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"Assessing Gender Bias in Climate Policy Interventions: Green Nudges and Commuting Choices"

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Abstract

Private transport is a leading contributor to climate change and local pollution in many countries. As a result, commuting choices have become paramount. Our main research question is how gender affects these choices. This paper analyzes the gender heterogeneity of informational interventions (green nudges) on the willingness of car commuters to adopt more sustainable commuting habits. To isolate causal evidence, we conducted a survey experiment with a randomly assigned informational treatment – a visual representation of the carbon footprint associated with different commuting options – among students at a university in northern Italy. The results show that the nudge increased the participants' willingness to forego their private car by 7-9%. Heterogeneous analyses reveal a novel gender-specific pattern in nudge effectiveness: female car commuters exhibit a consistently greater reluctance to forego private vehicles in response to the treatment compared to male car commuters. Potential mechanisms include differing mobility patterns, security concerns, and lower social desirability bias among women. In all cases, this gender discrepancy documents the importance of integrating a gender perspective in climate policy interventions to enhance both effectiveness and public support.

Key Policy Insights

- Commuting choices significantly impact climate change and local pollution. Effective policies targeting these choices are crucial.
- Green nudges are effective and economical tools that foster environmental choices and attitudes, including among car commuters.
- Women are less responsive to informational nudges than men, possibly due to varied mobility patterns, security concerns, and lower social desirability biases.
- Not accounting for gender differences when designing green nudges undermines their effectiveness.
- Integrating gender perspectives can be key to enhancing public support for (unpopular) climate policies.

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1. Introduction

In recent years the impact of climate change, driven significantly by greenhouse gas emissions, has become increasingly evident. One of the main contributors to climate change, and a major source of local pollution, has been identified as road traffic (ICCT 2021; EEA 2022; IPCC, 2023), which has, moreover, demonstrable connections to the global burden of disease (Cohen et al., 2017; Rojas-Rueda et al., 2013). Thus, inducing sustainable commuting has become central to addressing today's environmental challenge. Against this backdrop, *green nudges* – that is, changes in the decision environment aimed at reducing negative externalities – have been shown to be effective in influencing the choices of individuals (Shubert, 2017; Carlsson et al., 2021; Congiu and Moscati, 2021; Aravind et al., 2024).

In this study, we investigate the influence of green nudges on individuals' willingness to switch from private car commuting to more sustainable modes, such as public transport, cycling, or carpooling. Our primary focus is on understanding how gender interacts with low-carbon attitudes. While the experimental evaluation of green nudges in the context of commuting is valuable due to the limited existing evidence (Aravind et al., 2024), our key contribution lies in examining potential gender differences in response to these nudges and climate policy more broadly.

Our main hypothesis in this respect is inspired by a situation detected in the medical sciences: although biological differences between men and women often justify differential medical treatments, significant gender inequalities persist in several diseases. For instance, in the case of cardiovascular diseases, women are at a disadvantage when it comes to drug development as they remain largely under-represented in clinical trials (Nidorf et al., 2020; Regitz-Zagrosek and Gebhard, 2023). Indeed, when facing cardiovascular diseases, research has found that women face persistent treatment delays, underdiagnosis and undertreatment compared to men (Regitz-Zagrosek and Gebhard, 2023; Todorov et al., 2021; Udell et al., 2023). In the context of climate policy, it is, therefore, a valid hypothesis that policy instruments may well be similarly biased: insofar as gender roles are socially determined, gender differences may be relevant in explaining policy effectiveness and determine, or at least modulate, particular responses to climate policies.

Policy instruments such as green nudges are increasingly used by policymakers to enhance consumers' environmental choices. Evidence regarding their effectiveness is, however, mixed. Product labels have boosted sales of energy-efficient appliances (Solà et al., 2023; Ruiz-Tagle and Schueftan, 2021), but tailored fuel economy information hasn't significantly impacted vehicle purchases (Allcott and Knittel, 2019). Immediate or real-time feedback reduces residential electricity use (Di Cosmo and O'Hara, 2017; Buckley, 2020). Evidence on commuting behavior is limited. In Zhengzhou, pollution information reduces active commuting (Fan et al., 2021). In Germany, green nudges promote public transport for short commutes (Zimmermann et al., 2023), and social labelling increases bus use in Rotterdam (Franssens et al., 2021). Similar results were found for university communities in Canada (Kormos et al., 2015). However, nudges aimed at reducing single-occupancy vehicle commutes show no significant impact (Kristal and Whillans, 2020).

Importantly, these studies report the average effect of the instrument, which is key for policymakers assessing its suitability. However, they often overlook gender differences, frequently because this factor is not observed. We argue that understanding gender-specific may provide relevant insights into the overall effectiveness of a policy. Hence, this paper has two primary concerns: first, we evaluate the effectiveness of informational green nudges in relation to preferences on sustainable commuting behaviour; and, second, we examine whether gender differences in response to such nudges are sufficiently relevant to justify differential policies in this particular context.

Importantly, our evidence is framed in terms of intentions, as behavioural changes are not directly observed. This distinction is significant because while intentions may not always translate into actual changes in behaviour, they remain relevant indicators that can inform about public support—a crucial aspect for the effectiveness of climate policies (Drews and van den Bergh, 2016).

To address these goals, a field experiment was designed among a student population at a university in northern Italy (University of Insubria). As in Kristal and Whillans (2020)[1], working with a homogenous sample of individuals that share the same destination is convenient as it can greatly ease identification. Here, we conducted an online survey in which the informational treatment, the green nudge, was randomly allocated. The

[1] These authors use a sample comprising employees at a major European airport.

treatment comprised an image of the carbon footprints and emissions associated with the different modes of transport available to the students for their commute. The image was positioned just before questions asking participants about their propensity to change to more sustainable means of transport. Given our specific research object, our sample included only those respondents that use a private car for their commute. The randomization ensures our treated and control groups are well balanced in terms of all observed covariates, including residence (at the postal code level) and the public transport options available to them. All in all, this goes some way to strengthening the plausibility of a good balance in non-observable factors, thereby facilitating the causal interpretation of our main results.

We find that the informational green nudge increased the willingness of students to forego the use of their private car for commuting. The probability of the treated group expressing a willingness to substitute their private car for a bike and for public transport (bus or train) was, respectively, 8.5 and 7% higher than that of the control group. We fail to find a statistically significant effect for carpooling, suggesting that it is not conceived socially as a clean mode of transport. These results are robust to different specifications and models – linear and non-linear probability models.

Analyses by gender show that women do not respond to the informational treatment, while the probability of men expressing a willingness to forego their private vehicles is 8.1% higher that of the control group. When asked about their willingness to switch their cars for public transport, the green nudge increased this probability to 8.6% among male respondents. In contrast, the effect on female drivers is not statistically significant at standard levels. In the case of cycling, the increase in the willingness of women exposed to the nudge to switch to a bike is 6%; yet, the effect on men is 12.1%. Hence, the average main effects of the green nudge on car-commuters appear to be driven mainly by male respondents, with their female counterparts being less inclined to forego their private vehicles.

These results could be attributed to documented differences in women's mobility patterns, which tend to be more complex than those of men given the gender gap associated with care-giving and domestic responsibilities (Gauvin et al., 2020). Another potential mechanism might be gender-related security concerns, with safety-related problems on public transport affecting women significantly more than men (Yavuz & Welch, 2010).

Indeed, there is extensive evidence in different showing the higher risk aversion of women in different social dimensions (Friedl, Pondorfer and Schimdt, 2020; Fisher and Yao, 2017; Filippin and Crosetto, 2016). A different mechanism could be that women are less susceptible to social desirability bias, making them potentially more immune to green nudging (Hebert et al. 1997; Kamas and Preston, 2015). This insight is equally relevant for understanding support for climate policies.

Our main contribution here is to highlight that the effectiveness of green nudges is not gender neutral. This suggests that integrating a comprehensive gender perspective in climate policy, especially when these involve behavioural interventions, can be key to increasing its effectiveness; not doing so can underpower the instrument.

These results are also relevant in terms of public support for climate policies. The lack of broad public support in climate policies often prevents its effective implementation (Dechezleprêtre et al., 2022; Maestre-Andrés et al., 2019). The role of gender in this critical aspect has been neglected in this literature and, so far, limited to gendered attitudes towards climate change but not to differential response climate policies (Rode et al., 2021). Here, by identifying causal responses to green nudges affecting stated willingness to change commuting behaviour, we provide novel evidence on how public support to particular climate policies can be influenced by gender perspectives.

The rest of this paper is structured as follows. Section 2 reports the main outcomes of a review of the literature dedicated to sustainable commuting and the power of informational treatments or nudges in field experiments. Section 3 describes the methodology and data employed herein, while section 4 describes and analyses the results. The final section is concerned with drawing conclusions and identifying the policy implications of our experiment.

2. Commuting habits

Commuting represents a cost for the household, one that is offset, in theory, by either the labour or the housing market. As discussed above, however, when the commute is by private car, external costs are incurred that are not always properly compensated for. Road transportation, among which the private car represents the lion's share, is a key contributor to climate change (IPCC, 2023; EEA, 2020) and an important driver of premature mortality and morbidity (WHO, 2022). Despite this, transport is the only sector not to have registered a reduction in emissions since 1990 and part of this failure is attributable to commuting habits. In the EU-27, the passenger car accounted for 79.5% of the overall passenger-km travelled in 2019 (EEA 2022), largely because private vehicles continue to be the main mode of transport for commuting in Europe. This, in turn, has resulted in increased carbon emissions and congestion costs in recent decades (ECA - European Court of Auditors, 2020). According to the French National Institute of Statistics and Economic Studies (INSEE, 2021), 75% of French workers in 2017 were commuting by car. Even over shorter distances (< 5 km), the car still accounted for 60% of commutes. Similarly, in Italy in 2019, 62.5% of commutes were done by car, and in terms of passengers per kilometer, the percentage of car usage reached approximately 70% (ISFORT, 2022).

Changing commuting habits is a challenge. Firstly, because commuting choices are endogenous to the externalities to which they give rise: commuters do not bear the full costs of their commuting decisions (Silvestri et al. 2022). Besides, by foregoing the private car, commuters incur other costs, including greater planning time and less independence (Kristal & Whillans, 2020). Generally, access to greater information can increase respondents' sense of concern about an issue, but not necessarily win their support (Kuziemko et al., 2015). Indeed, while several surveys show that people are aware of the environmental and health benefits from shifting their commute from the private car to public transport or more active modes, they are often more reluctant to change their habits in response to purely environmental concerns, as such a decision involves a major loss of utility (IPSOS, 2017; Bouscasse et al., 2022). Hence, in common with many other pro-environment decisions, commuting choices depend on a wide array of socio-economic, institutional and psychological factors and are potentially constrained by the transport infrastructure and the availability of alternative commuting modes that do not mean incurring significant penalties in terms of safety, convenience and cost (Whillans et al., 2021; De Witte et al., 2013; Zhou 2012).

Gender is a key factor to take into consideration in any discussion of commuting choices. For example, mobility patterns differ notably between men and women in response to the presence of children (White, 1986). Gender also has a marked impact on perceived (in)security in public transit environments (Börjesson, 2012; McCarthy et al., 2016; Ouali et al., 2020). Likewise, gender is a key factor in labour market decisions: on the supply side, Becerra and Guerra (2023), based on experimental evidence, find that women forego more earnings than men to avoid a late shift, with perceived safety explaining only a part of this gap. On the demand side, Farré et al. (2023), exploiting an instrumental variable approach, find that commuting time penalizes women more than it does men in the labour market. More specifically, they find that a 10-minute increase in the commute of married women reduces their probability of working by 4.6%, while the estimated effect on men is not statistically significant. Clearly, taken together, this evidence explains why women adhere to different psychological paths when choosing commuting modes.

3. Methods and Data

The study draws on the data collected from an on-line survey carried out between 22 December 2022 and 26 January 2023 at the University of Insubria in Como-Varese (Italy). Universities attract a huge number of daily commuters and many trips are made in single-occupancy vehicles, especially when campuses are located in peripheral areas with varying accessibility to railway stations, as is the case here (Crotti et al., 2022a,b). By focusing on a university community, we are able to ensure a greater degree of homogeneity in commuting decisions. This is especially convenient in this context as it eases identification and allows a cleaner interpretation of results.

Seeking to investigate the home-university commute of the university's academic population, a questionnaire was developed to acquire information about their sociodemographic characteristics, commuting habits and propensity to change towards more sustainable mobility. The response rate was 20.03% for undergraduate students (2,395 respondents) and 19.92% for doctoral and postgraduate students (140 respondents). In the present study, we are interested only in those who use a private vehicle for their commute (n=1,625 respondents).

The collection of information was combined with a nudge experiment. Thus, students were randomly divided into two groups and contacted by e-mail. The first group (control) received the baseline questionnaire, while the second group (treatment) received an additional question, supported by an image concerning the environmental impact of different modes of transport designed by the Institute for Sensible Transport. The 'nudge' was introduced in the questionnaire just before the section referring to the propensity to change transport mode.

As completing the online survey was not compulsory, respondents self-selected into our sample. This means our estimates do not capture population (University) parameters but rather only those of the sample. However, such randomization guarantees causality in our estimates and, hence, informative value.

3.1 Survey structure

The survey presents the following block structure.

Welcome page

The questionnaire opens with a description of the survey and seeks the respondents' informed consent. The latter are informed of their legal rights as participants of the survey and are requested to provide considered responses to guarantee the quality of the analysis. Participants are assured that their responses remain entirely anonymous and confidential.

Pre-treatment

Participants, having first been randomly and automatically divided by the software, are asked to fill out the form with their personal data (region, province and municipality of residence; postal code and address including house number; gender and age). They then respond to a series of questions about their attachment to the University (role, degree course, campus, the days and times they attend that campus). After verifying each student's mobility capital (i.e. driving license and private means available to the family), participants are asked to describe the means of transport (on foot, bike, scooter, urban and extra-urban bus, train, metro, motorbike or car) employed for their commute to and from university. The participants are asked to state the distance travelled (mileage) using their chosen means of transport and, in the case of public transport, requested to select the type of travelcard (fares) applied. Participants commuting by private motorized vehicle are asked to provide details about the car model, fuel used and engine capacity.

Treatment

Before investigating the respondents' willingness to switch their mode of transport, participants in the treatment group received an informative question together with an image informing them of the carbon footprint of each of the commuting options (Figure 1).

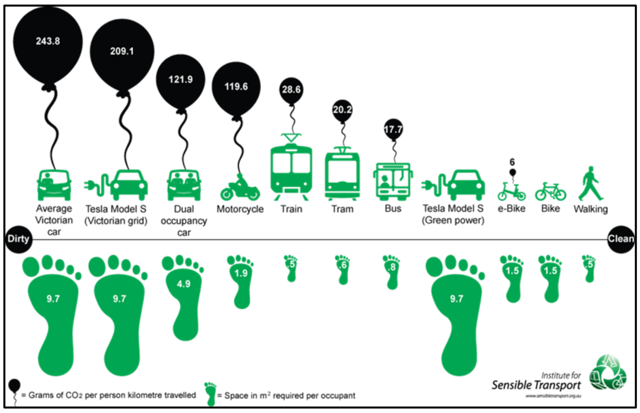

Figure 1. Image included in the treatment questionnaire.
Source: Institute for Sensible Transport

The image includes two types of information: the emissions associated with vehicle usage (grams of CO_2 per person kilometer travelled, illustrated using black balloons) and space consumption (space in m^2 required per occupant, illustrated using green footprints). The question was "Choosing your own daily means of transport can make the difference! Did you know that the transport sector is responsible for 30% of global emissions?" (ICCT, 2021). This question required a simple binary answer: "Yes" or "No". The image and the question were only made visible to the group of participants randomly assigned to the treated group.

To avoid any strategic behaviour when answering the questions, participants did not specifically know they were engaged in an experiment setting or that there were two different questionnaires.

Post-treatment

Different questions were included to test the commuters' willingness to change from the car to more sustainable means of transport. These constitute our outcome variables.

In particular, participants were asked if they would be willing to use a bike or public transport (bus or train): "Would you be willing to change your habit by replacing the car with the public transport/bike?". In a subsequent question, respondents were informed that the University would shortly activate a carpooling application for the exclusive use of Insubria students and staff. This would allow them to share the car journey with someone who lives nearby and attends the same campus at compatible times. They were then also asked to express their willingness to use carpooling. In order to reduce any pressure to provide an answer when it's not appropriate, besides of yes and no options, participants could also respond "yes, but under certain conditions".

Finally, we also include a more general question with a simple binary (yes/no) answer was asked: “Would you be inclined to change your home-university commuting habits to make your mobility more sustainable?”.

Therefore, we have four outcome variables that assess individuals' willingness to transition to alternative modes of transportation, specifically (i) public transport, (ii) biking, (iii) carpooling, and (iv) a general inclination to switch transportation modes. The latter is also regarded as a validation question.

3.2 Covariate balance between control and treated groups

A total of 2,535 participants responded to the questionnaire, corresponding to 20% of the University’s student population. Of these, we are only interested in those who reported using a car —exclusively or in combination with other means— for their home-university commute. Thus, we ended up with a sample of 1,625 participants, of whom 625 completed the control and 1,000 the treated questionnaire.

As shown in Table 1, the distribution of covariates across the treated and control groups is statistically equal (t-test) at standard significance levels. Thus, we are able to avoid any selection bias in relation to our independent variable of interest, i.e. the information nudge. The only significant differences at the 10% level are presented by students studying the degrees of Environmental Science, Economics and Engineering. These, however, are small differences (between 2-3%) in relatively small groups that should not constitute any significant biases.

Importantly, both student origins (i.e. the province of residence) and the campus of destination are well balanced between the two groups, further demonstrating the robust experimental nature of the empirical design. This means, for example, that the treated group does not have a statistically different access to public transport that might bias our results. Similarly, the distribution of commuting times is also statistically equal across the treated and control groups, as are the distribution of car types and the availability of public transport. All in all, the tests conducted show that our treatment has been randomly assigned and, therefore, our regressions can effectively identify the average treatment effect on the treated (ATET) of the green nudge on the willingness to use private cars for the commute.

Table 1. Student characteristics by treatment status

Covariates	Control group	Treated group	Mean difference	P value
	(N=625)	(N=1000)		
Gender (%)				
Female	58.00	61.60	-3.60	0.155
Male	41.44	38.10	3.34	0.18
Prefer not answer	1.30	0.80	0.50	0.341
Role at University (%)				
Student	93.40	95.10	-1.70	0.155
PhD Student	6.60	4.90	1.70	0.155
Num. of working days	3.55	3.59	-0.043	0.483
Degree studied (%)				
Environmental Science	5.44	3.50	1.94	0.059
Biology	10.88	10.10	0.78	0.617
Chemistry	3.20	2.30	0.90	0.272
Communication	10.72	10.60	0.12	0.939
Economics	13.28	16.60	-3.32	0.071
Physics	1.28	1.90	-0.62	0.342
Law	5.92	5.20	0.72	0.535
Computer Studies	4.80	6.40	-1.60	0.179
Engineering	4.48	2.80	1.68	0.071
Languages	4.96	4.70	0.26	0.812
Mathematics	0.64	1.40	-0.76	0.155
Healthcare	28.00	27.30	0.70	0.759
Sport	2.40	2.90	-0.50	0.546
History	0.80	1.10	-0.30	0.552
Tourism	3.20	3.20	0.00	1
Car characteristics and commuting options (%)				
Electric/hybrid	6.40	6.10	0.30	0.829
Gasoline car	71.30	73.90	-2.60	0.252
Diesel car	17.90	16.00	1.90	0.31
Other fuel (GLP, Methane)	4.30	3.90	0.40	0.693
Own a bike	1.10	0.70	0.004	0.373
Train available	21.90	20.20	1.70	0.407
Bus available	20.20	18.70	1.50	0.468
Commuting time (%)				
0-15 min	3.80	5.20	-1.40	0.207
15-30 min	16.80	16.00	0.80	0.671
30-45 min	24.00	22.60	1.40	0.515
45-60 min	27.20	27.30	-0.10	0.965
60-75 min	13.00	15.80	-2.80	0.116
75-90 min	7.50	6.30	1.20	0.341
>90 min	7.70	6.80	0.90	0.503
Campus (%)				
Busto Arsizio	1.00	0.80	0.20	0.734
Como Sant'Abbondio	11.00	9.90	1.10	0.463
Como Valleggio	11.20	11.20	0.00	1
Varese Bizzozero	72.30	73.30	-1.00	0.666
Velate	1.00	0.80	0.20	0.734
Other	3.50	4.00	-0.50	0.623
Province (NUTS3) (%)				
Alessandria	0.20	0.00	0.20	0.208
Bergamo	0.30	0.40	-0.10	0.789
Biella	0.00	0.10	-0.10	0.428
Brescia	0.00	0.20	-0.20	0.262

Como	22.50	24.60	-2.10	0.322
Cremona	0.20	0.00	0.20	0.208
Lecco	2.30	1.30	1.00	0.155
Lodi	0.00	0.10	-0.10	0.428
Milano	16.20	16.00	0.20	0.922
Monza e Brianza	7.40	6.70	0.70	0.584
Novara	1.30	2.20	-0.90	0.174
Pavia	0.20	0.20	0.00	0.85
Sondrino	0.50	0.10	0.40	0.135
Torino	0.00	0.10	-0.10	0.428
Varese	46.80	45.70	1.10	0.647
Verbano-Cusio-Ossola	2.10	2.10	0.00	0.961
Vercelli	0.20	0.10	0.10	0.741

Notes: *** $p<0.001$, ** $p<0.01$, * $p<0.05$

Figure 2 illustrates the density functions for the sample's two continuous variables: commuting distance (in km) and the respondents' age. This shows that, above and beyond the mean values (here indicated by the dashed vertical lines), the characteristics of the treated and control groups are well balanced.

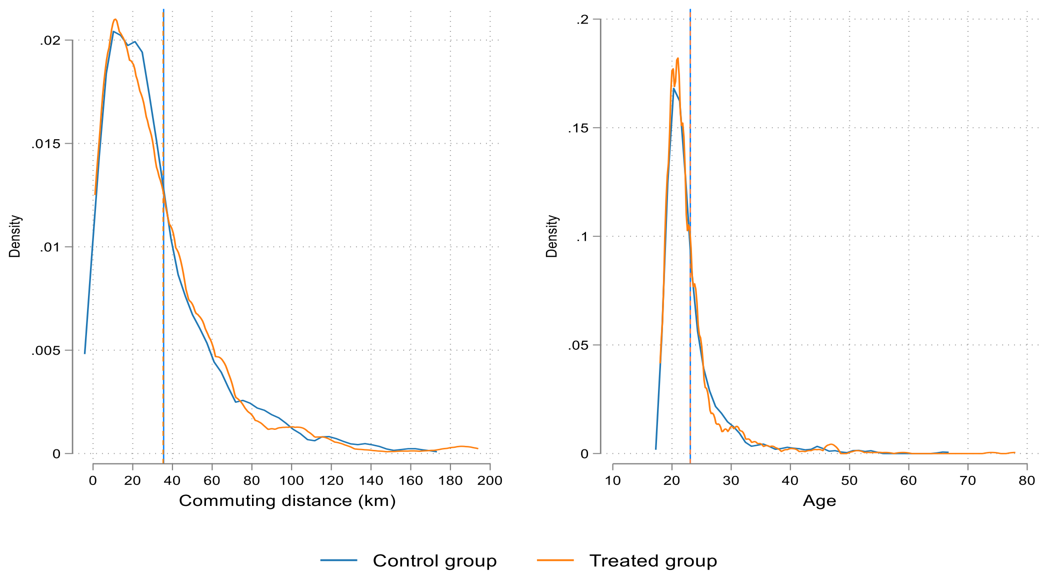

Figure 2. Comparison of students' commuting distances and ages (control vs. treatment groups)

The randomization of the treatment successfully avoids selection bias as shown by the balance in the observable characteristics. The implicit assumption is therefore is that unobservable characteristics will also remain as balanced. This includes potential individual biases when responding these particular questions emerging from, for instance, social desirability bias. Considering this, we are interested in measuring how the informational nudge affects willingness in commuting decisions, and, in particular, how these varies across gender.

To test our hypothesis, we specify the following general regression:

$$y_i = \alpha + \beta D_i + \varepsilon_i$$

where y_i represents one of our four dependent variables associated with the willingness to switch to a more sustainable mode of transport: that is, willingness in general, willingness to cycle to campus, willingness to take public transport and willingness to participate in the carpooling system. All these are dummy variables that take a value of 0 where students show no willingness to forego their private vehicle and a value of 1 when they express a willingness to change. D_i is our treatment variable, with a value of 0 indicating the individual has been assigned to the control group (and, hence, received no information treatment), and a value of 1 when an individual has been assigned to the treatment group (and, hence, received a green nudge). Because of the random nature of treatment assignment, the specification does not require that we control for observed covariates. Nevertheless, we report results that control for observer covariates, specifically the respondents' postal code; in fact, despite the experimental nature, residence plays the most important role in the commuting choice. In this regard, we cluster standard errors at the postal code level.

4. Results

4.1 Main effects

Table 2 shows the treatment effects from a linear probability model (LPM)[2]. Column 1 shows the effect of the information treatment on the willingness to forego the private vehicle and switch to a more sustainable transport mode: treated individuals were 4.5% more likely to give a positive response but this was not statistically significant at the 5% level. When asked about their willingness to switch to a specific transport mode, this probability became significant and increased to 7% in the case of the bus or train (column

[2] These results are virtually identical to the marginal effects of the probit or logit models (see table A1 in the appendix). We have, therefore, opted only to describe the LPM results here.

2) and 8.5% in that of bicycle (column 3). However, unlike the other transport modes, the treatment effect was not statistically different from 0 in the case of carpooling (column 4). This latter result is consistent with previous findings on the willingness of participants to sign up for a carpooling initiative (Kristal & Whillans, 2020). The negative sign of the latter, however, is informative: because the information treatment is designed to increase the respondents' awareness of their carbon footprint, an average negative effect (albeit not statistically significant) suggests that carpooling, unlike the bus, train or bicycle, is not socially conceived as a clean mode of transport. Columns 5 to 8 replicate the previous analysis but controlling for observable covariates (which, as expected, are always non-significant). These include personal characteristics like age or gender, geographic characteristics like commuting distance, province they live and the availability of train, bus or bike to do the commute. Our results, however, remain highly consistent when including this control.

Table 2. Information treatment effect on willingness to forego private car to complete commute

VARIABLES	(1) Willingness to change	(2) To Bus/train	(3) To Bike	(4) To Carpool	(5) Willingness to change	(6) To Bus/train	(7) To Bike	(8) To Carpool
Treatment	0.045	0.071*	0.085***	-0.036	0.049	0.082*	0.091**	-0.030
	(0.025)	(0.030)	(0.019)	(0.024)	(0.026)	(0.032)	(0.019)	(0.024)
Constant	0.658***	0.618**	0.147***	0.696**	-0.251	1.246**	0.068	0.577**
	(0.019)	(0.022)	(0.015)	(0.017)	(0.163)	(0.178)	(0.194)	(0.212)
Observations	1,625	1,625	1,625	1,625	1,609	1,609	1,609	1,609
Control variables	No	No	No	No	Yes	Yes	Yes	Yes

Notes: This table shows the effects of the information treatment in terms of commuter willingness to change to different modes of transport. Specifications in columns 1 to 4 do not include any control covariates and specifications, while specifications 5 to 8 include control covariates, including role, age, gender, commuting distance, study field, region province and dummies for bus, train or bike availability. Robust standard errors, clustered at the postal code level, in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Figure 3 shows the observed effects of the treatment (as reported in Table 2) compared to the effects of a randomly assigned placebo treatment, independent, that is, of the actual information treatment. This allows us to discard any randomness in our sample underlying our effect, such as regression to the mean. This robustness check further confirms that our experimental setting is successful in avoiding any potential selection biases in relation to our independent variables.

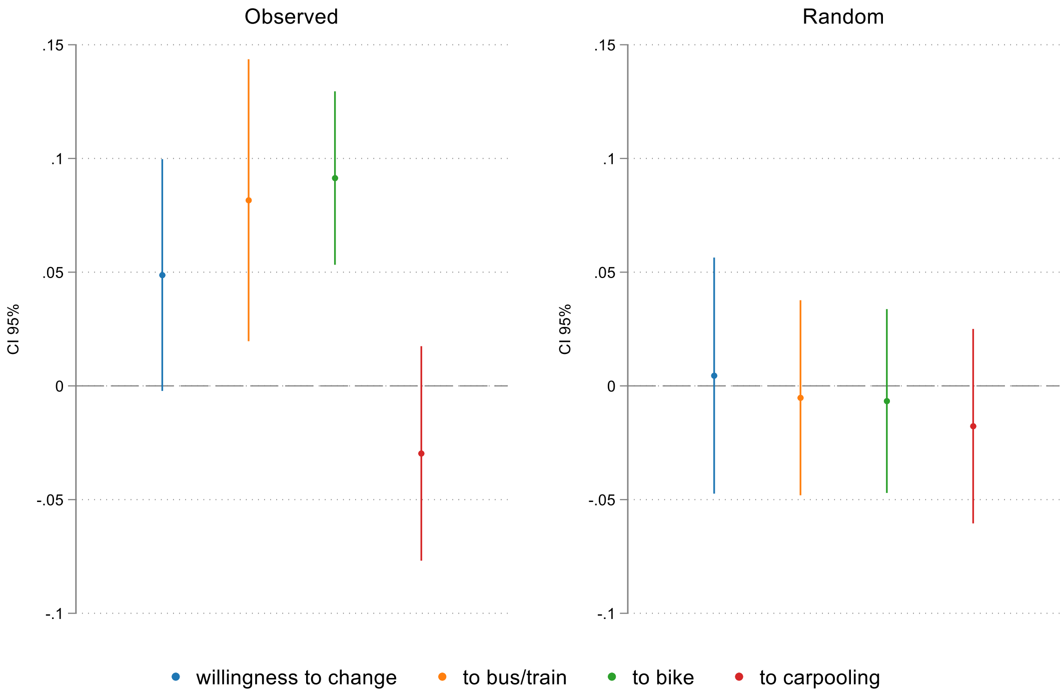

Figure 3. Information treatment effect on willingness to change mode of transport for commute

4.2 Gender effects

Among the social characteristics that might influence an individual's choice of transport, gender seems to be important. Indeed, there is a growing consensus that mobility patterns in the urban setting are not gender neutral (Brown et al., 2014; Gauvin et al., 2020; Law, 1999)[3]. Men and women experience mobility differently: because of their greater propensity to take on the role of care-givers and to be engaged in part-time jobs, women tend to present more complex mobility patterns – typified by shorter, more frequent journeys – than men, whose mobility is often limited to home–workplace–home commuting (ADB, 2013; Civitas, 2020; Gauvin et al., 2020). In addition, feelings of insecurity in public spaces or when using public transportation (i.e. transit environments) have been found to be more prevalent among women (Loukaitou-Sideris, 2014). Likewise, women have been reported to be far less willing than men to travel after dark (EC, 2011). All these is consistent with gender differences in risk preferences.

[3] Among other gender differences as regards mobility patterns, women have been reported to be more frequent users of public transport and to have lower rates of motorization in general (Civitas, 2020). Here, however, we focus solely on car drivers.

Alternatively, gender differences in social preferences have also been well documented in the literature, although with different results depending on the particular situation (Croson and Gnezy, 2009). In any case, these differences could lead women (men) to respond differently to the informational treatment. All these considerations could explain and justify differential treatment effect by gender in terms of their willingness to forego their private car.

Because the specific subsample here could have a potential effect on the covariate balance of the experimental setting, Table A2 in the appendices show student characteristics by treatment status and gender. According to this, balance between treated and control groups is largely maintained despite the subsampling. Table 3 shows results by gender. Adding control covariates (columns 3 and 4) to the main specification does not change results. To further ensure that our results are not confounded by unobserved factors related to the heterogeneity of the commuting needs, in columns 5 and 6 we restrict the sample to students that study at the Campus Bizzozero in Varese (73 % of the sample) and live in the same province (46% of the sample). This is 603 students (38% of the full sample). Results consistently show women not reacting to the informational nudge.

Table 3. Information treatment effect by gender

Treatment effects	(1) Women	(2) Men	(3) Women	(4) Men	(5) Women	(6) Men
Willingness to change	0.019	0.081*	0.014	0.091*	-0.041	0.126*
	(0.032)	(0.036)	(0.034)	(0.038)	(0.055)	(0.055)
W. to take bus/train	0.060	0.086*	0.071	0.090*	0.009	0.143**
	(0.037)	(0.042)	(0.038)	(0.043)	(0.075)	(0.053)
W. to switch to bike	0.061*	0.121***	0.064*	0.118***	-0.022	0.166***
	(0.030)	(0.036)	(0.030)	(0.035)	(0.063)	(0.042)
W. to use carpool	-0.020	-0.056	-0.015	-0.033	-0.051	0.045
	(0.030)	(0.040)	(0.031)	(0.040)	(0.059)	(0.073)
Control variables	No	No	Yes	Yes	No	No
Observations	969	656	956	630	344	259

Notes: This table shows the effects of the information treatment on men and women in terms of their willingness to change to different modes of transport. Columns 1 and 2 report estimates for specification without control variables; columns 3 and 4 show results when we control for role, age, gender, commuting distance, study field, region province and dummies for bus, train or bike availability; columns 5 and 6 show results when we limit the sample to students from Campus Varese living in Varese. Robust standard errors, clustered at the postal code level, are shown in parentheses. *** $p<0.001$, ** $p<0.01$, * $p<0.05$

We find that the general willingness to shift to a more sustainable mode of transport is only statistically different from 0 in the case of men: 8.1% vs. a non-significant 2% in the case of women. Consistent with this outcome, the green nudge increases the probability of taking the bus/train and cycling by 6.1 and 6%, respectively, for women vs. 8.6 and 12.1%, respectively, for men. The average effect on carpooling is again negative and non-significant for both genders. These results remain similar in significance and magnitude when we control for observable factors. This is expectable given the randomized nature of the treatment assignment. However, when we reduce respondents heterogeneity by limiting the sample to one campus and province, results become a bit more extreme: general willingness to forego private car rises to 12.6% when exposed to the green nudge, while remains not statistically significant and even with negative sign for women. Willingness to use public transport or bike rises to 14 and 16% in men and not different from zero for women. Figure 4 provides a clearer visual representation of these effects.

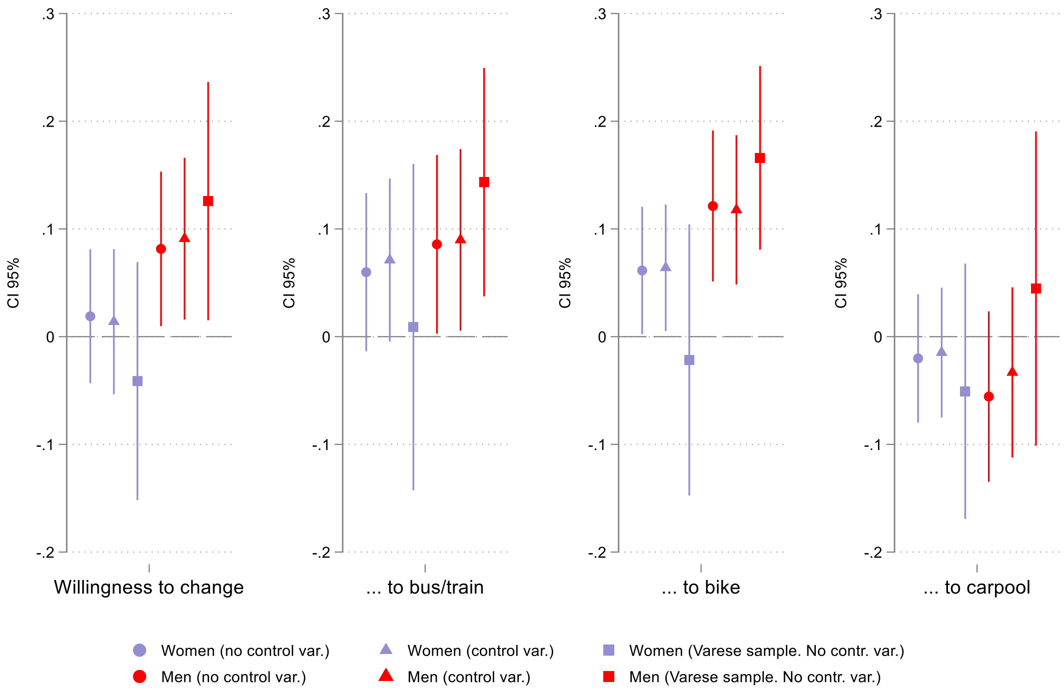

Figure 4. Gender effects of the information treatment

According to this, the willingness of women to forego private car to commute to campus tends to be less sensitive to the information treatment than is the case among men. This would appear to be consistent with women's different mobility patterns and their greater resistance to forego their private car. Also, if insecurity in public transit environments is a more pressing issue for women, then their unwillingness to forego their private vehicles in favour of other means can be considered only natural. According to this, these practical and risk preferences may enter in conflict with other preferences the literature has also attached to women, like having socially oriented preferences (Hebert et al., 1997; Kamas & Preston, 2015) or being more concerned for climate change (Bush and Clayton, 2023; Rode et al., 2021). Importantly, these results refer to car commuters only, which is a very particular situational setting although a critical one in upcoming climate policies.

4.3 Other heterogenous effects

To show that treatment heterogeneity goes also beyond gender, Table 4 illustrates the heterogenous nature of the treatment effect by the field of study of the respondents. We divide the sample in three main fields: Science, Technology, Engineering and Mathematics or STEM; the Social Sciences, including Economics, Law, History, Tourism studies and Linguistics; and the Health Sciences.

In response to the information treatment, we find that the Health Sciences students express a greater willingness to cycle to the campus (12%) after the treatment while the Social Sciences students are the only ones significantly increasing their willingness to take public transport (16%). Finally, the STEM students present a non-significant response to any of the alternatives transport options, indicating that for these students the information treatment seems to be less effective than it was for the other two groups. Finally, the carpooling results are, in general, somewhat imprecise, presenting a negative sign in the case of the STEM and health students.

Table 4. Information treatment effect by field of study

Willingness to...	Bus/Train			Bike			Carpool		
	(1) *STEM*	(2) *Social Sc*	(3) *Health*	(4) *STEM*	(5) *Social Sc*	(6) *Health*	(7) *STEM*	(8) *Social Sc*	(9) *Health*
Treatment	0.048	0.161*	0.072	0.038	0.030	0.126***	-0.069	0.053	-0.052
	(0.047)	(0.062)	(0.048)	(0.032)	(0.051)	(0.034)	(0.043)	(0.061)	(0.047)
Observations	476	317	448	476	317	448	476	317	448

Robust standard errors, clustered at postal code level, in parentheses
*** p<0.001, ** p<0.01, * p<0.05

The percentage of women matriculated in each field of study seems not to be the main driver here, but particularities of the different student's communities- Up to 57% of car commuters in STEM field are men but show a non-significant effect. In contrast, for Health Sciences that account for the largest percentage of women (67%), the green nudge significantly increased their willingness to cycle to campus. This outcome could reflect an interaction with the greater awareness among these students of healthy habits. Similarly, in the case of the Social Sciences that commute to campus in their own vehicle (60% women), they would only be likely to shift their commute to public transport in response to the treatment.

5. Conclusions and Policy Implications

Exploiting an experimental design, this paper has identified the effect of an informational green nudge on the willingness of individuals to change their private car for more sustainable options in their daily commute. To do so, we conducted an online survey with a randomly assigned information treatment with a sample of students in the north of Italy that commute to campus by car. The green nudge comprised an image of the private car's carbon footprint compared to the footprints of other means of transport, including the bus, train and bike.

We show that this informational green nudge has an effect on the willingness of individuals to forego their private vehicle when commuting to campus (7–9% increase in the willingness to switch from the car to the bus, train or bike). Consistent with the literature, we find no effect on carpooling, potentially because this initiative is not perceived as constituting a greener option, at least not to the same degree as traditional public transport or cycling.

The main contribution of this paper is the light we shed on associated gender effects. We find novel causal evidence that green nudges can be less effective among women than men. In particular, when asked to switch to a more sustainable means of transport, we find no statistical difference between the responses of women in the treated and control groups; women are apparently immune to the green nudge. In contrast, the response among men to the treatment reflects a 8–12% increase in their willingness to forego their private vehicle. The 'no-treatment effect' on women is further confirmed by the lower level of willingness they express to switch to specific modes of transport (i.e. public transport or bicycle). Here, the response of the female participants is consistently lower than that of their male counterparts and often non-significant. This result remains robust across specifications.

This gender differential – novel in the literature on green nudges – shows that gender differences permeate decision-making in relation to commuting preferences. This is of particular relevance in environmental terms as it suggests that gender differences can prevent green nudges from maximizing their effects. The potential mechanisms responsible for this differential response may be associated with women's more complex mobility patterns, which are not as limited as male home–workplace commutes (Civitas 2020), or with women's greater perceptions of insecurity in public transit environments (Börjesson, 2012; McCarthy et al., 2016; Ouali et al., 2020). This is consistent with the significant effects reported for cycling and the insignificant effects for switching to the bus or train. Critically, this potential greater resistance on the part of women to forego their private vehicles on their daily commute is, besides being a notable environmental concern, confirmation that gender discrimination is a constant in their everyday lives. In policy terms, embracing a gender perspective is essential not only for addressing gender discrimination but also for advancing more effectively toward a sustainable commuting model.

Importantly, while our results do not imply behavioral change but only changes in stated willingness, the significance of the identified gender differential can be crucial in driving the political change needed for a more sustainable mobility. Climate policies require broad public support to ensure effective implementation. If car commuting needs to be reduced in favor of public and active transport, potential policies such as congestion taxes or carbon pricing for may require the widest public support. Failing to include gender perceptions in these policies may undermine their effectiveness and result in unintended consequences. It is imperative for policymakers to consider and address these gender nuances to foster inclusivity and enhance the overall impact of sustainable mobility initiatives.

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Appendix

Table A1. Non-linear probability model (probit)

	(1) Willingness to change	(2) To Bus/train	(3) To Bike	(4) To Carpool
Treatment (probit coef.)	0.127	0.194*	0.316***	-0.100
	(0.069)	(0.082)	(0.072)	(0.068)
Treatment marginal effect	**0.045**	**0.071****	**0.085*****	**-0.036**
	(0.023)	(0.024)	(0.019)	(0.024)
Observations	1,625	1,625	1,625	1,625

Robust Standard errors, clustered at the postal code level, in parentheses
*** p<0.001, ** p<0.01, * p<0.05

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