable, encompassing urban areas excluded from this study, as well as rural regions. This expansion should extend beyond municipal boundaries by focusing on the larger commuting catchment areas of (intermodal) cyclists. Finally, the issue of emerging micromobility could be further enriched by exploring shared micromobility in order to determine if it responds in the same way to the need for a bicycle system integrated to the urban development. These suggestions include the development of a multivariate analysis that encompasses all variables, in order to explore cause-and-effect relationships to better understand the role of each factor in reducing the gender gap.

## Acknowledgements

The author is thankful for the help and support provided by the research director Alain L'Hostis, the research assistant Ndèye Aïta Cissé and the *Fédération des Usagers de la Bicyclette* (FUB) organization. The author is also grateful for the assistance provided by Iñigo Aguas Ardaiz, Jordan Bassetti, Elorri Chagneau, and Romain Labesse in contributing to the implementation of quantitative observations. This research has benefited from the support provided by the *SNCF Gares & Connexions*' French mobility manager and the University Gustave Eiffel's Data Protection Officers (DPO). The author acknowledges the open access database provided by the FUB (2021) and the Insee (2023). Additionally, this paper was enhanced through the valuable interactions with conference attendees, during the Paris 2022 International Geographic Union (UGI) Centennial Congress. The author would like to express its gratitude for the insightful presentations and exchanges that took place during the 'Gender, Feminism, and Mobility' seminar at the *Laboratoire Ville Mobilité Transport* (LVMT) on October 6, 2023, in Paris. These discussions have contributed significantly to the reflective understanding of this topic.

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