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# Sustainable urban mobility: evidence from three developed European countries

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**Abstract**
The importance acquired by private cars as the leading travel mode in most advanced countries has drawn attention to concerns related to pro-environmental travel behaviour. Indeed, the car has brought great benefits to society, albeit causing a whole lot of environmental and socio-economic consequences. In this perspective, we exploit Eurobarometer data on the attitudes of Europeans towards urban mobility to investigate the main motivations of citizens' public transport use frequency. Ordered logistic regressions are estimated by country (Germany, Italy, and the Netherlands) and by gender. Our results suggest the key role played by a comprehensive set of socio-demographic, economic, and environmental aspects in determining urban travel behaviour. Moreover, our investigation brings to light some relevant cross-country and cross-gender commonalities and differences. The provided evidence may give policymakers a better knowledge of travel behaviour, useful for designing new interventions for environmentally-sustainable travelling.

**Keywords** Cross-country comparison · Eurobarometer · Ordered logistic regression · Pro-environmental travel behaviour · Public transport · Sustainable travel

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## 1 Introduction

Travel behaviour has been investigated since the 1970s (Hägerstrand 1974), albeit the analysis of pro-environmental travel behaviours (PETBs) at the individual and societal level has been developed only since the 1990s (see, e.g., Garvill 1999; Van Lange et al. 1998; Van Vugt et al. 1996). This growing interest is linked to the continuous increase in car use during the last 30 years (Buehler et al. 2017), which brought the car to become the primary travel mode in most advanced nations (Eurostat 2019; Wang and Lin 2019). Indeed, cars bring benefits to passengers over alternative modes (e.g., flexible timing, door-to-door mobility, comfort, and social status) but also significant impacts for society from environmental (e.g., air pollution, excessive use of resources and land, noise) and socio-economic (e.g., traffic congestion, car accident damages, mobility disadvantages, human health, community liveability) perspectives (see, e.g., Habib et al. 2021; Khreis et al. 2017; Redman et al. 2013; Mackett 2012). Hence, current transport policies aim at reducing reliance on private vehicles (Haustein and Hunecke 2013; Magueta et al. 2018), by encouraging the move towards cleaner travel modes (e.g., travelling shorter distances by car, using public transport, cycling and/or walking, using less environmentally-harmful vehicles), also in order to achieve sustainable goals (e.g., Kyoto Protocol, Green Paper and Action Plan on urban mobility, White Paper "European Transport Policy").

The analysis of individuals' travel decision-making process aimed at developing more PETBs cannot overlook that acting in the community's best interest may conflict with acting in one's self-interest (Garvill 1999; Van Vugt et al. 1996). For example, a long-term benefit associated with more PETBs may conflict with the immediate disadvantages that citizens should bear in terms of longer travel time or less flexible and comfortable travel. Therefore, a drastic reduction of circulating private vehicles is not realistic, as there currently are no similarly flexible alternatives capable of meeting people's mobility requirements. Some solutions have been proposed, including city planning and infrastructure measures (Redman et al. 2013; Loukopoulos 2007). However, introducing cleaner transport systems (e.g., providing safe and inexpensive alternatives to private motor vehicles such as active and public transport, see Buehler et al. 2017; Holmgren 2007) does not necessarily guarantee a more rational use of private vehicles. Indeed, some studies demonstrated the gap between expected and realised outcomes of various policies, with most case studies not leading to the projected results (see Ramezani et al. 2018a for a review). Therefore, a better understanding of the characteristics of public transport users may help design strategies to ensure that more people switch from private to public transport modes.

By assuming environmental sustainability to be proxied by transport mode choice (Buehler et al. 2017; Palliyani and Lee 2017; Steg and Vlek 2009), this paper investigates the motivations of citizens' public transport (PT, henceforth) use frequency. More precisely, in light of the existing literature, our interest lies in throwing new insights into whether and how a wide range of variables regarding travel mode choice, own financial perception, politics and environment, and socio-demographic characteristics may help explain PT use frequency in three European countries (Germany, Italy, and the Netherlands). The analysis of the connection between the factors underlying PT use frequency choice (outcome variable) across countries and the assessment of PETBs from a gender perspective can yield insights to assist policymakers in developing targeted strategies for pro-environmental travel.

The choice of countries to be compared reflects the cross-national comparison approach identified by Kohn (1989), which enables to analyse nations sharing some underlying characteristics, without losing sight of the peculiarities of each national context (Livingstone 2003).

Indeed, these three countries share certain features in respect of which they can be thought of as leaders in sustainable mobility: Italy is the leading country in EU for natural gas[1] vehicles (about 75% of European gas vehicles are registered in Italy) and has, together with Germany and the Netherlands, the highest number of natural gas stations; the Netherlands is also the first country in the EU for the number of e-vehicles (at least until 2016, before a change in the tax rules) and daily use of bicycles, as well as being the gas-to-liquid (i.e., a refinery process to convert gas into gasoline or diesel fuel) pilot country in the EU (European Alternative Fuels Observatory 2019; European Commission 2015).

We carry out our analysis for each gender separately, in order to consider the different motivations, needs, and constraints for PT usage of men and women. This allows us to investigate the social and cultural geographies of mobility, also looking at gendered identity and at how it may affect travel patterns. We believe that understanding gender differences in travel behaviour could help design more efficient, equitable, and gender-responsive transport policies.

Numerous studies highlighted gender differences in transport demands and experiences, clarifying how women's travel patterns and needs are usually distinct from those of men in terms of purpose, time and mode of travel (Sovacool et al. 2019; Levy 2013; Hanson 2010; Shearmur 2006). Whitzman et al. (2013) argued how gender-based violence or fear of violence may strongly affect access to active and sustainable transport options (e.g., walking, cycling, using PT). In particular, they considered the redistribution (i.e., creating greater access to safe urban spaces), recognition (i.e., intersectional awareness of different concerns and needs) and encounter (i.e., interactions in public space in which notions of difference are encountered) as the main three dimensions in which women's mobility requires to be understood. Gender differences are also grounded in the gender-based division of labour within the family and community (United Nations 2008), whereby women and men play different roles in household chores, child-rearing and elder-care responsibilities. This inevitably affects their patterns of commuting, as well as their attitudes towards private and public transport (Duchène 2011; Dobbs 2007).

The remainder of this paper is organised as follows. Section 2 provides an overview of the case study countries, which help contextualise the analysis. Section 3 presents the methodology and the data used to perform the analyses. Section 4 goes into the main empirical results, for each country and then from a cross-country perspective. Then, Sect. 5 concludes by providing discussions, best practices, and policy implications that stem from the results.

## 2 Overview of case study countries

In each country, governments set the policy framework for individual travel behaviour through targeted transport plans which influence the cost, accessibility, and convenience of travel. In the EU-28, urban and suburban public transport services carried approximately 185 million passengers on an average working day in 2014, out of a total population of 507

[1] As discussed by the International Gas Union, natural gas, which is a fossil fuel comprised mostly of methane, represents the cleanest of all fossil fuels in terms of nitrogen monoxide and particulate matter emissions. It can be used in the form of compressed natural gas (CNG) for passenger cars and city buses or in the form of liquefied natural gas (LNG) for heavy duty trucks. See https://www.igu.org/natural-gas-cleanest-fossil-fuel.

million (Union Internationale des Transports Publics 2016). Germany, which ranked above the EU average, has seen a growth of these figures over the five previous years, while the ridership figures were below the EU average in Italy and the Netherlands. If a country has multiple cities served by wide public transport networks, national-level ridership is less likely to be influenced by developments in the capital city. In Germany and Italy, the number of public transport journeys in the capital is almost a third of the national total. However, in Italy, the share of the capital city within the total ridership usage has decreased from 2010 to 2014.

It is noteworthy, in order to analyse the impact of car ridership in the three different countries, that the automotive industry for the national economy is particularly important in Germany and Italy, while only one large-scale car manufacturer is located in the Netherlands. All the three countries have access to the same petroleum prices of international markets and then impose different taxes and subsidies which shape the gasoline prices across countries, thus influencing travel behaviour by increasing the costs of car use for individuals. In particular, the Netherlands currently imposes the highest gasoline price in the EU (year 2019), and this can be one of the reasons behind the low car ridership rates in the country, on which reduction policymakers have been working on since the 1970s. Indeed, the 1973 petrol crisis introduced the themes of energy saving and alternative energy all over the world; in the Netherlands, this global energy crisis was seen as an opportunity to change habits, giving way to an urban transport revolution. In December 1973, the then prime minister Joop Den Uyl reassured Dutch citizens about the crisis in a speech and encouraged them to take on a cleaner lifestyle, in order to move forward without weighing further on the national economy. The Dutch government was the only one in Western Europe to introduce petrol rationing at the time (Hellema et al. 2004).

Western Germany and the Netherlands pioneered the idea of pedestrianisation, and examples of successful car-free areas can now be found in every part of these countries (Clout et al. 2014), in which policies for making car use expensive and inconvenient–through a host of taxes and restrictions on car ownership, use, and parking–are common (Pucher and Buehler 2008). In particular, the world's earliest pedestrianisations of existing streets took place in Essen (1929), Cologne (1930), and Bremen (1931); by 1955, twenty-one German cities had closed at least one street to traffic (Hass-Klau 1990).

Prior to 1970, both eastern and western German societies devoted their energies to economic growth with little concern for environmental wellbeing (Panarello 2021); pollution was worse in the West because the expansion was more rapid. After 1970, the West was to initiate environmental improvements while the East continued on its damaging course (Dominick 1998). Nowadays, after decades of successful sustainable policymaking, the country is commonly seen as Europe's green leader (Buehler et al. 2011).

Germany and Italy currently have the largest stocks of vehicles in the EU (Eurostat 2019). In particular, looking at regional car motorisation rates, the highest rate in the EU in 2016 was that of Valle d'Aosta (in northern Italy), with 1173 passenger cars per 1000 inhabitants. Alongside Valle d'Aosta, both the second and third highest regional motorisation rates in the EU were also recorded in northern Italy, while the only other region recording a rate of above 800 passenger cars per 1000 inhabitants was Flevoland in the Netherlands; moreover, half of the 20 regions with the highest motorisation rates in the EU were Italian. On the opposite side, the German capital city region of Berlin has one of the lowest motorisation rates in the EU (less than 350 cars per 1000 inhabitants), and Noord-Holland (in the Netherlands) also records motorisation rates considerably below the EU-28 average. Such low rates may be linked, among other things, to difficulty to park, greater availability of public transport, better walking and cycling facilities, and higher concerns over sustainable development issues, which may lead households to choose to own just one car rather than multiple cars or to have no car at all, and as a consequence to rely more or exclusively on active and public transport.

Many environmental policies were adopted in these countries (International Institute for Labour Studies 2011). For instance, in Germany, mandatory fuel efficiency labelling for new passenger cars were adopted since 2004 to provide consumers with information about fuel consumption and $CO_2$ emissions, and a new vehicle car tax system was developed in 2009. In Italy, energy performance monitoring in vehicle certification has been progressively implemented since 1998, a new tax system for the registration of vehicles was developed in 1999, car sharing incentives have been offered since 2001, motor vehicle scrapping subsidies (car bonuses) were introduced in 2007, personal income tax allowances for PT since 2008, subsidy programs to increase bicycle use since 2009, and funding for new bike sharing projects since 2010. In the Netherlands, duties on petrol were applied since 1990, taxes in connection with mineral oil stocks and taxes for commuting in a private car since 2001, taxes on the registration of passenger cars and motorcycles since 2006, labelling of vehicle efficiency for all new passenger cars stating fuel consumption, level of $CO_2$ emissions, and efficiency category since 2001 (updated in 2006), new eco-driving policies to optimise driving behaviour and encourage a modal shift from passenger vehicles to other forms of transport since 2006, and a kilometre pricing system for road usage since 2007.

A basic overview of territorial characteristics, data about motor vehicles, and share of land passenger transport, for each country and with reference to the year of analysis, is shown in Table 1.

## 3 Methodology and data

According to the travel behaviour theory (Chatman 2008; McCarthy 2001; Ben-Akiva and Lerman 1985), travellers are assumed to maximise their utility when participating in out-of-home activities such as work, shopping, or leisure. This approach to decision-making behaviour implies that individuals follow a utility-maximisation strategy which leads them to select the alternative with the highest subjective utility within alternative space. Within the microeconomic utility-maximisation theoretical framework (McFadden 2001; Hensher 1994), travel mode choice can be statistically analysed through discrete choice models.

We consider PT use frequency as the dependent variable in our analyses. It can be seen as a proxy of the degree to which a traveller is environmentally-oriented. Given the nature of the variable (ordinal variable measured through a 7-point Likert scale), we estimate ordered logistic regressions by country and gender on a set of covariates supposed to influence PETBs. Indeed, the estimates obtained by means of ordered logit and probit models are generally quite similar, since they are not affected by the assumed variance of the errors. However, interpretation of the parameters in terms of odds requires the ordered logit model. Interpreting odds ratios rather than coefficients is more straightforward, as the effect of a unit change in $x_k$ on the logit does not depend on the level of $x_k$ or on the level of any other variable (Long 1997).

The ordinal regression model can be derived from a measurement model in which a continuous latent variable, $y^*$, is mapped to an observed variable $y$. The continuous unobservable propensity ($y_i^*$, latent variable), capturing the underlying decisional process based on the evaluation of the utility arising from using PT to a different extent,

**Table 1** Country overview–Year 2013

| Content | Variable | Germany | Italy | Netherlands |
|---|---|---|---|---|
| Territory | Square km. land | 357,168 | 302,073 | 41,540 |
| | No. inhabitants (31 December) | 80,767,463 | 60,782,668 | 16,829,289 |
| | Population density | 226.13 | 201.22 | 405.13 |
| Motor vehicles data | No. passenger cars per 1,000 inhabitants | 543 | 608 | 471 |
| | Stock of registered cars (thousands) | 43,851 | 36,963 | 7,932 |
| | Stock of registered buses (thousands) | 76.8 | 98.6 | 9.9 |
| | Avg. cost of gasoline in Euro (16 December) | 1.55 | 1.73 | 1.69 |
| Modal split of passenger transport on land (passenger-km, % of the total of passengers) | Passengers by car | 84.4 | 79.7 | 82.5 |
| | Passengers by bus and coach | 5.7 | 13.2 | 6.6 |
| | Passengers by railway | 8.4 | 6.3 | 10.0 |
| | Passengers by tram and metro | 1.6 | 0.9 | 0.8 |
| Transport infrastructure | Length of railway lines (km) | 37,860 | 3,013 | 16,752 |
| | Length of motorways and e-roads (km) | 12,917 | 6,751 | 2,666 |
| | Length of other roads–state, provincial, municipal (km) | 612,860 | 249,288 | 129,204 |
| | Number of metro systems | 4 | 7 | 2 |
| Air pollution | Pollutant emissions from transport | 71.9 | 57.0 | 71.7 |
| | Exposure to particulates < 2.5 μm (population weighted annual mean concentration) | 14.6 | 20.1 | 14.0 |
| | Exposure to particulates < 10 μm (population weighted annual mean concentration) | 20.4 | 30.2 | 21.2 |
| | Average CO2 emissions per km from new passenger cars | 136.1 | 121.1 | 109.1 |

Source: Eurostat databases

would cross thresholds ($\tau$) that distinguish contiguous levels of the observed ordered $y_i$'s. The latent variable is supposed to be linearly related to the observed $x$'s through the structural model:

$$y_i^* = x_i\beta + \varepsilon_i \tag{1}$$

where $\beta$ is the vector of coefficients and $\varepsilon_i$ is the error term with mean zero and standard deviation $\pi/\sqrt{3}$. The manifest ordinal variable $y_i$, which measures respondents' PT use frequency, is related to $y_i^*$ according to the model:

$$y_i = m \; if \quad \tau_{m-1} \le y_i^* < \tau_m \quad for\ m = 1\ to\ J \tag{2}$$

where m identifies the seven levels (J = 7) of the manifest variable (never, less than twice a month, two/three times a month, about once a week, two/three times a week, once a day, several times a day) and $\tau$ the estimated thresholds on a latent variable employed to distinguish PT use levels.

The observed $y$ is related to $y^*$ according to the following measurement model:

$$y_i = \begin{Bmatrix} 1 \rightarrow never & if\ \tau_0 = -\infty \le y_i * \le \tau_1 \\ 2 \rightarrow less\ than\ twice\ a\ month & if\ \tau_1 \le y_i * \le \tau_2 \\ 3 \rightarrow two/three\ times\ a\ month & if\ \tau_2 \le y_i * \le \tau_3 \\ 4 \rightarrow about\ once\ a\ week & if\ \tau_3 \le y_i * \le \tau_4 \\ 5 \rightarrow two/three\ times\ a\ week & if\ \tau_4 \le y_i * \le \tau_5 \\ 6 \rightarrow once\ a\ day & if\ \tau_5 \le y_i * \le \tau_6 \\ 7 \rightarrow several\ times\ a\ day & if\ \tau_6 \le y_i * \le \tau_7 = \infty \end{Bmatrix} \tag{3}$$

The probability that the individual $i$ will select the alternative $m$ is:

$$p_{im} = P(y_i = m|x_i) = F(\tau_m - x_i\beta) - F(\tau_{m-1} - x_i\beta) \tag{4}$$

where $F$ is the logistic cumulative density function.

We use Eurobarometer data on the attitudes of Europeans towards urban mobility (European Commission 2017). The survey was carried out between May and June 2013 in the then 27 EU Member States plus Croatia and consisted in conducting computer-assisted personal interviews (CAPI) in people's homes to collect information on their experiences, opinions, expectations, and transport habits. A multi-stage, random probability sampling design was used for this Eurobarometer. The use of harmonised data from Eurobarometer allows for overcoming the potential restrictions related to cross-country differences in data collection methods and variables (Ramezani et al. 2018b; Buehler 2010). Population size weighting factors are provided, to be able to represent each country sample in proportion to its population size. Therefore, each national sample is representative of the country it belongs to. In total, 27,680 citizens were interviewed, with about 1000 respondents per country. The sample size for Germany amounts to about 1500 respondents, to consider the representativity both for the Eastern and Western parts.

In the selected nations, people are allowed to drive without supervision only since the age of 18. Therefore, we include only individuals aged 18 and above in the analysis, assuming that the use of PT before that age is driven by necessity rather than personal choice. We also exclude people aged more than 79, as driving becomes increasingly hazardous at that age and such people may not be entitled to drive anymore, thus making car alternatives an obvious choice. Post-stratification weights, based on a comparison of each sample with the respective universe description, were properly accounted for when performing the analysis.

We use 30 independent variables that are supposed to affect the frequency of PT usage, classified into four groups. A detailed description of the used variables, along with descriptive means and sample sizes for the three different countries and gender, can be found in Table 2.

All the variables that were not originally dichotomic had been turned into dummy variables for an easier interpretation of the models' results.

In particular, in the socio-demographic group, to create the dummy variables, we used the "Married" category from the "Marital status" variable; the "Up to 15 years" category from the "Age at completion of education" variable, to imply a low level of education; the "61–79 years" category from the "Age" variable, to analyse the particular behaviour of the elderly; high-level jobs such as "Manager" and some of the professions included in the "Other white collar" group from the "Profession" variable, to generate the "Job level (professional/manager)" dummy variable; "Large town" from the "Community" variable; "One or more kids aged < 10 in the household" to define the "Children" dummy variable, while the original one included the exact number of children under the age of 10 present in the household.

The "Travel mode choice" group includes the frequency of car use, bicycle use, pedestrian paths use, and urban travel. These variables were originally coded the same way as our dependent variable (Public transport use frequency), i.e., with 7 levels going from "Never" to "Several times a day". We turned each of them into two "Daily" (at least once a day) and "Weekly" (about once, twice or thrice a week) dummy variables.

As regards the last two groups–"Own financial perception" and "Politics and Environment"–some of the variables were already coded as dichotomic, while some others were originally coded as Likert scales and had been recoded into two levels only.

## 4 Results

We perform ordered logistic regressions to verify whether and how the impact of the selected covariates on PT use frequency differs across countries and genders. It is worth remarking that logit regression includes variables that can be considered as two sides of the same coin regarding PT usage: this means that the results do not necessarily imply causation. In order to gauge issues about multicollinearity (see Giacalone et al. 2018), a correlation matrix between regression coefficients in each of the six estimated models is computed. The matrixes show acceptable values, highlighting that collinearity issues are not present. The results are provided online as supplementary material.

Hereafter, we first sketch a profile for each country and then discuss the results from a cross-country perspective.

### 4.1 Germany

Table 3 shows the ordered logit estimations for Germany. Riding a bike about once, twice or thrice a week increases the probability of using PT. Using pedestrian paths and travelling within the city some days a week increases this probability for men only, while it increases for both genders when considering daily frequency.

Moving on to political and environmental perceptions, even if costs are usually a sensitive issue for mobility (Vidyattama et al. 2013; Zha et al. 2020), German male PT users are the only ones who appear to be influenced by ticket prices, with a positive

**Table 2** Percentages of the considered variables, by country and gender

| Variable | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Germany | Italy | Netherlands | Germany | Italy | Netherlands |
| *Public transport use frequency* | | | | | | |
| Never | 24.4 | 47.5 | 36.1 | 16.6 | 41.4 | 31.6 |
| Less than twice a month | 41.3 | 22.6 | 29.6 | 43.7 | 21.4 | 35.8 |
| Two/three times a month | 8.1 | 5.3 | 9.6 | 6.0 | 7.0 | 11.0 |
| About once a week | 5.2 | 3.4 | 7.2 | 8.5 | 5.9 | 6.1 |
| Two/three times a week | 6.9 | 8.9 | 8.5 | 13.9 | 13.0 | 10.2 |
| Once a day | 4.8 | 4.3 | 4.0 | 4.7 | 5.5 | 1.8 |
| Several times a day | 9.3 | 8.0 | 4.9 | 6.6 | 5.7 | 3.5 |
| *Socio-demographic* | | | | | | |
| Marital status | | | | | | |
| Unmarried | 20.9 | 17.5 | 28.9 | 16.1 | 16.7 | 26.7 |
| Married | 69.6 | 76.3 | 62.3 | 65.8 | 71.9 | 62.1 |
| Divorced or separated | 9.5 | 6.2 | 8.7 | 18.2 | 11.4 | 11.2 |
| Age at completion of education | | | | | | |
| Up to 15 years | 17.2 | 30.1 | 7.4 | 19.8 | 30.7 | 9.4 |
| 16–19 years | 45.0 | 38.1 | 32.5 | 53.7 | 45.5 | 40.0 |
| 20 years and older | 29.9 | 24.2 | 51.7 | 20.8 | 18.5 | 44.5 |
| Other (still studying, no education, etc.) | 7.9 | 7.5 | 8.4 | 5.7 | 5.3 | 6.1 |
| Age | | | | | | |
| 18–40 years | 29.7 | 37.1 | 28.5 | 32.7 | 36.7 | 31.4 |
| 41–60 years | 38.8 | 38.5 | 37.4 | 39.7 | 37.9 | 40.9 |
| 61–79 years | 31.5 | 24.4 | 34.1 | 27.6 | 25.4 | 27.7 |
| Job level | | | | | | |
| Self-employed | 9.4 | 18.2 | 13.9 | 6.0 | 8.9 | 11.0 |
| Manager | 15.3 | 7.8 | 15.5 | 11.5 | 5.5 | 7.7 |
| Other white collar | 6.6 | 19.1 | 17.0 | 11.2 | 22.2 | 13.3 |
| Manual worker | 19.8 | 19.6 | 9.2 | 21.3 | 10.3 | 16.9 |
| House person | 0.4 | 0.2 | 0.9 | 9.5 | 25.5 | 12.0 |
| Unemployed | 8.7 | 5.5 | 4.3 | 7.9 | 6.2 | 7.9 |
| Retired | 31.9 | 22.3 | 30.9 | 26.9 | 16.2 | 25.1 |
| Student | 7.9 | 7.3 | 8.3 | 5.7 | 5.2 | 6.1 |
| Community | | | | | | |
| Rural area or village | 23.4 | 13.7 | 39.5 | 27.4 | 14.8 | 43.3 |
| Small or middle town | 51.2 | 67.0 | 38.3 | 51.1 | 62.6 | 35.5 |
| Large town | 25.4 | 19.3 | 22.2 | 21.5 | 22.6 | 21.2 |
| Children | | | | | | |
| No kids aged < 10 in the household | 88.9 | 82.0 | 85.0 | 81.1 | 80.4 | 79.6 |
| One or more kids aged < 10 in the household | 11.1 | 18.0 | 15.0 | 18.9 | 19.6 | 20.4 |
| *Travel mode choice*[#] | | | | | | |
| Car use frequency (1: *daily*) | 60.5 | 76.5 | 52.9 | 47.9 | 62.5 | 43.4 |
| Car use frequency (1: *weekly*) | 24.7 | 16.6 | 31.2 | 30.4 | 21.7 | 40.5 |
| Bicycle use frequency (1: *daily*) | 21.1 | 14.1 | 39.7 | 20.3 | 10.9 | 44.6 |

**Table 2** (continued)

| Variable | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Germany | Italy | Netherlands | Germany | Italy | Netherlands |
| Bicycle use frequency (1: *weekly*) | 24.7 | 13.7 | 30.9 | 24.8 | 11.9 | 29.1 |
| Pedestrian paths use frequency (1: *daily*) | 69.7 | 51.3 | 39.9 | 72.2 | 58.2 | 45.6 |
| Pedestrian paths use frequency (1: *weekly*) | 18.6 | 21.2 | 35.7 | 20.2 | 24.2 | 34.4 |
| Urban travel frequency (1: *daily*) | 55.0 | 74.3 | 43.7 | 48.4 | 73.0 | 28.5 |
| Urban travel frequency (1: *weekly*) | 25.1 | 18.9 | 25.1 | 27.7 | 18.7 | 29.3 |
| *Own financial perception* | | | | | | |
| Cost of living (1: *good*) | 57.6 | 11.8 | 67.7 | 53.3 | 10.1 | 57.0 |
| Cost of energy (1: *good*) | 29.7 | 16.6 | 63.9 | 30.2 | 16.9 | 57.2 |
| Household financial situation (1: *good*) | 78.4 | 51.9 | 85.9 | 73.1 | 45.0 | 84.7 |
| Car ownership (1: *yes*) | 81.0 | 89.3 | 83.9 | 76.8 | 84.9 | 81.3 |
| Apartment/house ownership (1: *yes*) | 33.2 | 56.3 | 13.2 | 27.7 | 52.7 | 12.2 |
| *Politics and Environment* | | | | | | |
| Road congestion issues (1: *important*) | 76.8 | 80.0 | 65.0 | 73.5 | 81.0 | 69.2 |
| Air pollution issues (1: *important*) | 72.7 | 87.5 | 75.8 | 77.9 | 89.7 | 82.5 |
| Travel cost issues (1: *important*) | 73.9 | 78.1 | 44.8 | 74.6 | 83.1 | 57.6 |
| Lower public transport prices (1: *important*) | 75.5 | 33.0 | 70.0 | 75.2 | 38.6 | 75.2 |
| EU policies against poverty (1: *important*) | 41.6 | 50.3 | 33.4 | 42.1 | 48.4 | 31.4 |
| Higher public transport quality (1: *important*) | 57.4 | 46.9 | 65.7 | 54.4 | 49.5 | 58.0 |
| Walking facilities (1: *important*) | 23.7 | 28.5 | 18.2 | 23.9 | 30.2 | 19.3 |
| Cycling facilities (1: *important*) | 36.8 | 25.1 | 43.9 | 40.5 | 23.8 | 42.4 |
| Access time restrictions (1: *important*) | 15.6 | 18.9 | 11.9 | 16.6 | 17.1 | 12.8 |
| Car sharing incentives (1: *important*) | 34.2 | 10.9 | 26.2 | 30.9 | 9.6 | 33.2 |
| Urban traffic responsibles (1: *citizens*) | 29.0 | 27.3 | 46.4 | 24.8 | 30.4 | 54.8 |
| *Observations* | *693* | *439* | *446* | *698* | *562* | *491* |

*#Daily: at least once a day; Weekly: about once, twice or thrice a week; Reference group: less than once a week*

effect on the frequency of use. Moreover, for males, thinking that the EU should focus more on policies about poverty negatively affects PT usage. The same applies to men who believe that access restrictions at specific times would be an appropriate measure to improve urban travel quality. Men who think that car sharing could improve travel within cities are more likely to use PT.

German women who have kids are less likely to use PT. Indeed, although women generally exhibit higher PEBs than men (Lynn and Longhi 2011), their behaviour changes when they are also mothers. The presence of children may generate constraints, in terms of time and practices, that make it harder to pursue pro-environmental behaviours, including those concerning the use of public transport (Thomas et al. 2018). Germany is the only country in which over-60 women are less likely to use PT, maybe because they value safety concerns more than similarly-aged men, and fear to be more exposed to potential wrongdoers (Föbker and Grotz 2006).

**Table 3** Ordered logit estimation–Germany (2013)

| Variable | Men | | Women | |
|---|---|---|---|---|
| | Odds Ratio | S.E. | Odds Ratio | S.E. |
| *Socio-demographic* | | | | |
| Marital status (1: *married*) | 0.797 | 0.173 | 0.725 | 0.146 |
| Age at completion of education (1: < *16 years*) | 0.710 | 0.184 | 0.733 | 0.156 |
| Age (1: *61–79 years*) | 0.641** | 0.143 | 0.668* | 0.144 |
| Job level (1: *professional/manager*) | 0.806 | 0.174 | 1.364 | 0.354 |
| Community (1: *city*; 0: *town/rural area*) | 3.221*** | 0.735 | 5.105*** | 1.213 |
| Children (1: *with kids aged* < *10*) | 1.023 | 0.270 | 0.661* | 0.144 |
| *Travel mode choice*[#] | | | | |
| Car use frequency (1: *daily*) | 0.095*** | 0.035 | 0.115*** | 0.042 |
| Car use frequency (1: *weekly*) | 0.305*** | 0.105 | 0.412*** | 0.132 |
| Bicycle use frequency (1: *daily*) | 1.211 | 0.299 | 0.717 | 0.180 |
| Bicycle use frequency (1: *weekly*) | 2.289*** | 0.488 | 1.440** | 0.268 |
| Pedestrian paths use frequency (1: *daily*) | 3.205*** | 0.958 | 2.705** | 1.271 |
| Pedestrian paths use frequency (1: *weekly*) | 2.115** | 0.692 | 2.184 | 1.064 |
| Urban travel frequency (1: *daily*) | 2.437*** | 0.619 | 2.088*** | 0.458 |
| Urban travel frequency (1: *weekly*) | 1.823** | 0.444 | 1.322 | 0.307 |
| *Own financial perception* | | | | |
| Cost of living (1: *good*) | 1.350 | 0.259 | 1.337 | 0.237 |
| Cost of energy (1: *good*) | 1.389 | 0.286 | 1.472** | 0.281 |
| Household financial situation (1: *good*) | 0.865 | 0.222 | 0.908 | 0.204 |
| Car ownership (1: *yes*) | 0.565* | 0.176 | 0.533** | 0.154 |
| Apartment/house ownership (1: *yes*) | 0.795 | 0.194 | 0.838 | 0.167 |
| *Politics and Environment* | | | | |
| Road congestion issues (1: *important*) | 0.898 | 0.205 | 1.370 | 0.308 |
| Air pollution issues (1: *important*) | 0.959 | 0.191 | 0.711 | 0.177 |
| Travel cost issues (1: *important*) | 0.724 | 0.154 | 0.886 | 0.181 |
| Lower public transport prices (1: *important*) | 1.937*** | 0.457 | 1.216 | 0.302 |
| EU policies against poverty (1: *important*) | 0.525*** | 0.101 | 0.771 | 0.131 |
| Higher public transport quality (1: *important*) | 1.342* | 0.234 | 1.163 | 0.214 |
| Walking facilities (1: *important*) | 0.879 | 0.188 | 1.252 | 0.264 |
| Cycling facilities (1: *important*) | 1.201 | 0.241 | 0.858 | 0.155 |
| Access time restrictions (1: *important*) | 0.552** | 0.142 | 1.106 | 0.243 |
| Car sharing incentives (1: *important*) | 1.520** | 0.285 | 0.856 | 0.149 |
| Urban traffic responsibles (1: *citizens*) | 1.093 | 0.224 | 1.671*** | 0.315 |
| cut 1 | −2.000 | 0.567 | −2.641 | 0.558 |
| cut 2 | 0.633 | 0.572 | 0.218 | 0.561 |
| cut 3 | 1.305 | 0.574 | 0.655 | 0.564 |
| cut 4 | 1.723 | 0.574 | 1.307 | 0.560 |
| cut 5 | 2.463 | 0.573 | 2.799 | 0.593 |
| cut 6 | 3.169 | 0.580 | 3.661 | 0.621 |
| *Observations* | *692* | | *698* | |
| *Log-likelihood* | *−889* | | *−923* | |

**p* < 0.10; ***p* < 0.05; ****p* < 0.01*

[#]*Daily: at least once a day; Weekly: about once, twice or thrice a week; Reference group: less than once a week*

### 4.2 Italy

Among daily car users, only women are less likely to take a bus, a tram or another urban public mean of transportation. Men who cycle are about three times more likely to use PT relative to the ones who do not, while walking once, twice or thrice a week increases this probability for women only. Among all EU States, Italian citizens are the ones who are most likely to travel within the city daily (European Commission 2013). Our results show that frequent urban travel positively affects PT usage for women. Indeed, travel frequency may influence transportation choices differently for men and women: as women commonly use the car less and make shorter trips compared to men, it becomes more likely for them to use PT (Hanson 2010). Men who believe that better cycling facilities and car sharing services could enhance urban travel quality are less likely to use PT than men who do not, showing a poorer multimodal attitude. In addition, Italy is the country with the lowest support for car sharing incentives, with only about 10.2% of Italians considering them to be important (Table 2).

Women who were 16 or older at the completion of education and have got a high-level job are prone to use PT with a greater frequency than women with fewer years of schooling and either with a low-level job, students or unemployed. These results are in line with the literature demonstrating that well-educated people are more aware about environmental issues, with a positive impact on commuting behaviour (Chankrajang and Muttarak 2017; Meyer 2015; Östh and Lindgren 2012).

Nevertheless, Italians with a better socio-economic status, proxied by home ownership and perceived financial conditions, are more likely to travel by PT if men, and less likely if women. Italian women who have kids are less likely to use PT, probably due to the scarcity of childcare services, which make urban travelling uneasy (Castellano et al. 2018). The results for Italians are shown in Table 4.

### 4.3 The Netherlands

The Netherlands is the country with more evident gender differences in travel behaviours (Table 5). Indeed, as regards Dutch travellers considering road congestion to be a relevant urban issue, men are less likely to use PT, unlike women, who tend to use it with a higher frequency. Thus, women appear to be more inclined to change their travel habits according to the urban issues they care about. As additional evidence of this, men believing air pollution to be an important urban problem and/or believing that citizens play the major role in causing urban traffic tend to use PT less frequently. For women, thinking that the EU should focus more on policies about poverty negatively affects PT usage. Men who think that travel costs are an important urban problem are more likely to move within the city by PT, apparently in order to save money. However, as shown in Table 2, it is noteworthy that Dutch citizens do not consider travel cost issues as much important as people from the other countries even though transport services in the Netherlands are currently about 35% more expensive than the EU average, making them the most expensive among EU Member States.[2] The high PT prices go hand in hand with the high quality of Dutch PT, which

[2] Eurostat, 2019, https://ec.europa.eu/eurostat/statistics-explained/index.php/Comparative_price_levels_of_consumer_goods_and_services#Price_levels_for_personal_transport_equipment.2C_transport_services.2C_communication.2C_restaurants_and_hotels.

**Table 4** Ordered logit estimation–Italy (2013)

| Variable | Men | | Women | |
|---|---|---|---|---|
| | Odds Ratio | S.E. | Odds Ratio | S.E. |
| *Socio-demographic* | | | | |
| Marital status (1: *married*) | 0.730 | 0.184 | 1.299 | 0.257 |
| Age at completion of education (1: < *16 years*) | 0.686 | 0.180 | 0.360*** | 0.078 |
| Age (1: *61–79 years*) | 0.439*** | 0.133 | 0.758 | 0.167 |
| Job level (1: *professional/manager*) | 1.387 | 0.362 | 1.672* | 0.469 |
| Community (1: *city*; 0: *town/rural area*) | 2.606*** | 0.674 | 1.484* | 0.315 |
| Children (1: *with kids aged* < *10*) | 0.766 | 0.262 | 0.661* | 0.150 |
| *Travel mode choice*[#] | | | | |
| Car use frequency (1: *daily*) | 0.560 | 0.277 | 0.221*** | 0.066 |
| Car use frequency (1: *weekly*) | 2.146 | 1.040 | 0.735 | 0.208 |
| Bicycle use frequency (1: *daily*) | 3.248*** | 0.957 | 1.347 | 0.467 |
| Bicycle use frequency (1: *weekly*) | 2.566*** | 0.723 | 1.191 | 0.343 |
| Pedestrian paths use frequency (1: *daily*) | 2.359*** | 0.604 | 2.675*** | 0.778 |
| Pedestrian paths use frequency (1: *weekly*) | 1.497 | 0.422 | 2.661*** | 0.809 |
| Urban travel frequency (1: *daily*) | 1.713 | 0.666 | 2.220*** | 0.632 |
| Urban travel frequency (1: *weekly*) | 1.606 | 0.679 | 2.777*** | 0.929 |
| *Own financial perception* | | | | |
| Cost of living (1: *good*) | 0.931 | 0.335 | 1.969** | 0.603 |
| Cost of energy (1: *good*) | 1.588 | 0.509 | 0.945 | 0.238 |
| Household financial situation (1: *good*) | 1.464* | 0.331 | 1.241 | 0.234 |
| Car ownership (1: *yes*) | 0.329*** | 0.122 | 0.500** | 0.140 |
| Apartment/house ownership (1: *yes*) | 1.007 | 0.232 | 0.488*** | 0.091 |
| *Politics and Environment* | | | | |
| Road congestion issues (1: *important*) | 0.717 | 0.245 | 1.000 | 0.274 |
| Air pollution issues (1: *important*) | 0.782 | 0.310 | 0.737 | 0.285 |
| Travel cost issues (1: *important*) | 1.355 | 0.439 | 1.409 | 0.364 |
| Lower public transport prices (1: *important*) | 0.806 | 0.180 | 1.067 | 0.207 |
| EU policies against poverty (1: *important*) | 0.822 | 0.171 | 0.907 | 0.156 |
| Higher public transport quality (1: *important*) | 1.016 | 0.211 | 1.599** | 0.313 |
| Walking facilities (1: *important*) | 0.998 | 0.222 | 0.918 | 0.178 |
| Cycling facilities (1: *important*) | 0.557** | 0.135 | 1.053 | 0.205 |
| Access time restrictions (1: *important*) | 1.223 | 0.291 | 0.967 | 0.198 |
| Car sharing incentives (1: *important*) | 0.623* | 0.161 | 0.959 | 0.287 |
| Urban traffic responsibles (1: *citizens*) | 0.851 | 0.182 | 0.675** | 0.125 |
| cut 1 | −0.955 | 0.629 | −0.707 | 0.549 |
| cut 2 | 0.301 | 0.625 | 0.374 | 0.540 |
| cut 3 | 0.682 | 0.624 | 0.774 | 0.542 |
| cut 4 | 0.958 | 0.627 | 1.132 | 0.539 |
| cut 5 | 1.846 | 0.631 | 2.218 | 0.548 |
| cut 6 | 2.469 | 0.642 | 3.049 | 0.553 |
| *Observations* | *438* | | *560* | |
| *Log-likelihood* | *−632* | | *−782* | |

*$*p < 0.10$; $**p < 0.05$; $***p < 0.01$*

*[#]Daily: at least once a day; Weekly: about once, twice or thrice a week; Reference group: less than once a week*

also implies a high frequency of PT usage such that some routes are already very crowded. Therefore, a price reduction could generate overcrowding, which would paradoxically induce Dutch citizens to take the car.

Being married seems to affect the probability of PT usage, while this does not happen elsewhere: for both genders, married citizens are less likely to get the bus or other PT services for their urban travel. This could mean that marital status change affects the traditional ways in which individual members relate to one another and divide household responsibilities, with clear transportation implications (Lee and McDonald 2003). While a better perceived financial situation leads to a more pro-environmental way of travelling only for women, a low education level has a negative effect on the probability of using PT for both genders. The Netherlands is the only country where owning a car does not affect PT usage. Probably, this is due to Dutch citizens being those who mostly believe that a higher public transport quality and better cycling facilities are important for improving urban mobility (see Table 2), leading them to rely more on means of transportation alternative to the car.

### 4.4 Cross-country comparison

Results show that the variety of factors has different roles in shaping travel behaviours in the three countries and for each gender. Nevertheless, some cross-national parallels in PETBs may be drawn.

As expected by looking at the very high shares of daily car use and car ownership in the whole sample (Table 2), citizens with a private car are less likely to use PT services, but not in the Netherlands, which seems to offer more dynamic and multimodal infrastructures, thereby Dutch people can reach PT nodes by car and continue their journey by public transit.

Indeed, using pedestrian paths every day increases PT use frequency for each profile but Dutch women. This is because PT is primarily accessed on foot (Buehler et al. 2017), and with pedestrians often being marginalised in car-oriented cities, the short trips on foot necessary to access PT stops become inconvenient.

While men from each country seem not to be affected by the cost of energy for what concerns the use of PT, German and Dutch women are likely to use it even when they think that energy is affordable. Looking at the descriptive statistics (Table 2), Italy seems to be the only country with no large support for lower public transport prices, maybe as average costs are already low compared to the other considered countries, or because the fare is linked to the quality of service provided. Italian women who believe citizens to be the main responsible of the urban traffic situation appear to use PT services with a higher frequency than women who do not, and the same holds true for Dutch men, who look to be concerned about urban environmental quality and eager to improve it. In addition, Dutch citizens are the ones who most indicate themselves as the main responsible for the current traffic situation (Table 2). German men, Italian women, and both women and men from the Netherlands, who think that a higher PT quality improves urban travelling, are more likely to use it. Therefore, most PT users demand a higher PT quality, tending to favour the development of policies that improve conditions for the transport modes they habitually use. In the Netherlands, the different approach to road congestion between the genders highlights that men do not care much about urban problems, as they are less likely to use PT as a sustainable solution to road traffic and air pollution but are more likely to use it when concerned about travel costs. For what

**Table 5** Ordered logit estimation–Netherlands (2013)

| Variable | Men | | Women | |
|---|---|---|---|---|
| | Odds Ratio | S.E. | Odds Ratio | S.E. |
| *Socio-demographic* | | | | |
| Marital status (1: *married*) | 0.599** | 0.150 | 0.410*** | 0.098 |
| Age at completion of education (1: < *16 years*) | 0.378** | 0.171 | 0.529* | 0.176 |
| Age (1: *61–79 years*) | 0.562** | 0.139 | 0.752 | 0.176 |
| Job level (1: *professional/manager*) | 1.311 | 0.330 | 0.999 | 0.252 |
| Community (1: *city*; 0: *town/rural area*) | 1.732** | 0.465 | 1.727** | 0.462 |
| Children (1: *with kids aged* < *10*) | 0.994 | 0.296 | 0.840 | 0.225 |
| *Travel mode choice*[#] | | | | |
| Car use frequency (1: *daily*) | 0.118*** | 0.065 | 0.217*** | 0.086 |
| Car use frequency (1: *weekly*) | 0.438 | 0.225 | 0.444** | 0.157 |
| Bicycle use frequency (1: *daily*) | 3.627*** | 1.228 | 1.667* | 0.446 |
| Bicycle use frequency (1: *weekly*) | 2.187*** | 0.656 | 1.134 | 0.308 |
| Pedestrian paths use frequency (1: *daily*) | 1.844** | 0.500 | 1.342 | 0.384 |
| Pedestrian paths use frequency (1: *weekly*) | 1.223 | 0.338 | 1.381 | 0.414 |
| Urban travel frequency (1: *daily*) | 1.851** | 0.456 | 2.230*** | 0.548 |
| Urban travel frequency (1: *weekly*) | 1.218 | 0.335 | 1.672** | 0.411 |
| *Own financial perception* | | | | |
| Cost of living (1: *good*) | 1.409 | 0.358 | 1.411 | 0.327 |
| Cost of energy (1: *good*) | 0.933 | 0.216 | 1.714** | 0.430 |
| Household financial situation (1: *good*) | 1.806 | 0.681 | 0.609* | 0.178 |
| Car ownership (1: *yes*) | 1.381 | 0.691 | 0.677 | 0.250 |
| Apartment/house ownership (1: *yes*) | 1.005 | 0.304 | 1.002 | 0.319 |
| *Politics and Environment* | | | | |
| Road congestion issues (1: *important*) | 0.603** | 0.145 | 1.671** | 0.358 |
| Air pollution issues (1: *important*) | 0.595** | 0.151 | 0.749 | 0.201 |
| Travel cost issues (1: *important*) | 1.820** | 0.458 | 0.780 | 0.156 |
| Lower public transport prices (1: *important*) | 0.761 | 0.207 | 1.218 | 0.295 |
| EU policies against poverty (1: *important*) | 0.729 | 0.169 | 0.677* | 0.140 |
| Higher public transport quality (1: *important*) | 1.849*** | 0.417 | 1.490** | 0.285 |
| Walking facilities (1: *important*) | 1.546* | 0.398 | 1.837** | 0.484 |
| Cycling facilities (1: *important*) | 1.052 | 0.239 | 0.954 | 0.195 |
| Access time restrictions (1: *important*) | 0.898 | 0.335 | 1.019 | 0.293 |
| Car sharing incentives (1: *important*) | 1.231 | 0.324 | 1.196 | 0.240 |
| Urban traffic responsibles (1: *citizens*) | 0.595** | 0.130 | 0.925 | 0.174 |
| cut 1 | −0.880 | 0.585 | −1.736 | 0.529 |
| cut 2 | 0.944 | 0.583 | 0.284 | 0.534 |
| cut 3 | 1.664 | 0.584 | 1.053 | 0.543 |
| cut 4 | 2.205 | 0.588 | 1.640 | 0.559 |
| cut 5 | 3.241 | 0.589 | 3.001 | 0.566 |
| cut 6 | 3.996 | 0.613 | 3.485 | 0.581 |
| *Observations* | *446* | | *491* | |
| *Log-likelihood* | *−653* | | *− 653* | |

*$*p < 0.10$; $**p < 0.05$; $***p < 0.01$*

[#]*Daily: at least once a day; Weekly: about once, twice or thrice a week; Reference group: less than once a week* concerns air pollution, about 8 out of 10 individuals in the three countries consider it problematic, which is about the same share of people who own a car (Table 2).

In all three countries, living in a big city has a positive influence on the probability of PT usage, as populous urban areas are usually characterised by shorter distances and more developed PT infrastructures. It is also remarkable that urban lifestyles offer good conditions for promoting multimodal mobility behaviours (Nobis 2007). In addition, some interesting cross-country and gender differences can be observed: while, in the Netherlands, the odds of increased PT usage is about 1.73 times as large for urban citizens compared to villagers, with almost identical behaviours for the two genders, stronger differences are evident in the other countries. German men who live in a big city have 3.2 times the odds of a more frequent use of PT than that of German men who live in towns or rural areas, and women from big cities have 5.1 times greater odds than women from smaller communities. In Italy, men living in a big city have odds of increased PT usage of about 2.6 times the odds of men from a town or countryside. Considering females, the same odds is 1.5 times as large for urban women with respect to rural women. In general, PT usage has declined in rural areas, even though the mobility of the rural population has increased (Droogleever Fortuijn 1999).

In each country, elderly male citizens are less likely to use PT than their younger counterparts, showing to be more reliant on private vehicles than the new generations, and confirming that the rate of people using multiple modes of transportation, rather than just the car, declines in later life stages. Indeed, while most adolescents are multimodal, the share of multimodal people declines since the entry into professional life (Nobis 2007).

Men are found to be more inclined to multimodal and active transport than women, notably by integrating the use of PT and bikes. Women appear to combine PT use and cycling in daily life only in the Netherlands, probably because of their proverbial bicycle culture and advanced cycling infrastructure: the odds of higher PT usage for Dutch women who cycle daily is almost 1.7 times as large as the odds for those who do not use the bicycle every day. However, for Dutch men, this difference is even stronger: men who use the bike every day have an odds 3.6 times as large as that of men who do not use it daily. This may mean that women are led to regularly use PT even when they are not used to frequently take their bike for daily commuting, while men, by contrast, seem to be relying on PT only if they combine it with active transport. Using pedestrian paths on a daily basis also seems to be positively related to PT use. By contrast, frequent car users are less likely to use PT. These results prove that public and active transport can be combined, while a car-based mobility approach does not give way to further transport means.

Additional gender differences are highlighted by socio-economic status, proxied by home ownership and perceived household financial situation: men and women with a better individual or family economic and social background exhibit higher and lower PETBs, respectively. Indeed, a higher socio-economic status decreases the probability of travelling by PT for women (in Italy and the Netherlands) and increases this probability for men (Italy), maybe because women are usually travelling shorter distances to work than men (Hanson 2010), which does not make PT an attractive (i.e., fast, cheap) alternative to the car. Moreover, a high education level has a positive effect on PT usage for Dutch people, irrespective of their gender. Conversely, in Italy, only women who are well-educated and have got a high-level job appear to be using PT with greater intensity. This states the key role of education in environmental matters: the higher environmental awareness of well-educated people makes them more willing to engage in pro-environmental behaviours.

However, the environmentally-friendly mobility behaviour of women may be partly mitigated by the presence of children in the household, which discourages the use of PT for German and Italian women, but not for the Dutch ones.

## 5 Discussion and best practices

Our results highlight the complexity of the dynamics of travel behaviour, whose knowledge is the prerequisite for the development of efficient sustainable transport policies, tailored on the basis of local context and gender. It is striking to see the variety of situations in the selected countries. In general, as several governmental bodies are usually involved in transport decisions, the different authorities must frame a common transport policy to deliver an appealing and interconnected transport system, as well as to encourage people to make sustainable mobility choices. In this context, the regions with less experience in new eco-friendly modes of transport may benefit from working together with more advanced regions in this field, drawing on their knowledge and expertise.

Improvements to be made also depend on the individual motivations for using private vehicles. Without considering these, planning and projects would not adequately meet the demands of a large part of users, so transport would be neither efficient nor sustainable. Target groups are heterogeneous, and different information is required to reach the different travellers and obtain the best performances, considering that some groups–such as women, travellers with children, the elderly, young people, rural dwellers, those on low incomes, and people with communication difficulties and mobility impairments–are, for specific reasons, already mostly dependent on PT, while less vulnerable groups require more efforts in order to be convinced to change their transportation habits.

Our results highlight the importance of addressing policymakers' attention to delivering transportation that is gender-sensitive and that considers the mobility needs of vulnerable and disadvantaged groups, focusing on their safety and comfort in urban transport. For instance, it is worth recalling that, in France, rolling stock manufacturers are used to collaborate with women's associations during the design of new vehicles, in order to consider the distinct needs and demands arising from the different gender contexts. This helps to improve the design of PT vehicles to better accommodate women, with measures such as women-only carriages, child seating, and storage spaces for prams and shopping bags (UN Habitat 2017). Elderly people's lack of mobility can result in disengagement from civic and social life, resulting in loneliness and poor quality of life in general (Dickerson et al. 2007). Most elderly people are women (Peck et al. 2017) and, in developed countries, differences in access to a car are more apparent in generations where fewer women had a driver's licence. When elderly women start suffering from physical problems that make walking more difficult and no longer have a man at their side who drives, they often become isolated, especially in rural areas where PT services are weak (Duchène 2011). Policies such as providing dedicated seats to the elderly have always been a good practice and, as most of them are retired with low spending power, cheap dedicated travel fares also improve their mobility. However, it is worth investing in safety as, especially for these vulnerable groups, the fear of being robbed, harassed or murdered while waiting at a PT stop can discourage them from using such services (Föbker and Grotz 2006).

As remote and rural regions are generally characterised by low population densities and, thus, by a relatively low number of potential passengers for PT, it is usually not financially viable to provide frequent transport service to citizens. However, policymakers can still choose to subsidise public transport services in remote areas, as well-organised public transport services have the potential to stimulate social inclusion through improving accessibility and mobility (Eurostat 2019). In this context, smart mobility platforms, such as on-demand shuttles, could allow multiple passengers heading in the same direction to be matched with a moving vehicle, optimising the use of buses. A better accessibility to PT, especially during off-peak hours or in low affluence areas, such as sub-urban and rural zones, would help reduce car-dependency, traffic congestion and $CO_2$ emissions, improving PT services' efficiency.

Once the crucial attributes for the targeted car users and the motivations which make them prefer private vehicles over PT have been explored, the appropriate improvements can be implemented to enhance their demand for PT services. Eboli and Mazzulla (2008) argued that lower fares and high frequency can significantly contribute to improving customer perceptions of PT quality, which are usually poor (De Vos 2019). Some studies (e.g., Fujii and Kitamura 2003; Thøgersen and Møller 2008) found that tactics such as periodically providing free PT tickets can attract car users but that the sustainment of this mode switch over time largely depends on perceived high-quality attributes of the service, which needs to be appealing and to emulate the same attributes that users perceive to be specific to privately-owned vehicles.

In light of our results, supporting multimodality would be one of the winning strategies to spread a positive approach towards urban mobility: the coordination of transport infrastructure, services, and facilities should enable links between different transport modes, thereby facilitating trip-chaining (Teske et al. 2018). The development of park-and-ride areas near cities where people can easily switch from car to PT allows smooth transfers between different mobility modes. Households might well be willing to give up owning a car and use PT to meet most of their travel needs, providing they can still have access to a car for those trips where it is seen as essential, such as family holidays or supermarket shopping; in such a way, they could avoid ownership costs, and pay only for the car journeys that they make. Car sharing is a practical solution in this respect. For example, in order to reduce private vehicle trips and improve PT mobility, air quality, and stress, the German city of Stuttgart developed an integrated mobility services platform thanks to the synergies among PT and car-sharing providers, bike and e-bike rental schemes, municipal undertakings, banks and technology providers, and improved the PT network as well as the cycling paths. Multiple infrastructures give people the key to multimodality and allow the services to be complementary or supplementary (i.e., granting the preservation of the links if one of the modalities fails). At the same time, PT on these links is likely to become increasingly appealing (Geels 2019). The integration of advanced travel information for different modalities could also increase the attractiveness of PT. Some cities in Western Europe have taken the lead in facilitating modal integration in different ways, especially between public and non-motorised transport.

Cycling, for example, significantly increases the catchment area of PT stops beyond walking range, while access to PT makes longer trips possible for bicyclists. A clear delineation of cycling paths could provide greater security for all road users and a more suitable environment for the development of active mobility. A good practice in this respect comes from the Dutch town of Houten, where each neighbourhood is connected to the railway station and to the adjoining town centre by tree-like systems of direct cycling routes. The specific access system of cars to each neighbourhood from a ring road that encircles the town and the specific structure of the streets, designed to keep speeds low, makes the cycling route shorter than the motorised route for almost every trip and, as a result, cycling and walking account for a larger share of the modal split within the town (Foletta and Field

2011). Similarly, the "woonerf" (convivial street), conceived in the Netherlands in the 1970s and later spread to other countries, was designed to pacify the conflict between people and urban traffic in the streets. The first woonerf in Delft made access to the local train station easily and sustainably through a suitable system of pedestrian and cycling facilities. In general, guarded facilities for storing bikes, together with complementary services such as maintenance and repair, are available at all main train stations in the Netherlands, where 35 per cent of train users get to and from train stations by bike. Several bike stations located at train stations in Germany enable cyclists and PT users to a smooth transition from one mode to the other. All metro and express interurban train stations at the peripheries of Berlin are now provided with bike parking facilities. Already in 2006, Berlin implemented Low Emission Zones to combat air pollution, requiring those who wished to access these zones to show a special environmental sticker (Umweltplakette) indicating whether the vehicle meets the environmental standards. Since 2011, other German cities started requiring cars to show the sticker for entering delimited ecological zones. The Italian city of Milan launched the "Area C" program in 2012, with the aim of facilitating traffic flow and reducing emission levels in the city, as well as promoting PT use. New restrictions for cars entering the historical centre started to be imposed on working days, with a congestion charge of 5 Euro a day only for petrol cars and excluding electric and hybrid ones. The measure generated a 30% decrease in the number of cars and a revenue of over 20 million Euros in the first year, which was used to enhance ecological transportation modes.

Generally, in order to make PT more attractive, especially in the proximity of PT stops, pedestrian facilities and safety need to be expanded and improved, for instance, with better street furniture, improved pavement, better lighting, wider sidewalks, removal of barriers to facilitate use by people in wheelchairs and walking baby carriages. Improved crosswalks and intersections are also essential, especially when the PT stops are far from the place of destination, with measures such as median refuge islands, pedestrian-activated crossing lights, and reduced waiting times for pedestrians to cross. In addition, barriers should be installed so to not allowing private vehicles to stop or park close to PT access points. Reducing the number of private vehicles streamlines the traffic of PT vehicles and positively affects the punctuality and regularity of service, contributing to an increase in competitiveness of this transport mode. Car parking restrictions–which cause that accessing the target location takes longer on foot, making it comparable in time to distances walked to and from PT stops–can also contribute to increasing the probability of choosing PT for urban mobility (Knoflacher 2006).

Transport policies must be based on a positive approach to mobility, and their benefits must be communicated and demonstrated to car users to ensure that the service quality is perceived as such. Indeed, communicating the benefits of behaving pro-environmentally is an effective strategy aimed at increasing the switch to less harmful travel modes. Information campaigns aimed at reducing harmful emissions should stress the consequences of intensive car usage on people's living environment and health (De Groot and Steg 2009). It is vital to provide reliable information to raise awareness about how individual behaviours could contribute to environmental issues, as well as directions on how to adopt environmentally-friendly behaviours (Pagani et al. 2021; Punzo et al. 2019), also by promoting knowledge sharing and joint discussion on best practices in sustainable urban mobility. For instance, media should provide not only information about the effects of climate change on the environment but also about the way through which individuals can contribute to its safeguarding (Liobikienė and Juknys 2016), making people understand that changing their behaviour at the individual level could have a real impact on the environment.

The present work does not come without limitations. The paper considers the "demand side" of PT use frequency choices. We believe the "supply side" (e.g., availability, quality, safety, and cost of PT) is equally important in making decisions about PT usage. However, the unavailability of this type of information in the Eurobarometer dataset and the inability of linking precise territorial data from external sources to Eurobarometer data forced us to limit our analysis to the demand side only.

Moreover, the inclusion of other important factors (e.g., cost saving, safety, trip chaining, time saving) could have provided a more relevant gender-based analysis. It would also be worthy to incorporate data about smart mobility options, which have been increasingly penetrating EU cities in recent years and are characterised by evident gender and cross-country differences towards their use; indeed, as Special Eurobarometer studies are not provided with a high frequency, it is desirable for future surveys to collect such information.

The analyses are computed at the national level. As Eurobarometer data come with about the same–and not excessively large–number of observations for each considered country, it would be difficult to go into a subnational detail: a representative sample at the national level is not necessarily representative at the subnational one. Finally, albeit Eurobarometer data cover all the countries belonging to the EU, the paper deliberately focused on three adequately selected European countries. However, it could also be interesting, in terms of giving both academic insights and more applicable policy implications to the wider interested audience, to extend this analysis to a broader group of countries.

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**Data availability** Data shall be made available upon request.

**Code availability** Code shall be made available upon request.

## Declarations

**Conflict of interest** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.



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