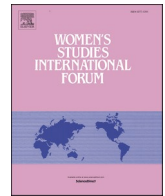


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Traffic compliance effect of more women behind the wheel: Pride or prejudice?

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ABSTRACT

Driving offences can cause road accidents with serious outcomes and are a topic where differences in attitudes and behaviour can be found between sexes. While men are more prone to taking risks and, statistically, are involved in a greater number of traffic accidents, even today, sex stereotypes persist with women regarded as worse drivers. To explore the truth behind the myth, this study analyses how the increase in the number of females in the driver census in Spain, could impact the effectiveness of traffic law enforcement in terms of traffic offences recorded by the traffic police (including the main violations such as passive safety feature use, speed limits and drunk driving) while considering a set of control variables related to the quality of infrastructure, legal reforms and other socio-economic attributes. The results point to Spanish women paying closer attention to traffic regulations, behaving more carefully, which should be considered in designing specific preventive policies and road safety awareness strategies.

1. Introduction

Despite the gap between women and men having reduced more than ever before at work and home, a large part of the literature shows that gender stereotypes persist in the second decade of the 21st century (Kiefer & Shih, 2006; Merma-Molina, Ávalos-Ramos, & Ruiz, 2022; van Breen, Spears, Kuppens, & de Lemus, 2018) and impact social interaction between women and men (Ellemers, 2018; López-Zafra & García-Retamero, 2012). Albeit more cultural and social than biological (Havet, Bayart, & Bonnel, 2021), these stereotypes can be seen in areas such as land transport, where gender differences can be found that impact mobility behaviour (Hanson, 2010). Indeed, international organisations such as the Organization for Economic Co-operation and Development (ITF, 2019) and the United Nations (2022) have highlighted that a fully efficient and equitable transport policy cannot be implemented if the gender perspective is not included.

During recent decades, research has analysed sex differences in mobility (Olivieri & Fageda, 2021) from several points of view. For example, women's mobility patterns are usually more complex and multipurpose, with shorter travel times and distances and more breaks (see, e.g., Jain, Line, & Lyons, 2011; McGuckin & Murakami, 1999). This could be due to women's daily activities (Tiikkaja & Liimatainen, 2021) and a reflection of the different roles that they continue to play in

household chores, caring for children and their responsibility for elderly relatives (Marcén & Morales, 2021; Punzo, Panarello, & Castellano, 2022; Scheiner, 2020; Tilley & Houston, 2016).

Sex differences have also been studied in the choice of transport mode. Several empirical studies have found that in both developed and developing countries, women are frequently more inclined to use public and sustainable modes (Saigal, Vaish, & Rao, 2021) and even other new mobility modes such as shared vehicles and app-based rental/sharing services, especially in the wake of the recent COVID-19 pandemic (Awad-Núñez, Julio, Gomez, Moya-Gómez, & González, 2021). Scholars such as Olmo-Sánchez and Maeso-González (2016) have stated that the sex gap in the availability of driving licences to women and their access to private cars may determine their mobility choice to some extent. Although authors such as Scheiner (2020) have noticed some convergence between sexes in recent years, especially in some specific countries (e.g., Soltani, Pojani, Askari, & Masoumi, 2018 for Iran), licence possession and car access/ownership continue to be higher for men (Bose, Segui-Gomez, & Crandall, 2011; Kuhnimhof, Buehler, Wirtz, & Kalinowska, 2012; Priya Uteng, 2021).

The current paper's object of study lies in the road transport field, specifically in the area of traffic safety, which is another key factor for sex differences (Pravossoudovitch, Martha, Cury, & Granié, 2015). The emergence of the car used to be considered a threat to the social status of

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women and the meaning of family life (Berger, 1986) and, even today, it remains a controversial topic in some countries (Wheeler, 2020), with a gender stereotype continuing to prevail that considers women's behaviour at the wheel to be careless (Lawrence & Richardson, 2005) and an overrepresentation of female drivers in the media's public discussion of traffic accidents (Li & Luo, 2020). However, traffic accident figures show the truth to be otherwise: approximately 73 % of the 1.3 million people killed in road traffic accidents worldwide are young men under the age of 25, which shows that men are more likely to be involved in road crashes than women (WHO, 2018, 2022) (despite some authors pointing to a higher incidence of post-traumatic stress among women drivers who have experienced car crashes; see Abd El Fatah, 2021).

To a large extent, the literature agrees that sex differences in road safety can be explained by the different traffic violation behaviour of men and women (Özkan & Lajunen, 2006). However, following Laapotti, Keskinen, and Rajalin (2003), more studies are needed on the driving behaviour of female drivers to determine whether, as speculated by Cordellieri et al. (2016), it is true that women have become more 'masculinised' in their driving patterns.

Therefore, to explore the effect of the presence of women on Spanish road safety, this paper aims to analyse the impact of an increasing number of female drivers on compliance with traffic regulations, expressed as the number of violations recorded by the traffic police on interurban roads during the 2005–2019 period. This period was selected, firstly, based on the Strategic Road Safety Plan 2005–2008 applied by the Spanish Directorate General of Traffic (DGT). This marked a turning point in road safety management in Spain (Pérez, 2009), as the very first approach to the gender dimension with the recommendation that the 'feminisation' of driving would be desirable for the 21st century (AEVAL, 2009). Secondly, the research period ends in 2019, which was the last year with normal mobility before the recent COVID-19 pandemic.

Our work contributes to the literature on how sex differences in driving behaviour and attitudes influence compliance with traffic rules, at several levels (i.e., methodological approach, territorial unit and temporal dimension of analysis and type of law compliance categories). From a methodological point of view, we perform an analysis based on official reported data provided by the Spanish traffic police from a collection of objective and actual traffic violations committed by a population of male and female drivers. This is in contrast to previous research, which was mostly based on self-reported traffic violations in the Driver Behaviour Questionnaire (DBQ) or Driver Skill Inventory (DSI) applied to sub-groups of drivers as predictors of traffic offences. In this sense, according to several authors, self-reports on driving behaviour and accidents could present certain design limitations (due to sample choice and composition, time period selected and questionnaire design, Mullinix, Leeper, Druckman, & Freese, 2015) and biases as self-reporters may modify their answers for social desirability (Bergen & Labonté, 2020), remember episodes incorrectly (Martinussen, Møller, Prato, & Haustein, 2017) or even provide unreliable answers on driving convictions given their fear of losing their licences (Finestone et al., 2011).

Other relevant aspects can be added to this strength. The first of these is the length of the time sample: 15 years. This broad period of time enables events to be included that are determinants of Spanish road safety, including the effect of economic cycles such as the 2007–2008 financial crisis (Wegman et al., 2017), and the various road safety legislation reforms implemented in Spain, such as the introduction of the points-based driving licence in July 2006 (Aparicio-Izquierdo, Arenas-Ramírez, Mira-McWilliams, & Páez-Ayuso, 2011) and the toughening of traffic Penal Law in December 2007 (Castillo-Manzano, Castro-Nuño, & Pedregal, 2011) (see Table A.1 in the Annex for a summary of all the main strategies implemented during our research period). Furthermore, from a territorial perspective, the country under study, Spain, has been internationally recognised for its road safety achievements during the 21st century (Castro-Nuño & Arévalo-Quijada, 2018). Lastly, we

consider a panel of 43 Spanish NUTS-3 regions, which provides a wide analysis that allows to detect sex differences in driving behaviour that, if treated at the country level, could remain undetected.

Finally, the broad spectrum of the violations analysed (related to the main causes of crashes) stands out (exceeding the permitted amount of alcohol in the blood; speeding; unauthorised overtaking; inappropriate mobile phone use, and violations related to seatbelt use, helmet use by motorcycle riders and child restraint systems) and will enable further development of the sex perspective in road safety and provide deeper knowledge of the problem to guide the design of the most appropriate policies and strategies.

To achieve these objectives, this paper is organised as follows: after this Introduction, Section 2 gives a brief literature review of our topic of analysis: differences in male and female compliance with traffic regulations. Section 3 explains the data collection and methodology. Section 4 offers a discussion of the results and, finally, we include a set of concluding remarks.

2. Sex differences and compliance with traffic regulations: a brief literature review

The prior literature has analysed sex differences and road safety extensively and concluded that the fatality rate (Santamariña-Rubio, Pérez, Olabarria, & Novoa, 2014), risk of accidents with damage and personal injury (Oltedal & Rundmo, 2006) and fatal accident involvement rate (Li, Baker, Langlois, & Kelen, 1998) are all higher for males.

From a road safety outcome perspective, it would seem clear that there is a close link between the accident rate and sex differences between women and men; but safety should not only be measured by accidents and fatalities as road safety is more than a simple absence of accidents (Oppenheim, Oron-Gilad, Parmet, & Shinar, 2016). Driver behaviour and violations also need to be considered and analysed. As Zhang, Yau, and Chen (2013) demonstrate, traffic violations are one of the major risks that threaten road safety and their control through compliance with regulations is a key instrument for reducing serious injury and fatality rates. In this sense, according to researchers, sex differences in driving patterns should not only be explained according to a perceived gender stereotype regarding competency and driving-related skills (Bener, Özkan, & Lajunen, 2008; Degraeve, Granié, Pravossoudovitch, & Lo Monaco, 2015; McKay & Huber, 1992) but also by men and women exhibiting different behaviours that may influence their compliance with traffic rules, attitudes and risk-proneness in terms of aggressive, competitive and hostile driving (Özkan & Lajunen, 2006).

Other factors may also exist that contribute to these results. Firstly, there may be some bias in both the sanctioning authorities' perceptions (Homel, 1983) and in the way that gender stereotypes apportion blame in traffic accidents (Lawrence & Richardson, 2005). Secondly, according to data from Lonczak, Neighbors, and Donovan (2007), females are more likely than males to drive with children in their cars, which is a strong incentive to be more cautious while driving. Thirdly, exposure to driving is a major factor as, for some authors (see Lawton, Parker, & Stradling, 1997), it is plausible that men commit more violations than females as a result of their increased mileage. However, no consensus exists in this respect, given that Laapotti et al. (2003) demonstrated that sex differences in driving behaviour persist even after controlling for mileage. Lastly, the fact that some elderly women prematurely stop or markedly reduce their driving despite there being no medical or financial reason for doing so may also have an effect (Wilkins, Stutts, & Schatz, 1999).

In general terms, and without distinguishing between types of accidents, there is extensive evidence of a higher involvement of men than women in risk-taking (Morgenroth, Fine, Ryan, & Genat, 2018) and that it is observed to be significant in a wide variety of settings for young and novice male drivers with higher levels of sensation-seeking (Factor, 2018; Harris, Jenkins, & Glaser, 2006). Risk-taking can even persist as men get older (Cullen et al., 2021; Song et al., 2021), which leads them to commit more traffic violations and offences (Jing, Shan, & Zhang,

Table 1
Description of the variables (Spanish NUTS-3 regions, excluding the Basque Country and Catalonia) and descriptive statistics.

Variable	Definition	Source	Mean	Std. dev	Min.	Max.
Endogenous variable: recorded traffic offences						
Total offences	Total no. offences	Civil Guard Traffic Task Force	50,362.740	33,578.560	12,229	248,744
Drunk driving (driving under the influence of alcohol)	Positive breathalyser tests		2125.825	1777.585	138	7744
Speed	Number of speeding offences		20,404.410	12,638.100	1939	66,783
Phone	Mobile phone use offences		2428.887	3424.102	270	29,685
CRS	Child safety restraint system offences		167.761	209.311	1	1946
Overtaking	Overtaking offences		406.457	290.619	32	1688
Belt	Seatbelt offences		3212.947	2828.609	394	22,342
Helmet	Helmet offences	238.544	569.368	1	7319	
Exposure variable						
Registrations	Number of new motor vehicle registrations	Spanish Directorate General of Traffic Yearbook	29,299.56	62,259.29	1073	500,993
Exogenous variables by category						
Sex differences variable						
Women drivers ¹	% of females with driving licences ² out of total drivers on driver census	Spanish Directorate General of Traffic Yearbook	0.402	0.028	0.334	0.508
Traffic law enforcement variables						
Alcohol control	Number of breathalyser tests administered by CGTF (in hundreds of thousands)	Civil Guard Traffic Task Force	1.260	0.911	0.130	6.349
Speed control	Number of vehicles subjected to speed tests using CGTF radar equipment (stationary and mobile) ³ (in hundreds of thousands)		5.835	5.093	0.461	49.773
Officers	Number of CGTF officers deployed (annual average) (log)		7.655	0.416	6.685	9.209
Demographic and economic variables						
Mean age	Mean age of population in years	Spanish National Statistics Institute	42.974	3.025	36.9	50.93
GDP	Gross domestic product at current prices (in millions of euros)	Spanish National Statistics Institute	18.782	30.401	1.890	242.093
Infrastructure variable						
Quality of infrastructure	Ratio between the sum of the length of highways and the sum of the length of all types of roads	Spanish Ministry of Transport, Mobility, and Urban Agenda	0.0716	0.0360	0.0109	0.1897
Meteorological variables						
Rainfall	Rainfall (in tenths of a millimetre)	Spanish State Meteorological Agency	5147.605	3053.1	586	18,837
Mean temperature	Mean temperature (in tenths of a °C)		156.896	29.380	100.3	225
Legislation reform variables						
Points licence	Dummy variable for the introduction of the points-based driving licence in 2006	Prepared by authors	0.93	0.24	0	1
Penal Code	Dummy variable for the Penal Code reform in 2007	Prepared by authors	0.86	0.34	0	1
Linear time trend						
Time trend		Prepared by authors	2012	4.324	2005	2019

¹ We consider a binary sex categorisation (male/female) as official statistics on driving licences are only available according to this categorisation.

² It does not include moped and scooter licences, licences for people with reduced mobility and licences to operate agricultural equipment.

³ The Speed Control variable only quantifies controls conducted by radar mounted on Civil Guard Traffic Task Force vehicles. Controls using permanent roadside radar equipment are, therefore, excluded.

2022; Laapotti, Keskinen, Hatakka, & Katila, 2001) including, e.g., speeding (Hassan, Shawky, Kishta, Garib, & Al-Harthei, 2017; Varet, Apostolidis, & Granié, 2023), seat-belt use (Bose et al., 2011), use of mobile phones while driving (Przeziorka, Blachnio, & Sullman, 2018) and drug use and drunk driving (DeJoy, 1992; Mathijssen, 2005), with the consequent greater likelihood of crashing (Coquelet, Granié, & Griffet, 2019; Oppenheim et al., 2016).

In summary, considering all the above, everything points to women presenting a greater sense of obligation to comply with traffic regulations (Yadav & Velaga, 2021; Yagil, 1998) than men, who tend to overestimate their driving skills and abilities, especially in the case of young males who are more prone to negatively evaluating traffic regulations and underestimating the risks attached to traffic violations (Sundström, 2008).

In the case of Spanish road safety, which is the research object of the current paper, an in-depth analysis of driving differences between women and men, is particularly pertinent as, according to DGT (2020) data, the number of women on the driver census has progressively increased from just below 7 million in 2000 (37 %) to 11.6 million in 2019 (43 %), which equates to an increase of 67 % (compared to a 30.7 % increase in male licences on the census).

This growth in the number of Spanish women behind the wheel may be what has sparked the increasing number of studies in recent years that have explored sex differences in relevant road safety issues. Basically, all these studies coincide in confirming the patterns already generally mentioned in the preceding paragraphs concerning men's higher accident involvement compared to their female counterparts and their clear tendency to engage in risk behaviours (González-Sánchez, Olmo-Sánchez, Maeso-González, Gutiérrez-Bedmar, & García-Rodríguez, 2021; Jiménez-Mejías et al., 2014; Lardelli Claret et al., 2003; Martínez-Gabaldón, Martínez-Peréz, & Méndez, 2019; Mateos-Granados et al., 2021), which can also be extended to some specific areas such as motorcycle crashes (Hidalgo-Fuentes & Sospedra-Baeza, 2019; Perez-Fuster, Rodrigo, Ballestar, & Sanmartin, 2013) and occupational road crashes (López, Oj, & Fontaneda, 2017; Rey-Merchán & López-Arquillos, 2021).

Previous findings are also confirmed that point to men exhibiting angrier and more aggressive driving behaviours (Gras et al., 2006) and a greater propensity to infringe traffic regulations (González-Iglesias, Gómez-Fraguela, & Luengo-Martín, 2012), as well as lower compliance with some specific regulations such as Vehicle Technical Inspections (VTIs) (Alonso, Useche, Gene-Morales, & Esteban, 2021), the Penalty-Points System (PPS) driving licence (Gras, Font-Mayolas, Planes, & Sullman, 2014; Pulido et al., 2021), and a greater likelihood that they will become repeat offenders (Lijarcio, Llamazares, Valle, Montoro, & Useche, 2022).

As already noted in the Introduction section, in the case of Spain, our original contribution to the literature is an unprecedented econometric analysis of different traffic compliance behaviours by sex, based on the objective official record of offences compiled by the Spanish road traffic police, who are responsible for enforcing traffic regulations, with the disaggregation of traffic violation typologies involved in the most serious traffic accidents according to evidence. In summary, to our knowledge, no precedent exists in the literature that addresses a sex difference perspective in traffic law compliance with such a deep territorial treatment, disaggregation by traffic law infringement category and based on unbiased data of observed real traffic violations for Spain or for other countries.

3. Data and methodology

The dataset is constructed using data available for a sample taken from the 43 Spanish NUTS 3 regions (provinces) according to Eurostat statistical classification. The chosen study period is from 2005 to 2019, as justified in the Introduction section.

The endogenous variable measures the total number of tickets issued

by the Civil Guard Traffic Task Force (CGTF) on interurban roads by different types of violation, in all of the Spanish national territory except the Basque Country and Catalonia as, during the period under analysis, the CGTF was responsible for policing compliance with traffic regulations in all regions except these two (see Castillo-Manzano, Castro-Nuño, Lopez-Valpuesta & Boby, 2022).

The explanatory variables cover the proportion of drivers on the Spanish driver census who are women, whose effect on the number of offences detected for traffic violations is this paper's study object. Also included is a further series of exogenous variable typologies previously established in the specialised academic literature that might also impact road safety and compliance with traffic regulations, including policing and surveillance, demographic and economic characteristics and infrastructure- and meteorology-related variables.

Table 1 gives the definitions of the different endogenous and explanatory variables used in each of the typologies, as well as their descriptive statistics and the sources from which they are taken.

Several panel data models have been estimated, assuming a negative binomial distribution with a logarithmic link function, which is the most natural link function for count data. Besides, the negative binomial is a count model regularly used in the academic literature to analyse road safety dynamics (see Albalade, Fernández, & Yarygina, 2013; Özkan & Lajunen, 2006) and, as in our case, is appropriate for traffic infractions (as stated in Cheng, Zhang, Wang, & Huang, 2022, Hagen, Reinfeld, & Saki, 2023 and Wang et al., 2022). It is also justified by the non-normal distribution of the variables (see Doornik-Hansen test results in Table 2) and the Pearson goodness-of-fit Chi-Squared tests.

Standard errors robust to heteroscedasticity (see Modified Wald Test results for heteroscedasticity in Table 2) have been estimated and an AR (1) correlation is assumed in the error term (see Wooldridge Test results for autocorrelation in Table 2). Province fixed effects have also been included as they enable the stable characteristics of the different NUTS-3 units to be taken into account. Finally, Table 2 shows that the variance inflation factors of all the variables used in the empirical analysis are below 5, so the models are not affected by any multicollinearity issues.

4. Discussion of results

Table 2 gives the estimation results for the models described in the previous section.

It shows that the number of women drivers is negatively related to the total number of offences managed by the CGTF and all the recorded offences of traffic violations except overtaking and helmet use, neither of which are significant.

An analysis by type of violation highlights, firstly, the negative signs of drunk driving and radar-detected speeding violations, which, according to Lardelli-Claret et al. (2005), are the main driver-dependent risk factors that cause vehicle collisions in Spain. This finding is in line with Gwyther and Holland (2012) and Kostyniuk, Molnar, and Eby (1996), for whom women are much less likely to drink and drive than men of the same age and are, therefore, less involved in alcohol-related crashes (Cordellieri et al., 2016; Kelley-Baker & Romano, 2010; Romano, Fell, Li, Simons-Morton, & Vaca, 2021; Romano, Peck, & Voas, 2012). Most studies also consider females to be less involved in speeding-related crashes than males (Islam & Mannering, 2021; Kelley-Baker & Romano, 2010; Kostyniuk et al., 1996).

Concerning mobile phone use, our results show a negative relationship between the number of women drivers and the number of mobile phone use violations. Once again, the literature observes substantial differences between males and females regarding their willingness to use their phones while driving, with a more significant proportion of males charged for this practice than females (Brusque & Alauzet, 2008; Lipovac, Đerić, Tešić, Andrić, & Marić, 2017). Better behaviour is also observed in females regarding the use of safety devices such as seatbelts and child restraint systems; Li et al. (2022) show that gender significantly affects parent support for child safety seat legislation, with female

Table 2
 Estimation results (panel data model, population averaged with negative binomial distribution and logarithmic link).

Exogenous variables	Total offences	Endogenous variables: offences						
		Drunk driving	Speed	Phone	CRS	Overtaking	Belt	Helmet
Women drivers	-9.65316 (2.45569)***	-13.37852 (2.55017)***	-12.77632 (3.14820)***	-15.24186 (2.95927)***	-26.47874 (4.64872)***	-8.35263 (3.12056)***	-14.25335 (3.53539)***	0.47122 (3.32433)
Alcohol control	0.15048 (0.07602)**	0.32094 (0.07073)***	-	-	-	-	-	-
Speed control	0.06026 (0.01021)***	-	0.12786 (0.02009)***	-	-	-	-	-
Officers	0.79755 (0.16257)***	0.92881 (0.15679)***	0.39119 (0.18944)**	2.25295 (0.18957)***	2.32966 (0.28674)***	1.63372 (0.17880)***	1.82939 (0.22278)***	1.01667 (0.23362)***
Mean age	-0.47207 (0.07652)**	-0.46395 (0.08618)**	-0.50018 (0.09284)**	-0.41671 (0.08851)***	-0.74626 (0.16511)**	-0.36468 (0.07782)***	-0.60843 (0.09344)**	-0.45798 (0.11349)***
GDP	-0.02684 (0.00959)***	-0.02160 (0.01166)*	-0.03816 (0.01285)***	-0.01505 (0.00504)***	-0.03048 (0.01577)*	0.00586 (0.00309)*	-0.01669 (0.00893)*	0.00271 (0.00416)
Quality of infrastructure	1.31997 (1.92811)	2.44923 (2.10839)	1.78077 (2.34286)	-0.69089 (2.27925)	2.74670 (3.65531)	-5.70578 (2.70551)**	1.77531 (2.68417)	-0.62437 (3.66354)
Rainfall	-0.000019 (6.78e-06)***	-0.000019 (5.53e-06)***	-0.000018 (7.75e-06)**	-0.000023 (7.17e-06)***	-0.000025 (0.000012)**	-0.000019 (6.39e-06)***	-0.000033 (9.27e-06)***	-0.000017 (0.000011)
Mean temperature	0.00201 (0.00208)	0.00148 (0.00171)	0.00442 (0.00300)	0.00345 (0.00236)	0.00136 (0.00350)	0.00399 (0.00214)*	0.00524 (0.00296)*	0.00331 (0.00334)
Points licence	0.12010 (0.03960)***	0.06473 (0.03842)*	-0.04018 (0.05416)	0.17232 (0.06675)**	0.34903 (0.09673)***	0.09903 (0.05062)*	0.15625 (0.07493)**	0.03123 (0.07581)
Penal Code	-0.17378 (0.03345)***	-0.09540 (0.02893)***	-0.06102 (0.04522)	-0.06519 (0.04518)	-0.07820 (0.08062)	-0.08872 (0.03593)**	-0.11809 (0.04877)**	-0.21613 (0.05913)***
Time trend	0.18871 (0.02035)**	0.17044 (0.02216)***	0.22319 (0.02366)***	0.20793 (0.02051)**	0.39025 (0.04050)***	0.08460 (0.01812)**	0.21209 (0.02288)***	-0.01455 (0.03179)
Province fixed effects					Yes			
Doornik-Hansen multiv. normality test	10,762.003***	10,535.452***	11,240.078***	10,882.890***	12,437.373***	12,740.924***	10,983.955***	12,582.688***
Modified Wald Test — heteroscedasticity	12,695.83***	2581.93***	27,980.92***	720.53***	3576.30***	19,588.05***	2036.65***	11,863.87***
Wooldridge Test — autocorrelation	169.559***	400.492***	146.091***	121.092***	133.243***	79.397***	156.086***	43.507***
Wald Test (joint significance)	859.83***	572.20***	435.69***	430.53***	533.41***	422.69***	335.03***	664.86***
Max. VIF/Mean VIF	3.41/2.67	3.29/2.57	3.34/2.46				3.18/2.44	
No. observations					645			
No. NUTS 3					43			

Note: Standard errors in brackets.
 *** Statistical significance at 1 %.
 ** Statistical significance at 5 %.
 * Statistical significance at 10 %.

drivers more likely to use child restraint systems (Ojo, 2018). As highlighted by Kostyniuk et al. (1996), Lerner et al. (2001), Ojo (2018) and Tipton, Camp, and Hsu (1990), the same reasoning applies to seatbelt use.

An interesting and significant result is obtained for the coefficient for overtaking violations, with a negative sign linked to the influence of drivers' sex differences. According to the prior literature, the most aberrant offenders for this type of violation are males (Peng, Wang, & Chen, 2019). The reasons for this are that, firstly, male drivers generally overtake more than female drivers (Dobson, Brown, Ball, Powers, & McFadden, 1999), and, secondly, they tend to maintain a shorter following time and tailgate distance from the vehicle in front before initiating an overtaking manoeuvre (Bucsuházy et al., 2020). Their driving speeds also tend to be higher than desired (Shukri, Jones, & Conner, 2022).

As can be seen in Table 2, this result is significantly reinforced by the negative sign of the quality of roads/infrastructure variable for this type of violation, since, as the previous literature indicates, drivers' manoeuvres on a multilane motorway are less aggressive than on a two-lane single-carriageway road (Llorca, Angel-Domenech, Agustin-Gomez, & Garcia, 2017; Puan et al., 2019).

Lastly, the results in Table 2 also highlight that traffic violations associated with helmet use are not linked to the driver's sex, in line with

other studies where differences in helmet use by male and female drivers were not significant (see e.g., Xuequn, Ke, Ivers, Du, & Senserrick, 2011).

Continuing with the sociodemographic variables, a negative relationship can be observed between population mean age and the number of offences, with a significance of 1 % to 5 % depending on the model. This result is in line with other studies that have shown that age is another demographic variable frequently related to risky driving, with young drivers committing the most violations. For example, Yagil (1998) and Zhao, Xu, Ma, Li, and Chen (2019) highlight that the lowest perceived importance of traffic regulations was found among young male drivers. Kostyniuk et al. (1996), Vardaki and Yannis (2013) and Palumbo, Pfeiffer, Metzger, and Curry (2019) agreed with this, with the latter differentiating the higher rates of fatal crashes for older people and the lower rate of moving traffic violations for middle-aged drivers. Although elderly drivers do not always perform as well as young drivers, when faced with some critical events, they use certain strategies to reduce risk such as driving slowly and taking fewer chances (Milleville-Pennel & Marquez, 2020), which results in their committing fewer violations.

In light of the findings obtained for the coefficient with a negative sign linked to GDP, according to previous studies, it could be assumed that a country's economic status would influence the quality of its road

infrastructure, traffic law enforcement and awareness-education programmes, and traffic culture. This could directly or indirectly improve road safety (de Winter & Dodou, 2016; Gaygısız, 2010) in the sense that a high-income level could be associated with higher perceived law enforcement and governance, which are important variables for traffic enforcement (Solmazer, Üzümcüoğlu, & Özkan, 2016). The opposite may also be true: authors such as Wagenaar (1984) and Vandoor, Avendano, and Kawachi (2018), among others, demonstrate that economic crises can increase stress conditions for drivers and negatively influence the psychological well-being of drivers, which can lead them to commit more driving offences.

Moving on to the remaining explanatory variables in the model and focusing on the role of police surveillance of compliance with traffic regulations (Castillo-Manzano, Castro-Nuño, López-Valpuesta, & Pedregal, 2019), some important conclusions can be drawn from Table 2 regarding the role of traffic regulation enforcement. Specifically, a positive relationship at 1 % significance can be observed between the number of violation control instruments at the CGTF's disposal and the total number of violations (which corroborates the conclusions obtained by authors such as Feng, Wang, & Quddus, 2020), as well as specific offences in the cases of positive breathalyser tests and speeding. Moreover, there is also a positive relationship, at 1 % in most cases, between the mean number of police officers patrolling the roads and the total number of offences of all types.

Concerning the variables related to the two main road safety regulations implemented during our period of study (i.e., PPS and Penal Code reform, see full list in Table A.1, Annex), our results offer mixed evidence. In general terms, a positive significant sign is obtained for the PPS variable while a negative significant sign is estimated for the Penal Code reform coefficient. These findings could represent another example of how certain types of coercive laws inspired by re-education (which was how the Spanish PPS was conceived) might not have a clear and long-lasting effect on subjects' behaviour (Castillo-Manzano, Castro-Nuño, & Pedregal, 2010; Roca & Tortosa, 2008), prove to be insufficient and, thus, fail to prevent further offences and recidivism (Walter & Studdert, 2015; Zámečník, Gabrhel, Kurečková, & Rezáč, 2017). Consequently, as Castillo-Manzano and Castro-Nuño (2012) argue, points systems could turn into a boomerang road safety policy which, as in the Spanish case, would require even tougher regulations to be implemented some years later (Izquierdo, Ramírez, McWilliams, & Ayuso, 2011) or the introduction of new, more severe penal legislation that would indeed obtain the desired dissuasion effect (Albalade et al., 2013) due to drivers' fear of receiving prison sentences (Castillo-Manzano et al., 2011). As Table 2 shows, in this case, the Penal Code reform's deterrence effect was particularly significant, at 1 %, for traffic enforcement to prevent drunk driving, which confirms previous results (e.g., Fell, 2020).

Finally, considering the meteorological variables, it can be highlighted that, as stated by Wang et al. (2022), the link between traffic offences and rainfall is negative. One of the motives that could explain this behaviour is that drivers may self-restrict or avoid risk-driving in bad weather (Naumann, Dellinger, & Kresnow, 2011) and take greater care while driving.

5. Concluding remarks

Despite the persistence of driving stereotypes that label women as 'bad drivers', the data seem to demonstrate that these are not true and that driving a car (well) is not the exclusive domain of men. For example, in the case of Spain, which is the study object of the present paper, despite women having initially been slower to take up driving due to socio-economic reasons that are not the focus of the analysis in this work, what is true is that the gap between the two sexes on censuses of the driving population has progressively reduced in recent years. An almost 70 % increase in the number of driving licences obtained by females thus far in the 21st century compared to slightly over 30 % in the case of males bears witness to this (DGT, 2021). Also, regarding road

safety figures, the numbers recorded in Spain are patently clear: according to INE (Spanish National Statistics Institute), between 2000 and 2019 (i.e., pre-pandemic), there were 65,332 deaths in traffic accidents of which 50,417 (77.1 %) were men and the remaining 14,915, women.

In general terms, the prior academic literature points to a large part of the greater involvement of males (especially, young males) in traffic accidents and the greater severity of these accidents being explained by their less respectful conduct towards traffic regulations compared to women, which results in their committing more traffic violations due to higher risk-behaviour in the moments preceding accidents. All of this justifies the aim of this study, which is to analyse econometrically and with territorial disaggregation at the NUTS-3 region level, the impact of sex differences (male and female) on compliance with traffic regulations in the Spanish case, based on an examination of the upward trend in the number of women recorded on the driver census during the 2005–2019 period. For this, rather than the questionnaire and population survey-based methodology usually used in previous studies, our research has pioneered the use of objective data on actual traffic violations compiled by the Spanish traffic police, who enforce traffic regulations on inter-urban roads, with the consideration of different traffic offence typologies.

Following Russo, Biancardo, and Dell'acqua (2014), the estimations obtained corroborate the idea that female drivers are a hazard is a myth and that Spanish women drivers are more respectful of traffic regulations in the cases of all the violations analysed (except overtaking and helmet use by motorcyclists, which are not significant). Doubtlessly, this may be of benefit to road safety. There is a more substantial representation of Spanish male drivers than females among those who have committed some type of offence, including speeding detected by radar and drunk driving. Our findings also show that Spanish women drivers contribute to more rigorous compliance with the regulations regarding mobile phone use, safety devices such as seatbelts and child restraint systems and legal overtaking, all of which would reinforce the more cautious character and behaviour of female drivers contributing to greater road safety.

These results have implications for both the design and enforcement of Road Safety Policy. Firstly, in general terms, our research contributes to sensitizing and reinforcing the need for transversal traffic safety management with the adoption of a sex-gender perspective, as the Spanish Directorate General for Traffic alludes to in the blueprint of the Road Safety Strategy for 2030 (DGT, 2022). Moreover, our findings might suggest that a certain 'calming effect' on road safety (in terms of compliance with traffic rules) will occur as the census of female drivers increases, which could benefit gender equality since access to a driving licence and, therefore, to the potential use of a vehicle, implies greater freedom and independence in terms of mobility and inclusion in the labour market (Havet et al., 2021).

On the other hand, our estimations can also guide the adaptation of educational and training policies and awareness campaigns to the different groups targeted from a gender perspective, providing a differentiated focus depending on the driver's sex to prevent specific risk and reckless driving behaviours. In this respect, according to our findings, the male driver audience should be targeted by advertising campaigns and training programmes to obtain driving licences specifically aimed at preventing traffic law violations regarding, for example, speeding offences or driving under the influence of alcohol and/or drugs.

From the point of view of traffic law enforcement, our results also highlight the importance of the police having sufficient equipment and number of officers for the surveillance and detection of traffic violations, which would result in an overall improvement in interurban road safety.

According to Laapotti et al. (2003), sociocultural factors can influence women's role in society and their performance as drivers, so the possibility of extrapolating our results to other countries should be considered with caution. In addition, we recognise that the non-availability of official gender and sex-disaggregated NUTS-3 region-

level data on driving behaviour in Spain (such as vehicle miles travelled and the presence of children in the vehicle, among others) may be a limitation on our research, while it also emphasizes the need to include a gender and sex perspective in data collection as an improvement recommendation for Traffic Authorities.

Notwithstanding, rather than replicating the analysis with the consideration of other traffic violations that are administrative in type, such as carrying out the mandatory VTI, we propose some other possible lines of future research that consider the impact of sex differences in terms of accident frequency and the evaluation of the influence of attributes such as age, the time elapsed since drivers passed their driving tests and education level. The aim would be to complement the results obtained in the present paper regarding traffic regulation compliance with an evaluation of whether the greater agreement with the regulations demonstrated here translates into better results in terms of accidents.

In summary, our contribution to this line may add to the social debate as to whether relevant initiatives are required to highlight the role of women with an increased presence in supposed male areas such as driving. These include, especially, the recent campaign launched in Spain by the NGO 'Action Aid' entitled #EllasConducen (#TheyDrive) (see <https://ellasconducen.midas.es/>), which aims to raise the number

of drivers among women at risk of social exclusion to enable them to gain commuting independence, and to generate new labour opportunities.

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Declaration of competing interest

None.

Appendix A

Table A.1

Summary of main Spanish road safety policy strategies implemented during our research period (2005–2019).

Year	Strategy	Goal
2005	Road Safety Key Strategic Action Plan 2005–2008	Alignment with the European Road Safety Action Programme and general objective of reducing fatalities by 40 %
2006	Penalty Point System Driving Licence came into force	Enforcement and economic penalties (i.e. fines) for traffic offences
2007	Reform of Penal Code 15/2007	Toughening of sanctions applied for traffic offences with penal consequences
2010	New general regulation on traffic and road safety 18/2009, and Drivers Regulation 818/2009	Reform of sanctions and regulation of driving licences
2011	Road Safety Key Strategic Action Plan 2011–2020	Principles of the Safe System adapted to suit Spanish reality, with special protection for the most vulnerable road users and promotion of sustainable mobility
2014	Reform of Road Safety Law 6/2014	Increased fines for driving under the influence of alcohol and/or drugs
2018	New general regulation on traffic	Reduction of the general speed limit on all rural roads from 100 km/h to 90 km/h
2019	2019–2020 Plan of Special Measures for the Road Safety of Motorcycles and Mopeds	Regulatory modifications to increase the number of penalty points for not wearing a helmet and the mandatory use of gloves for motorcycle riders
	New Driver Training Regulation	Measures linked to driver training regulation, including introducing 8 h of mandatory theory training to obtain a driving licence, in line with other European countries

Source: prepared by authors based on the DGT website (see <https://www.dgt.es/menusecundario/dgt-en-cifras/>).

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