Household Structure Predicts Cycling Gender Heterogeneities among French Bicycle Owners

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SHORT SUMMARY

The cycling gender gap and bicycle ownership-usage mismatch represent critical bottlenecks, particularly in France's sustainable mobility transition, as nearly a third of privately-owned bicycles are unused. This study utilizes a nationally representative sample of the 2019 French National Travel Survey (4817 males; 3494 female bike owners) to investigate behavioral heterogeneities. Partial Proportional Odds models estimate cycling frequency, controlling for age, commuting, residential density, and car ownership. Males exhibit baseline odds of cycling frequency 3 times higher than females across all thresholds. However, distinct gendered drivers emerge: while complex household structures correlate with increased frequency for men, the presence of children induces cycling frequency for females. Higher income decreases the odds of frequent cycling by 25% for males and 35% for females. Observably, e-bike adoption strongly increases cycling frequency. These suggest that the e-bike is a vital bridge to overcome car usage inelasticity and mitigate household structural barriers, toward gender-equitable cycling.

Keywords: Bicycle owners; Cycling behavior; Equity; Gender heterogeneity.

1. INTRODUCTION

Cycling remains one of the important pathways in the decarbonization and sustainable mobility agenda. The *European Declaration on Cycling* and France's 2023-2027 *Plan Velo* seek to enhance cycling participation. However, two issues remain critical to cycling adoption: the cycling gender gap (Goel et al., 2023) and an ownership-usage mismatch (Chen et al., 2022). The European Cyclists' Federation's *Women in Cycling* initiative is one practical testament of this gap. Aggregated models that put all cyclists together do not fully explain the gender heterogeneities. Beyond ownership, it is imperative to analyze retention and frequency of cycling with gender-inquisitive lenses.

What is the extent of cycling gender gaps among bicycle owners? Recent studies have contributed to understanding the cycling gender gap by intensifying the focus on how structural and sociotechnical factors sustain the cycling gender gap, even as infrastructure improves. The literature largely uses the binary gender of male and female as this study seeks to do. A systematic review confirms that the gendered gap remains a dominant theme, with females across Europe and North

America consistently reporting higher sensitivity to traffic stress and personal safety than males (Yuan et al., 2023). In France, while cycling participation has surged, females remain significantly more responsive to subjective safety, suggesting that infrastructure alone fails to bridge the gap if it does not address risk factors (Moinse, 2025). Furthermore, while high-density urban environments provide proximity, the energy needed for peddling and resultant sweat is a barrier for females (Lu et al., 2023).

A critical gap remains in addressing cycling gender gaps among bicycle owners, particularly regarding household type and structure and car ownership effects. Bicycle owners constitute a subgroup of cyclists who have committed to purchasing the resource. This singular act makes them different from novice cyclists in terms of intention to cycle. Household type and structure are associated with complex trip-chaining tasks, such as combining school runs with professional commutes, which can create gender gaps in mobility (Lee et al., 2007). In their analysis of gender differences in mobility among workers in France, they found that workers engaged in complex trip chaining between their home and workplace (Havet et al., 2021). Cycling complements public transport for distances <2 km and >10 km (Celbis and Bouzouina, 2025). There is evidence to show that females have substantially more exclusive access to the household vehicle than their male partners (Blumenberg et al., 2022). In Europe and Australia, there is a strong body of evidence suggesting that higher-income earners cycle more (Heesch et al., 2012; Tortosa et al., 2021). Additionally, the e-bike neutralizes the physical effort barrier that can break this car-ownership inelasticity (Tozluoğlu et al., 2024). How do these factors reflect among French bicycle owners?

By isolating these dynamics within a national-scale dataset of French bicycle owners, this study seeks to identify the extent of heterogeneities in cycling and potential mechanisms to close the gap. It provides an empirical blueprint for other European nations facing similar gendered divides.

2. METHODOLOGY

This study uses the rich socio-economic and travel data contained in the 2019 French National Travel Survey conducted by the National Institute of Statistics and Economic Studies (INSEE). This dataset provides a high-resolution baseline of French mobility patterns immediately preceding the disruptions of the COVID-19 pandemic. This dataset is the most recent French national travel survey with granular, individual-level variables necessary to model the complex drivers of cycling frequency. While longitudinal indicators show a significant increase in cycling volumes across European metropolitan areas post-2020 (Kone et al., 2025), household car usage rates remained inelastic in France. This suggests that while the modal shift to cycling may have evolved rapidly, its association with car ownership remains inelastic.

The sample size of individual bicycle owners is 8311. The dataset has individual socio-economic, cycling frequency, household and car ownership data including the residential bike parking types, number of bicycles owned, bicycle type, average trip distance in the past week, residential density, proximity to metro/tram, public transport membership, car ownership, household type and structure, impairment (disabled or not), age, and gender. For this research, bicycle types were coded into e-bikes and others as the reference category. Trip purposes were also recoded into work/school commuting and others as the reference category (exercise, leisure, and shopping), based on the question ("What do you usually use the bike for?"). Residential density is classified into high, medium, and low density, with low as the reference category (1 km² population grid).

Methodologically, the structure of the dataset and the ordinal dependent variable (cycling frequency: rarely, monthly, daily, weekly) are suitable for discrete choice modeling. First, the parallel lines assumption of proportional odds was tested based on the Brant test; it was statistically significant ($X^2 = 141.07, p < 0.001$), meaning the proportional odds assumption is violated. Accordingly, the Partial Proportional Odds model was selected to prioritize model parsimony for variables that do not violate proportional odds while relaxing the assumption for those that violate. While residential bike parking, physical impairment, and public transport membership were originally theorized as relevant factors, they were removed during the stratification process. The split between male and female owners resulted in empty cells for these categories in certain frequency thresholds, which compromised the model's ability to estimate reliable standard errors. Their removal allowed for the successful execution of the models without significantly altering the explanatory power of the primary variables of interest. The final male and female models controlled for age, commuting trips, household type and structure, residential density, car ownership, e-bikes, proximity to metro/tram, and trip distance. It also relaxes the constraints for density and household type, as they violate the proportional odds assumption.

3. RESULTS AND DISCUSSION

The partial proportional odds in Table 1 show good model fit with McFadden pseudo R^2 of 0.553 and 0.572. The intercepts reveal a significant baseline heterogeneity: the odds of high-frequency cycling for males are more than three times higher than those for females at all thresholds. This resonates with the established knowledge that males generally have a higher propensity to cycle than females (Goel et al., 2023).

One striking result is that work/school commuting does not significantly predict cycling frequency for both cohorts compared to the reference category - others (shopping, exercise, and leisure). French bicycle owners are cycling more for other trips than commuting purposes: only 10% reported using the bicycle to commute. 75% of the sample used the bicycle for shopping trips. This is consistent with Menai et al. (2015), who found in French cities that leisure and errands often follow different socio-demographic logics than commuting, suggesting that utility cycling is increasingly driven by local, non-work activities such as shopping and recreation. This finding suggests that policy should not only focus on commuter-centric planning but on understanding trip chains and multi-functional urban design to fully account for diverse cycling trips.

Household type and structure evidently influence the cycling frequency of males differently from females. For men, living in a complex household induces daily cycling (OR 12.30), whereas it has no significant effect on females. Conversely, the presence of children acts as a specific driver for females reaching the highest cycling frequency threshold (OR 1.28), a trend not evident in the male model. Our findings contradict the past findings that females have more access to household vehicles for the sake of family errands (Blumenberg et al., 2022). While suggesting that males in large households may use the bicycle as a reliable tool for independent mobility, females' high-frequency cycling is rather tied to trip-chaining for the needs of children, such as recurring errands to school and grocery shops (Havet et al., 2021).

Earning a higher income decreases the odds of frequent cycling by up to 25% for males and 35% for females. This contradicts previous findings that in Europe and Australia, which showed that higher-income earners cycle more (Heesch et al., 2012; Tortosa et al., 2021). Car ownership decreases the odds of frequent cycling by up to 76% for males and 70% for females. The lower odds are intuitive because of the competition between the two transport modes. It reinforces car substitution policies as strongly outlined in decarbonization policies.

Table 1: Partial Proportional Odds of Cycling Gender Heterogeneities

Predictors	Male		Female	
	Odds Ratio	z-value	Odds Ratio	z-value
(Intercept):1	12.4869	6.4519***	4.0735	2.9111***
(Intercept):2	3.4484	3.1742***	1.3157	0.5622
(Intercept):3	0.3471	-2.6027***	0.1494	-3.2219***
Age (ref. <18)				
18-24	0.4471	-6.1656***	0.7205	-0.9013
25-34	0.4421	-3.6880***	0.8461	-0.512
35-49	0.4335	-4.1514***	0.7082	-1.1009
50-64	0.4632	-3.7984***	0.914	-0.2851
65-74	0.4217	-3.9803***	1.0715	0.2141
75+	0.5173	-2.5835***	1.1660	0.4052
Trip purpose (ref. others)				
Work/School commuting:1	0.8618	-1.2200	0.8514	-1.0989
Work/School commuting:2	1.1238	0.9699	0.9586	-0.2753
Work/School commuting:3	1.14	1.0671	0.8722	-0.5945
Household income (ref. low)				
Average	0.7299	-2.3597**	0.7245	-2.0596**
High	0.7503	-2.0212**	0.6581	-2.3838**
Household Type (ref. single)				
Complex household:1	1.9792	1.8856*	1.624	0.9038
Complex household:2	2.3745	3.5585***	0.6608	-0.6303
Complex household:3	12.3069	9.5625***	0.869	-0.1122
Couple with child:1	1.2371	1.4818	1.4292	1.8171*
Couple with child:2	0.9027	-0.7209	0.9644	-0.1777
Couple with child:3	0.9532	-0.2326	1.2864	0.8346
Couple without child:1	1.0991	0.6980	1.0797	0.4485
Couple without child:2	0.9965	-0.0264	1.0043	0.0243
Couple without child:3	1.0373	0.1876	1.5565	1.6728*
Car ownership (ref. none)				
1	0.3965	-7.0966***	0.5779	-2.4676***
2	0.3237	-8.0130***	0.3638	-3.9476***
3+	0.2434	-7.8624***	0.2955	-4.2651***
Bicycle ownership (ref. 1)				
2	1.4208	3.2577***	1.2617	1.4922
3+	1.4238	2.3810**	1.2769	0.5930
E-bike (ref. others)	2.5329	3.6857***	2.9263	5.0365***
Proximity to metro/tram	1.0961	0.5904	0.9808	-0.0758
Residential density (ref. low)				
High:1	1.2265	1.7714*	0.8826	-0.8792
High:2	1.2723	2.1002**	1.1838	1.11304

Predictors	Male		Female	
	Odds Ratio	z-value	Odds Ratio	z-value
High:3	2.6083	5.2981***	2.4708	3.6451***
Medium:1	1.012	0.1114	0.9702	-0.2385
Medium:2	1.0136	0.1225	1.1338	0.9024
Medium:3	1.6517	2.6494***	1.2246	0.7446
Trip distance	0.9999	-0.4367	1.0006	2.1783**
N	4817		3494	
McFadden pseudo R^2	0.553		0.572	

Note: Significance threshold of |z|: 99%: 2.58***; 95%: 1.96**; 90%: 1.65*.

The model results support the fact that the e-bike boosts cycling for both cohorts. Trip distance is a significant predictor of cycling frequency for female but is insignificant for male bicycle owners. The shift toward e-bikes further decouples cycling from the commute, positioning it instead as a tool for managing the complex, shorter-trip demands of the household. This calls for more subsidies and e-bike promotion programs to close the gender gap.

High residential density significantly boosts daily cycling for both genders (males have higher odds), likely because dense areas make the short-trip nature of cycling more competitive than driving. Besides, it is easier for males to move from lower to higher cycling thresholds (rarely-monthly and monthly-weekly) in high-density areas than for females in the same urban environments. This low threshold effect is likely due to the perceived high risk for infrequent female cyclists who may be novices.

4. CONCLUSIONS

This study contributes a gendered analysis of cycling frequency among bicycle owners in France, using the 2019 national travel survey. The models demonstrate high explanatory power, revealing a household structure effect where household income and car ownership serve as primary barriers to frequent utility cycling. Higher income increases the opportunity cost of travel time, leading females in particular to lower odds of cycling. The analyses show that urban residential density and e-bike adoption are strong levers for cycling behavioral change. High residential density makes the short-trip nature of cycling more competitive than driving by reducing the spatial gap between daily destinations. Simultaneously, the e-bike serves as a vital mitigator for the physical energy and sweat exertion associated with longer distances. Notably, work/school commuting does not predict cycling frequency for both cohorts. Ultimately, this lack of statistical significance for commuting trips suggests that cycling frequency is not driven by school and work, but by how well the urban environment supports the multi-functional needs of daily mobility.

The specific heterogeneities identified here underscore the depth of the gender divide in cycling behaviors in France. Males exhibit a baseline odds of high cycling frequency three times higher than females across all thresholds. This is further complicated by household structure; while complex household structures induce cycling for men, the presence of children is the specific driver of cycling frequency for females. This confirms that gender roles within the family exert a powerful, underlying influence on bicycle ownership and usage. It has implications for equity. Future research can look at how to reduce heterogeneities emanating from household structure while taking advantage of the e-bike disproportionality for women to encourage frequent cycling. While e-bike ownership increases the odds of cycling for both cohorts, the effect is significantly more

pronounced for females, acting as a disruptive transport that bridges the car ownership and household structural barriers. Ultimately, these results demonstrate that bridging the cycling gender gap and the bicycle ownership-usage mismatch requires addressing the car ownership inelasticity and the household structural effects that impact cycling. For mobility planners, this emphasizes a need to reconsider the development of gender-sensitive urban design, multi-functional neighborhoods that support utility cycling, while promoting e-bike adoption and incentives.

This preliminary model has limitations, such as the lack of spatial, infrastructure, and weather variables. To address these travel survey constraints, we will employ econometrics to analyze the interactions between different socio-economic and spatial determinants while controlling for bike lanes and parking. These preliminary findings can guide the formulation of research and policy to close the cycling gender gap.

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