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# Gender and Age Differences in Metropolitan Car Use. Recent Gender Gap Trends in Private Transport

Jerònia Cubells <sup>1,\*</sup>, Oriol Marquet <sup>1</sup>  and Carme Miralles-Guasch <sup>1,2</sup>

<sup>1</sup> Research Group on Mobility, Transportation and Territory (GEMOTT), Department of Geography, Autonomous University of Barcelona—Building B, Campus de Bellaterra, Cerdanyola del Vallès, 08193 Barcelona, Spain; oriol.marquet@uab.cat (O.M.); carme.miralles@uab.cat (C.M.-G.)

<sup>2</sup> Institute of Environmental Science and Technology (ICTA), Autonomous University of Barcelona—Building ICTA-ICP, Campus de Bellaterra, Cerdanyola del Vallès, 08193 Barcelona, Spain

\* Correspondence: jeronia.vadell@e-campus.uab.cat

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**Abstract:** Urban mobility is currently undergoing significant changes in cities worldwide, as gendered mobilities are converging and automobility is on a downward trend among younger cohorts. The aim of this study was to examine the dynamics of gendered mobilities over generations and across three different urban contexts in the Barcelona Metropolitan Region (northeast Spain), in an effort to understand whether the mobility gender gap is closing and whether young adults have lowered their private transport levels. Generalized linear models were built to analyze travel survey data from the Working Day Mobility Survey (EMEF) to comprehend mobility changes between 2008 and 2018. The study identified a generational countertrend among new generations of young adults, who reported more sustainable mobility practices than their predecessors. Furthermore, results show a general trend towards gender convergence of travel behavior on the outskirts of the Barcelona Metropolitan Region, but also a tendency towards gender divergence in the core area of Barcelona City. Since the mobility gender gap is closer to convergence in those areas where private transport use is more widespread, future efforts towards achieving climate objectives should aim at decoupling such gender convergence from car-dependent built environments.

**Keywords:** mobility trends; gender; generations; automobility; Barcelona

## 1. Introduction

The transport sector is one of the major contributors to climate change, accounting for a quarter of all energy-related CO<sub>2</sub> emissions [1]. The greatest share of greenhouse gas emissions from transportation comes from road transport, and recent research has found that such emissions are clearly the result of gendered differences in travel behavior [2]. Male mobility patterns are consistently more car-dependent, which leads to higher energy consumption, higher emission rates, and thus higher climate change contribution than female mobility patterns [3,4]. These differences between male and female mobility patterns (commonly referred to as the mobility gender gap) also have an impact on social sustainability. Since mobility is closely connected to access to opportunities, wellbeing, and social inclusion [5,6], the study of gendered mobilities can also be viewed as a measure of gender equity [7].

Several studies have discussed the gender gap in travel behavior, although few have examined its dynamics over generations and across geographical contexts [5,8,9]. Debate continues around the gender convergence of travel behavior and the increasing reduction in car use and car-dependency among younger generations. In particular, previous research has found contradictory conclusions on the urban nature of this phenomenon: the results of the study by [9] indicate that these changes are more prominent in the urban context, whereas [8] found that these changes are more relevant in rural

areas. Furthermore, it remains unclear whether younger generations are likely to catch up with the automobility levels of their predecessors as they grow older. While [10,11] have suggested that new generations are likely to reach the previous cohort driving levels, [12] have reported the opposite trend.

In aiming at investigating these research gaps, this paper focused on understanding the dynamics of gendered travel patterns over different age groups and within clearly differentiated urban territories in the Barcelona Metropolitan Region (BMR) of northeast Spain. The study of generational and gendered mobility trends is not only important for environmental sustainability and transport research, but also to comprehend social equity concerns. Access to mobility contributes to possibilities for attending different welfare arenas, which are essential for human well-being and the satisfaction of basic needs [5,6]. Therefore, more egalitarian mobility patterns of different groups represent a rough estimate of a society where opportunities are better distributed. Using cross-sectional data from two different editions of the Working Day Mobility Survey (Catalan acronym is EMEF), the analysis explored how generational and gendered travel behavior have changed over time in three different urban contexts, testing the following hypotheses:

**H1.** *New generations of young adults experienced a decrease in private transport levels;*

**H2.** *Gender convergence of private travel behavior emerged in each urban context;*

**H3.** *'Gender turnaround' in private transportation occurred, particularly in the City of Barcelona.*

In order to find these hypotheses out, we first defined key concepts in this research and reviewed the main findings in the literature regarding gendered mobilities and their relation with age. Section 2 frames the spatial scope of the research within the BMR and presents the generalized linear models that were used to test H1, H2, and H3. Sections 3 and 4 corroborate and discuss the first hypothesis and, in contrast with mainstream trends reported in the literature, highlight a gender divergence of travel patterns in the urban environment. Conclusions and limitations are drawn in Section 5.

### 1.1. Gendered Mobilities

Gender is a relational and transforming concept, and social changes can shape gender dynamics in mobility [8,13]. Gender differences in travel behavior have been extensively acknowledged in the body of transportation literature and gender research. Studies focused on general travel patterns observed that women tend to drive shorter distances than men [12], although accounting for longer travel times [8,14]. Women also tend to travel less by car and more by public transportation [5,15,16] and have more trip-chaining and personal-trip behavior than men [17–19]. Previous research has attributed the mobility gender gap to gendered power relations [20,21], traditional gender roles [22,23], or gendered car culture [7,24]. These explanations are not mutually exclusive but rather they coexist in a context where car-dependent built environments have dominated urban development, hence entrenching the paradigm of car supremacy [6,8,24].

The concept of 'gendered mobilities' refers to the fact that gender differences in terms of access to socioeconomic resources, preferences in lifestyle, and social expectations of gender roles are reflected and reproduced by systematic differences in travel behaviors [8,12,21]. As a result of the structural reasons behind gender differences in travel patterns and their implications in mobility, a trend towards increased gender equality would result in the convergence of gendered travel behavior [12]. Since male travel patterns have been reported to be more carbon dependent [4,25], if the convergence of travel behaviors occurs by accepting and reproducing male mobility norms, an increase in gender equality would conflict with sustainability goals [2]. Therefore, [2,18] suggest that in order to change gender relations and achieve climate objectives, it is necessary to challenge the male norms that are currently dominant in the mobility sector.

### 1.2. Generational and Gendered Mobility Trends

Previous research using data from nationwide travel surveys has revealed generational automobility trends with a focus on gender [5,8,12,24]. Across countries from the Global North, two automobility tendencies have emerged in recent decades: 1) younger people having lower car dependency and 2) the reduction of the mobility gender gap.

Both in North America and Europe, a recent downturn in driving has been identified [8,10,11]. This has led to claims by some authors that automobility might have reached its historical peak [26]. Studies have hypothesized that those people born in the 1960s have reached the peak of car travel, while later generations marked a slow-down in automobility levels [11,26,27]. Hence, younger cohorts are reported to have lower car use and motorization rates that are mainly due to their delayed entrance into the job market and other related life events. Together with that, lower income levels and the affinity of younger generations for urban living contribute to explaining their lower levels of car dependency [10,27,28]. Notwithstanding, [12] identified a continued spatial extension of overall mobility and a switch from short-distance car travel to long-distance (air) travel.

The second trend supports a gender convergence of travel habits, and particularly with respect to automobility levels, despite the fact of women still travelling less by car than men [8,12,22,27,29]. These trends have been observed over generations and across geographical contexts. New generations of young men tend to travel less often by car than their predecessors [9,12]. By contrast, new generations of young women have experienced an increase in their driving levels [8,9]. While some authors have reported a 'gender turnaround', whereby young women have travelled more by car than young men [8,9], convergence has not completely eliminated the gender gap in other geographical contexts [12,22,28,30], particularly among older adults [5]. New generations of older adults have substantially increased their car use, especially women [5,8,12]. Notwithstanding, older women still make fewer car trips than men, and fewer older women hold a driving license [5]. The geographical context also influences the mobility of women and men differently [3,15] due to the high spatial complexity in women's daily commuting [7,19] and the mobility constraints suffered by women living in the suburbs [31].

Recent historical events, such as the Great Recession of 2007, also impacted gendered mobility trends by shrinking the gender gap. Automobility levels dropped at a higher rate for men than for women, hence contributing to gender convergence [18,32]. Nonetheless, the long-term effects of such events in both automobility levels and gendered mobilities remain unclear.

## 2. Materials and Methods

### 2.1. Study Area

Spread over 3000 km<sup>2</sup> and containing 5,103,053 inhabitants, the BMR is framed by two concentric rings that expand from the core area of the city of Barcelona. In 2018, the 164 municipalities, which are included in the BMR, housed 68% of the Catalan population, which represented 11% of the total inhabitants of Spain [33,34]. In the last decade, the region has increased its population by 3.5%.

The center of the BMR is occupied by the Municipality of Barcelona, with 1,620,343 inhabitants (16,150 inhabitants/km<sup>2</sup>), a compact planning organization and a good spatial distribution of services, amenities, and public transport [32]. While the first metropolitan ring constitutes an urban continuum with Barcelona, the second metropolitan ring combines historic cities with sprawled areas. These medium-sized cities share high density levels and a compact and mixed urban morphology. The rest of the second metropolitan ring, however, is composed of small municipalities with low density levels and sprawled development [35].

### 2.2. Data Source and Methods

Cross-sectional mobility data from the 2008 and 2018 editions of the EMEF were collected, with the rationale to analyze the most recent data with the perspective of a decade. The EMEF is an annual

survey promoted by the Authority of Metropolitan Transport (Catalan acronym is ATM), the Barcelona City Council, the Barcelona Metropolitan Area (Catalan acronym is AMB), and the Association of Municipalities for Mobility and Urban Transport (Catalan acronym is AMTU). The questionnaire aims to study daily mobility habits and attitudes towards mobility. The EMEF datasets were gathered through telephone interviews that were performed between March–May 2008 and October–December 2018, from a representative sample of the BMR residents, aged 16 or older. The survey collects questions about all trips conducted on the weekday before the interview, which are complemented with interviewee data and household characteristics. The EMEF database has been extensively used in previous research [18,32,35,36] and complete methodological details can be found elsewhere [37].

Two datasets were gathered from the EMEF to describe and analyze private mobility trends (Table 1). The first dataset included all interviewees who dwelled in the BMR and had reported at least one trip on the weekday before the questionnaire ( $n_{2008} = 5073$  and  $n_{2018} = 7324$ ). The second dataset only considered respondents who lived in the BMR and had reported a trip using private transport ( $n_{2008} = 2353$  and  $n_{2018} = 3713$ ). Due to their widespread use in the BMR [36], private transport also included mopeds and motorcycles.

**Table 1.** Sample characteristics.

	Mobile Individuals		Private Transport Users	
	2008	2018	2008	2018
<b>Sample</b>				
N (respondents)	5073	7324	2353	3713
N (trips)	18,340	30,959	7028	11,652
<b>Gender (%)</b>				
Female	50.3	51.0	41.8	43.6
Male	49.7	49.0	58.2	56.4
<b>Age (%)</b>				
16–29	22.0	17.2	25.0	15.2
30–65	56.4	62.5	64.3	72.5
>65	21.6	20.3	10.7	12.3
<b>Metropolitan region (%)</b>				
Barcelona	27.4	27.9	16.4	16.1
First ring	20.7	21.2	17.4	18.6
Second ring	51.9	50.9	66.2	65.4

Descriptive statistics were used to compare the evolution of private transport levels between 2008 and 2018. Moreover, to examine the interactions between gender, age, and geographical context, this study built three generalized linear models. The first model used the dataset that gathered information from all mobile individuals, whereas the rest of the models used the second dataset, which only considered private transport users. The models analyzed how gendered private mobility trends differentiated by generation and by spatial context. They tested the hypotheses of H1: a slow-down in private transportation levels in younger generations, H2: a gender convergence of travel behavior in each geographical context, and H3: a ‘gender turnaround’ in private transportation, particularly in the City of Barcelona.

The dependent variables included private transport use (binary variable, 1 = private transport trip), time (daily duration of private transport trips measured in minutes), and frequency (daily number of trips using private transportation). Since private transport use was a binary variable behaving as a factor (either 1 or 0, i.e., either undertaking a private transport trip or not) the first generalized linear model responded to a binomial approach. On the other hand, both time and frequency variables were numeric vectors, hence the second set of models was built using a Gaussian approach and a t-statistic was calculated through the Walden test, i.e., by dividing the coefficient by the standard error. The rationale for choosing each approach was the dependent variable class (factor or

numeric). Unlike the Gaussian family, the binomial approach enables users to specify a factor as the dependent variable.

In both sets of models, independent variables covered year (two categories: 2008, 2018), gender (two categories: female, male), metropolitan region (three categories: City of Barcelona, first metropolitan ring, second metropolitan ring), age (three categories: 16–29, 30–65, >65 years of age), profession (five categories: employed, unemployed, retired, student, homemaker), and education (three categories: primary, secondary, tertiary). To analyze whether generational trends were context and gender specific, the models incorporated a three-way ANOVA between the variables of year, gender, and metropolitan region, and between year, gender, and age.

Furthermore, the effect displays method was adopted to examine the marginal effects of the generalized linear models by combining high-order model terms with the related lower-order model terms [8]. To compute marginal effects, we set factors constant at their proportions instead of at reference level. In contrast with a more fluid understanding of gendered power relations and the ‘doing’ of gender [38], the binary gender categories approach used in this study corresponded to the survey design.

### 3. Results

#### 3.1. Private Transport Use

Table 2 summarizes changes in private travel patterns by gender, age group, and metropolitan region. The use of cars, mopeds, and motorcycles slightly increased during the past decade in the Barcelona Metropolitan Region (from 46.4% to 50.7%;  $p = 0.242$ ). Women expanded their use of private mobility modes (from 38.6% to 43.3%;  $p = 0.871$ ) at a higher rate than men (from 54.3% to 58.4%;  $p = 0.871$ ), yet women still held a lower share of private transport use in all of the analyzed areas ( $p < 0.001$ ) and across all age groups ( $p < 0.001$ ). Generalized linear models are presented in Table 3.

**Table 2.** Changes in private travel patterns between 2008 and 2018.

	2008			2018			Difference 2008–2018 (%)		
	Use <sup>1</sup>	Time <sup>2</sup>	Frequency <sup>3</sup>	Use	Time	Frequency	Use	Time	Frequency
<b>Gender</b>									
Female	38.6	104.4	3.0	43.3	117.6	3.1	4.8 (12.4%)	13.2 (12.6%)	0.1 (4.4%)
Male	54.3	109.1	3.0	58.4	128.0	3.2	4.1 (7.5%)	19.0 (17.4%)	0.2 (6.0%)
<b>Age</b>									
16–29	52.6	104.5	3.0	44.8	106.0	2.7	−7.9 (−15.0%)	1.5 (1.4%)	−0.3 (−10.3%)
30–65	52.9	109.3	3.0	58.8	128.8	3.3	5.9 (11.2%)	19.5 (17.8%)	0.2 (7.6%)
>65	22.9	99.9	2.6	30.7	113.7	2.9	7.7 (33.7%)	13.7 (13.7%)	0.3 (11.5%)
<b>Metropolitan region</b>									
Barcelona	26.9	89.6	2.6	29.2	116.1	2.8	2.4 (8.8%)	26.5 (29.5%)	0.2 (9.2%)
First ring	39.0	98.4	2.9	44.4	111.6	3.0	5.4 (13.9%)	13.2 (13.4%)	0.1 (3.1%)
Second ring	59.1	113.8	3.1	65.0	128.7	3.3	5.9 (10.0%)	14.9 (13.1%)	0.1 (4.5%)
<b>Total</b>	46.4	117.1	3.0	50.7	123.2	3.1	4.3 (9.3%)	6.1 (5.2%)	0.2 (5.4%)

<sup>1</sup> Private transport use (percentage of individuals who reported a private trip); <sup>2</sup> daily time spent traveling by private transport (minutes); <sup>3</sup> daily frequency of private transport trips (occasions).

**Table 3.** Generalized linear models estimating probabilities of using private transport, daily travel duration, and frequency.

	Use			Time			Frequency		
	Estimate	Std. Error	<i>p</i> (> z )	Estimate	Std. Error	<i>p</i> (> t )	Estimate	Std. Error	<i>p</i> (> t )
<b>Intercept</b>	−1.33	0.13	<0.001	72.68	8.7	<0.001	2.51	0.16	<0.001
<b>Year (ref = 2008)</b>			0.024			<0.001			0.071
2018	−0.39	0.16	0.015	16.21	10.47	0.122	−0.09	0.19	0.654
<b>Gender (ref = Male)</b>			<0.001			<0.001			0.021
Female	−0.24	0.17	0.171	−6.26	11.74	0.594	−0.39	0.21	0.069
<b>Age (ref = 16–29)</b>			<0.001			0.002			<0.001
30–65	0.04	0.12	0.760	−2.68	6.53	0.681	−0.2	0.12	0.100
>65	−0.64	0.17	<0.001	14.73	10.78	0.172	0.04	0.2	0.835

Table 3. Cont.

	Use			Time			Frequency		
	Estimate	Std. Error	<i>p</i> (> z )	Estimate	Std. Error	<i>p</i> (> t )	Estimate	Std. Error	<i>p</i> (> t )
<b>Metropolitan region (ref = Barcelona)</b>			<0.001			<0.001			<0.001
First ring	0.72	0.13	<0.001	19.82	8.41	0.185	0.32	0.15	0.037
Second ring	1.58	0.11	<0.001	27.36	6.91	<0.001	0.41	0.13	0.001
<b>Profession (ref = Student)</b>			<0.001			<0.001			<0.001
Homemaker	−0.03	0.14	0.829	22.64	9.58	0.018	0.3	0.17	0.083
Retired	−0.17	0.13	0.181	−10.96	8.16	0.179	−0.1	0.15	0.486
Unemployed	−0.07	0.11	0.504	3.68	7.32	0.615	0.3	0.13	0.022
Employed	0.83	0.09	<0.001	14.94	5.91	0.012	0.33	0.11	0.002
<b>Education (ref = Primary)</b>			<0.001			<0.001			0.251
Secondary	0.34	0.05	<0.001	5.79	3.07	0.059	0.06	0.06	0.279
Tertiary	0.46	0.05	<0.001	16.4	3.21	<0.001	0.16	0.06	0.008
<b>Year:Gender</b>			0.871			0.264			0.323
2018:Female	−0.35	0.23	0.136	−25.22	15.84	0.111	−0.55	0.29	0.056
<b>Year:Age</b>			<0.001			0.010			<0.001
2018:30–65	0.63	0.15	<0.001	15.77	8.49	0.063	0.42	0.15	0.006
2018:>65	1.07	0.18	<0.001	11.88	11.92	0.319	0.35	0.22	0.106
<b>Gender:Age</b>			<0.001			0.215			<0.001
Female:30–65	−0.31	0.16	0.042	5.04	9.12	0.580	0.31	0.17	0.059
Female:>65	−0.3	0.2	0.137	−5.49	14.33	0.701	−0.46	0.26	0.079
<b>Year:Metropolitan region</b>			0.155			0.339			0.837
2018:First ring	−0.12	0.16	0.474	−23.68	10.63	0.026	−0.24	0.19	0.207
2018:Second ring	−0.2	0.14	0.140	−13.88	8.7	0.111	−0.12	0.16	0.464
<b>Gender:Metropolitan region</b>			<0.001			0.138			<0.001
Female:First ring	−0.36	0.19	0.056	−25.87	13.41	0.054	−0.15	0.24	0.535
Female:Second ring	−0.07	0.16	0.651	0.74	10.62	0.944	0.29	0.19	0.135
<b>Year:Gender:Age</b>			0.298			0.832			0.069
2018:Female:30–65	−0.26	0.21	0.221	7.26	12.48	0.560	0.29	0.23	0.218
2018:Female:>65	−0.4	0.27	0.135	8.29	18.5	0.654	0.78	0.34	0.021
<b>Year:Gender:Metropolitan region</b>			<0.001			0.104			0.436
2018:Female:First ring	0.77	0.24	0.001	34.84	17.13	0.042	0.4	0.31	0.202
2018:Female:Second ring	0.73	0.2	<0.001	11.57	13.78	0.401	0.17	0.25	0.488

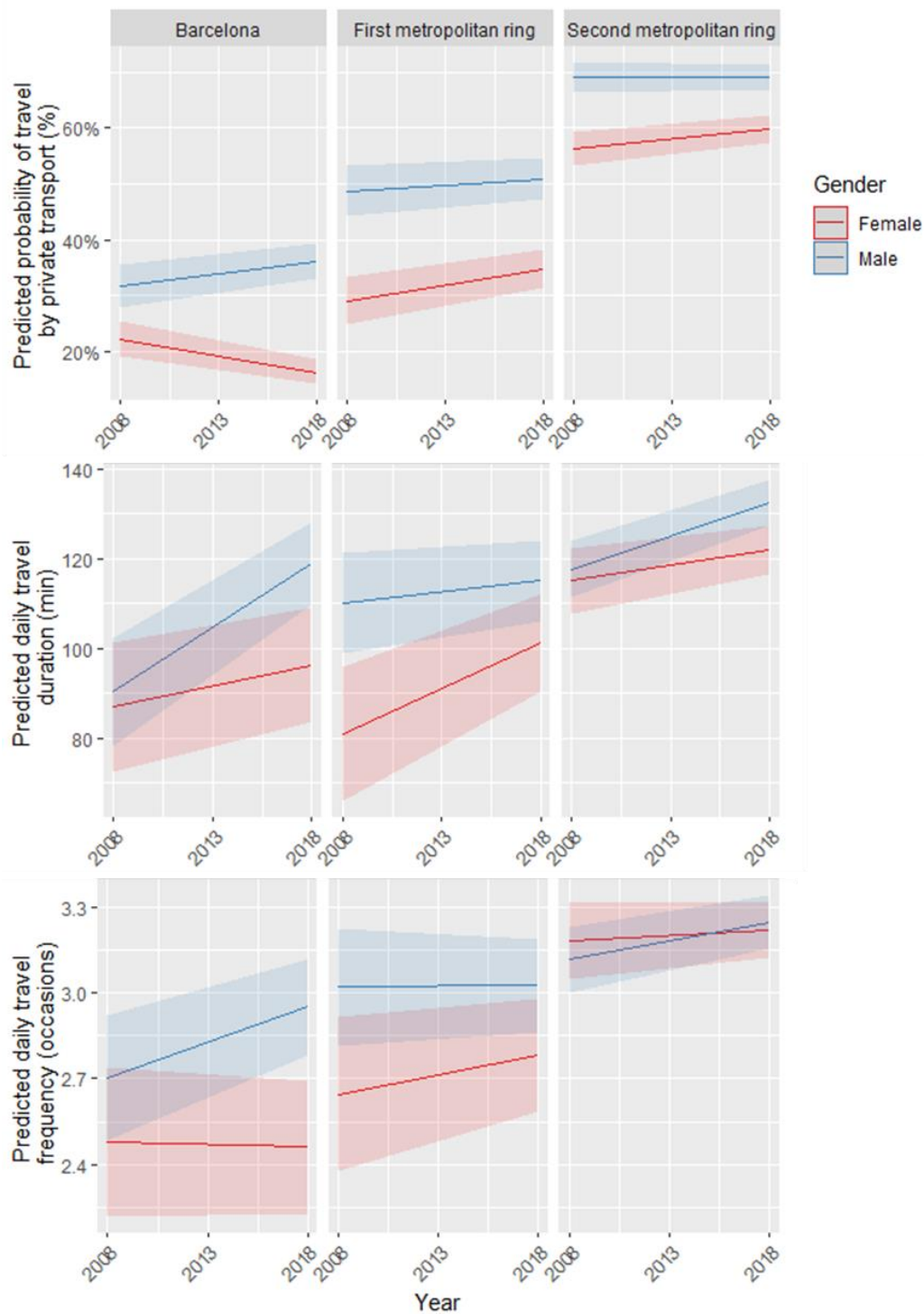
In terms of geographical context, the use of private transport grew from 2008 to 2018 in the three areas covered ( $p = 0.155$ ). Table 4 provides the estimated probabilities of private transport use and the predicted daily travel frequencies and durations (see the illustration of predicted probabilities of private transport variables in Figure 1). It is noteworthy that when data were disaggregated by gender, two opposite trends surfaced for Barcelona. While men dwelling in the city increased their use of private transport (from 31.6% to 36.2%;  $p < 0.001$ ), women lowered their use of private transport (from 22.1% to 16.3%;  $p < 0.001$ ), hence duplicating the width of the gender gap (difference went from 9.5 in 2008 to 19.9 in 2018). In 2018, there were twice as many male private transport users than female users in Barcelona (36.2% vs. 16.3%). In the first and second metropolitan rings, the gender gap shrunk (from 19.8 to 16.1 and from 13.0 to 9.3 difference), which was mainly due to the growth in the private mobility of females at a higher rate than for males.

**Table 4.** Estimated probabilities of travel by private mode, daily trip duration, and daily frequency [95% confidence limits].

	2008			2018			Difference 2008–2018 (%)		
	Use	Time	Frequency	Use	Time	Frequency	Use	Time	Frequency
<b>Female</b>									
Barcelona	22.1 [19.1–25.4]	87.0 [72.6–101.3]	2.5 [2.2–2.7]	16.3 [14.2–18.5]	96.3 [83.6–108.9]	2.5 [2.2–2.7]	–5.8 (–26.3%)	9.3 (10.7%)	0.0 (–0.8%)
First ring	28.9 [25.0–33.3]	80.9 [66.0–95.8]	2.7 [2.4–2.9]	34.8 [31.4–38.4]	101.4 [90.6–112.1]	2.8 [2.6–3.0]	5.9 (20.3%)	20.5 (25.3%)	0.1 (4.9%)
Second ring	56.2 [53.2–59.2]	115.1 [107.8–122.4]	3.2 [3.0–3.3]	59.9 [57.5–62.2]	122.1 [116.7–127.5]	3.2 [3.1–3.3]	3.7 (6.5%)	7.0 (6.1%)	0.0 (1.3%)
<b>Male</b>									
Barcelona	31.6 [28.0–35.4]	90.4 [78.3–102.4]	2.7 [2.5–2.9]	36.2 [33.1–39.4]	118.9 [109.7–128.2]	3.0 [2.8–3.1]	4.6 (14.6%)	28.5 (31.6%)	0.3 (9.3%)
First ring	48.7 [44.2–53.3]	110.2 [98.9–121.4]	3.0 [2.8–3.2]	50.9 [47.2–54.6]	115.0 [106.0–124.0]	3.0 [2.9–3.2]	2.2 (4.5%)	4.9 (4.4%)	0.0 (0.0%)
Second ring	69.2 [66.5–71.8]	117.7 [111.6–123.9]	3.1 [3.0–3.2]	69.2 [66.9–71.4]	132.4 [127.3–137.4]	3.3 [3.2–3.3]	0.0 (0.0%)	14.7 (12.5%)	0.1 (4.5%)
<b>Gender difference (%)</b>									
Barcelona	9.5 (30.1%)	3.4 (3.8%)	0.2 (8.15%)	19.9 (55.1%)	22.6 (19.0%)	0.5 (16.6%)	10.4 (109.2%)	19.2 (565.6%)	0.3 (122.7%)
First ring	19.8 (40.6%)	29.3 (26.6%)	0.4 (12.3%)	16.1 (31.7%)	13.7 (11.9%)	0.2 (8.0%)	–3.7 (–18.5%)	–15.6 (–53.31%)	–0.1 (–35.1%)
Second ring	13.0 (18.8%)	2.7 (2.3%)	–0.1 (–2.3%)	9.3 (13.5%)	10.3 (7.8%)	0.0 (0.9%)	–3.7 (–28.2%)	7.7 (28.2%)	0.1 (142.9%)

Despite gender differences being significant within each age category ( $p < 0.001$ ), generational trends did not reveal a gender-specific character ( $p = 0.298$ ). In this line, two generational counter trends had emerged over the last decade. Compared to their predecessors, new generations of young adults (16–29 years of age) dropped their use of private modes (from 52.6% to 44.8%;  $p < 0.001$ ). By contrast, private mobility rose among middle age adults (30–65 years of age) and older adults (>65 years of age) (from 52.9% to 58.8%, and from 22.9% to 30.7%;  $p < 0.001$ ).





**Figure 1.** Predicted probabilities of travel by private transport, travel duration, and frequency by gender, year, and geographical context. Source: own elaboration.

### 3.2. Duration and Frequency of Private Transport Trips

The daily amount of time spent on private transport trips grew significantly between 2008 and 2018 (from 117.1 to 123.2 min;  $p < 0.001$ ). In the same line, the number of trips slightly increased in the last decade (from 3.0 to 3.1;  $p = 0.71$ ). Overall, women still drove for less periods of time ( $p < 0.001$ ) and on fewer occasions ( $p = 0.021$ ) than men, while having increased their presence in private transportation.

Both duration and occasions using private mode increased in the three spatial scenarios, but particularly in Barcelona (from 89.6 to 116.1 min;  $p = 0.338$  and from 2.6 to 2.8 occasions;  $p = 0.837$ ). Although this spatial trend was not significantly associated with gender, it is noteworthy that the gender gap widened between 2008 and 2018 in the city, with a widening of the gap by up to 5.6 times in terms of trip duration (from 3.4 to 22.6 min difference), and duplicated itself in terms of travel frequency (from 0.2 to 0.5 difference). The slightest gender difference in travel patterns was located in the second metropolitan ring, where private transport use was more widespread among both men and women.

In terms of generations, middle-aged adults not only expanded their share in private transport, but they also revealed the highest growth rate in the time duration for driving (from 109.3 to 128.8 min;  $p = 0.010$ ) and travel frequency (from 3.0 to 3.3 trips per day;  $p < 0.001$ ). Older adults displayed a similar pattern, both in daily travel duration (from 99.9 to 113.7 min;  $p = 0.010$ ) and occasions using the private mode (from 2.6 to 2.9 occasions;  $p < 0.001$ ). By contrast, young adults presented the slightest time rise (from 104.5 to 106.0;  $p = 0.010$ ) and even decreased travel frequency (from 3.0 to 2.7 occasions;  $p > 0.001$ ). The number of trips using private transport was significantly associated with gender in each age group ( $p < 0.001$ ) and in each metropolitan context ( $p < 0.001$ ).

#### 4. Discussion

Over the last decade, private mobility levels have expanded all around the Barcelona Metropolitan Region (BMR), with an increase in private transport use, daily travel duration, and frequency. Nonetheless, a mobility countertrend surfaced among younger generations. In line with previous research, our results corroborate H1: a decrease in private mobility levels among new generations of young adults [10,11,28]. While the previous literature found that young men dropped driving at a higher rate than women [8,12], and attributed this phenomenon to an 'urban renaissance' [9], the generational countertrend reported in the BMR was not associated with either gender or geographical context. Therefore, we argue that the downward tendency in private mobility may be linked with demographic and economic factors, as well as preferences and attitudes.

From a demographic perspective, current Catalan young adults are less likely to be employed, married, or parents compared to young adults from previous generations [39–41]. [11] suggested that students, the unemployed, or the childless have fewer travel needs. This narrative hypothesizes that as young adults become employed or experience childbearing their travel needs will grow, but at a later age than previous generations [10,11]. Also, unemployment increases affordability constraints to access private transportation. Since the economic crisis of 2007, emancipation from the parental home has been delayed and household budgets, together with house-price inflation, have been major limitations among young Catalan adults [42]. Thereby, we argue that the financial costs of licensure and car ownership may constitute an economic burden for young adults [28].

The decline in private mobility among young adults may also be explained due to different preferences and attitudes towards transport than former generations. Unlike previous cohorts, new generations of young adults no longer consider the car as the single symbol of freedom, but greater value is placed in acquiring mobile technology and having internet access [9,11]. Indeed, technology may substitute physical interaction for online interaction (such as online shopping, telework, or social media), hence reducing travel needs [11]. [43] has argued that these technological changes may shape transport needs, particularly among new generations of young adults. Finally, raising environmental awareness regarding private transport use may also explain young adults' disaffection with driving [28].

Since travel behaviors are influenced by past life experiences and shaped by social changes, generational travel trends can predict future mobility patterns [8]. However, further long-term analysis is needed to conclude whether sustainable mobility trends of younger generations represent a structural change in travel behavior and whether those younger generations are likely to catch up with the mobility levels of their predecessors as they grow older. Therefore, the implications of these results for

policymakers are twofold. Planners will have to deal with the uncertainty of young adults' future travel trajectory, as well as encouraging sustainable mobility alternatives if their travel needs happen to increase. Policies should be tailored to reduce travel needs (e.g., through incentivizing telework) and to encourage modal shift from private vehicles to public or active modes (e.g., pricing of private use or improving public transport, pedestrian, or bicycle infrastructure) [11].

The generational decline in private transport usage among young adults contrasts with the mainstream mobility trends that have been reported in the BMR. In light of the aforementioned 'car peak' debate, our findings support a long-term growth in private transport usage with temporary interruptions due to economic circumstances, such as the Great Recession of 2007 [10,32]. While previous studies had found that male mobility became less car dependent and approached female normative travel behavior after the economic crises [18], our results suggest that male normative mobility patterns have remerged 10 years after the crisis. However, the evolution of gendered mobilities was not homogenous across the BMR, in that, whereas the travel gender gap diverged in Barcelona, this study found a tendency towards gender convergence in the first and second metropolitan rings. Therefore, H2 theorizing gender convergence of private travel behavior was confirmed for the two metropolitan rings and rejected for the City of Barcelona.

In contrast to the 'gender turnaround' hypothesis (H3) [9], our results indicate a gender drift in the core area of Barcelona City, even when the city benefits from its compact planning organization, homogenous distribution of services, and extensive fleet of public transport [36]. Although such an urban configuration is commonly associated with less car dependency [3], and even after years of planning for sustainability, our results suggest that unsustainable and gendered travel patterns have actually increased in the core area of the BMR. These findings contrast with previous research where men have substantially reduced private use in less car-dependent environments over recent decades [8,9]. We found that women's participation in private travel has decreased in less car-dependent areas, although this reduction might not be accompanied by an equivalent rise in alternative travel modes. Without feasible alternatives to the private mode, women face high risks of being homebound, immobile, or inactive [8].

Of greater cause for concern, in the two metropolitan rings, gender convergence was driven by a continued increase in women's private mobility rather than a downward trend in men's mobility levels. Although the fleet of drivers in the metropolitan rings was more balanced in 2018 than a decade ago, gender normative travel patterns persisted and expanded within driver population groups, e.g., men still accounted for the greatest share of private transport users and they undertook longer and more frequent trips. Previous studies have attributed this type of gender convergence, i.e., reproducing male normative mobility norms, to women's increasing labor force participation [27]. Nonetheless, women's occupation rate was similar in the two time periods [39]. We argue that the slight gender difference in the second metropolitan ring may be explained due to a scarcity of transport alternatives, hence if women have to travel, they will have to use private transport as often as men do.

Our results suggest that, counterintuitively, the gender gap is closer to convergence in those places where private transport use is more widespread. Therefore, increased gender equality conflicts with environmental sustainability goals. To achieve climate objectives in the BMR, specific public policy should be promoted to decouple gender convergence of travel behavior from the car-dependent built environment. In this line, [2] recommended challenging the gender norms that are dominant in the transport sector. Furthermore, policy interventions are needed to diversify mobility alternatives, especially in car-dependent contexts, to ensure both social and environmental sustainability.

## 5. Conclusions

This paper has explored recent trends in private mobility over generations and across the Barcelona Metropolitan Region, with a focus on gendered travel behavior. The study identified a generational countertrend among new generations of young adults, who reported more sustainable mobility practices than their older aged predecessors. Generalized linear models revealed that gender

convergence of travel behaviors occurred through the reproduction of male normative travel practices outside the core area of the city. One of the most significant findings of this research was the fact that the gender gap was increasing regarding private mobility use in Barcelona. In the future, to achieve gender equity and climate objectives, efforts should be made to decouple gender convergence of travel behavior from car-dependent built environments.

This study is not without limitations. Being limited to a descriptive and prospective approach, the lack of longitudinal data prevents us from establishing complete causal inferences. Changes in the urban environment and climate change awareness were not captured in our analysis and should be considered in future research. Furthermore, a more geographically detailed analysis that acknowledges the diversity of urban environments within each metropolitan region will help to study the relationship between geographical context and mobility trends in more detail.

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