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ABSTRACT

Carpooling: User Profiles and Well-being*

Carpooling is a sustainable daily mobility mode, implying significant reductions in energy consumption and CO2 emissions, although it remains an uncommon practice. With the aim of stimulating this green transportation mode, this paper focus on understanding why certain individuals will agree to share a car to a common destination, apart from the obvious environmental benefit in emissions. It first describes the profile of users and then explores the relationship between this transportation mode and the participants' well-being. To that end, we have selected two countries, the UK and the US, where the use of cars represents a high proportion of daily commuting. We use the UK Time Use Survey (UKTUS) from 2014-2015 and the Well-Being Module of the American Time Use Survey (ATUS) from 2010-2012-2013 to identify which groups in the population are more likely to pool their cars, and with whom those individuals enjoy carpooling more. Results indicate that individuals with certain socio-demographic characteristics and occupations are more likely to commute by carpooling, but the profile seems to be country-specific. Furthermore, our evidence reveals a positive relationship between carpooling and well-being during commuting.

JEL Classification: R40, J22
Keywords: carpooling, green mobility, user profiles, subjective well-being

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1. Introduction

Millions of people move every day, in cities and regions worldwide, from home to work, from home to school, from home to engage in non-market activities, and other types of travel. The car is the dominant mode of transport chosen by individuals for their daily travels (EEA, 2015). Private cars are currently used for nearly 75% of urban passenger transport in OECD countries, and over 60% in non-OECD countries (OECD, 2019). However, private car usage is one of the most important sources of fuel and energy consumption worldwide. The increasing levels of fuel consumption in recent decades has made cities and regions worldwide to consider how to change the daily mobility of the population, to reduce fuel consumption and environmental pollution.[1] These new strategies include eco-driving (Barkenbus, 2010; Schall, Wolf and Mohnen, 2016), the adoption of electric vehicles and plug-in hybrid vehicles (Jenn, Springel and Gopal; 2018; Jang and Choi, 2021), and other modes of transportation.

Alternative modes of personal mobility are promising options to decarbonize transportation, such as the use of public services and physical (e.g., walking or cycling) modes of transport (Stanley and Watkiss, 2003; Chapman, 2007; Gôssling and Choy, 2015; Holian and Kahn, 2015; Giménez-Nadal and Molina, 2019), along with electric bikes, scooters, and bike/scooter sharing services (Cherry, Weinert and Xinmiao, 2009). As part of shared mobility, carpooling emerges as an eco-friendly transportation mode alternative.[2] Carpooling - also known as ridesharing - allows travelers to share a ride by car to the same location (Shaheen and Cohen, 2019; Chan and Shaheen, 2012; SAE International, 2018), and is related to reductions in energy consumption (Minett and Pearce, 2011; Seyedabrishamia et al., 2012; Shaheen, Cohen and Bayen, 2018: Liu et al., 2019).[3] This strategy, along with

[1]A good example is found in Spain, where the Ministry for Ecological Transition continues to promote the European Mobility Week (SEM), which has been held from September 16 to 22 of each year since 1999, in various Spanish cities. Another example is the Zero Emissions Vehicle (ZEV) mandate, or local regulations, such as zoning in the United States.

[2]Carsharing is another sustainable alternative to the use of private cars, which refers to companies such as Car2Go or Zipcar providing cars to private users.

[3]Apart from the benefits of carpooling to energy consumption, carpooling users can individually benefit from shared travel costs, travel time savings from high occupancy vehicle (HOV) lanes, reduced commuter stress, and other incentives, such as preferential parking (Chan and Saheen, 2012; Cohen and Shaheen 2016; Shaheen, Cohen and Bayen, 2018).

things like driving bands, is one of the most effective ways to counter the impact of short-term supply disruptions (Noland, Cowart and Fulton, 2006).

But despite its environmental benefits, carpooling remains an uncommon practice for an activity that happens daily for millions of individuals worldwide, commuting to and from work (see Molina, Gimenez-Nadal and Velilla (2020) for a review). For instance, Molina, Gimenez-Nadal and Velilla (2020) indicate that carpooling in developed countries is not habitual for individuals, as less than 25% of the time spent commuting by car is done in the company of others. Given the importance of commuting trips in fuel and energy consumption, identifying which groups of the population are less likely to carpool may help authorities to design specific policies (e.g., advertisements, awareness, parking facilities) aimed at boosting the use of carpooling.

One reason why individuals do not usually carpool may be related to the degree of enjoyment/happiness of carpooling in comparison to driving alone. But evidence on how people feel during carpooling is scarce (Smith, 2017). If carpooling is detrimental to individuals in terms of well-being, in comparison with driving alone, this would explain why individuals are reluctant to participate. But if carpooling is beneficial for individuals in comparison to driving alone, the evidence would indicate that other factors (e.g., culture, transport infrastructures) may be related to its scarce use. Furthermore, the latter evidence could be helpful in highlighting the personal benefits associated with carpooling – apart from the benefits for the environment – relative to commuting alone, and policy makers may decide to raise awareness of the benefits. Additionally, employers may be interested in encouraging carpooling, given the positive relationship between individuals' happiness, on the one hand, and productivity (Oswald, Proto and Sgroi, 2017) and lower absenteeism (van Ommeren and Gutierrez-i-Puigarnau, 2011;Gimenez-Nadal, Molina and Velilla, 2019), on the other.

Within this framework, in this paper we analyze the profiles of individuals engaging in carpooling, as well as their experiences. Specifically, we aim to identify the characteristics of individuals who are more likely to share their journey with someone else in their travels to/from work, and analyze the relationship between carpooling and the well-being (e.g., instant happiness or enjoyment) of individuals during commuting, in comparison to driving alone. To that end, we use data from the 2014-2015 United Kingdom Time Use Survey (UKTUS) and the Well-Being Module (WBM) of the American Time Use Survey (2010, 2012, 2013). We first show that individuals with certain socio-demographic characteristics and occupations are more likely to commute by carpooling, but this profile seems to be country-specific. Furthermore, our evidence reveals a positive relationship between sharing the ride with someone else and enjoyment/happiness during commuting.

Our contribution to the literature is twofold. First, we contribute to the analysis of the carpooling behavior of individuals in the UK and the US, which represents an important mode of transport, alternative to driving alone, as a way to reduce energy consumption in those countries in particular, and worldwide in general. The fact that we analyze data that is representative of the two countries makes our results of general interest and application, in comparison to prior work that focused on specific cities or regions. Second, our well-being analysis adds to the scant evidence on how individuals feel when commuting by car with someone else, in comparison to driving alone. To our knowledge, no prior work has studied the relationship between well-being and carpooling depending on with whom the ride is shared. This analysis is important, since well-being comparisons between the two modes of driving (alone vs. carpooling) show that, despite that individuals are better off while carpooling, carpooling is not common, indicating that restrictions to carpooling - whatever they may be - are effective. These restrictions may be related to infrastructures, work schedules (e.g., individuals in same households cannot synchronize their work schedules), and others. This evidence opens a promising line of research about why carpooling is not a more common practice for individuals, and how to improve carpooling frequency.

The remainder of the paper is as follows. Section 2 presents a review of the literature. Section 3 presents the data and variables, Section 4 describes the empirical strategy, and Section 5 describes the results. Section 6 sets out our main conclusions.

2. Literature Review

The transportation sector plays a key role in the economy, but relies heavily on fossil fuels as sources of energy. Oil-derived fuels account for 95% of transport energy consumption in the European Union, and oil consumption associated with the transport sector has been increasing since 2014 at an average rate of 2.2 % each year. Within the sector, road transport accounts for the largest share of total oil-derived fuel consumption (71 % of total EU consumption). Even though the share of renewable energy for transport in the EU rose from 7.4 % in 2017 to 8.1 % in 2018, it is still below the EU target of 10 % set for 2020 (EEA, 2020). In the case of the US, transportation accounts for 26% of total energy use, and around 90% of the energy use in the sector is derived from petroleum. Light-duty vehicles (e.g., cars, small trucks, vans, sport utility vehicles, and motorcycles) account for 55.5% of total U.S. transportation energy use, while trains and buses account for only 2.4%. Further, total motor gasoline consumption for transportation has increased because of increases in the number of vehicles in use and in the number of miles traveled per vehicle (EIA, 2021).

The strong reliance of transportation on fuel consumption, which leads to greater greenhouse gas (GHG) emissions, air pollution, and health problems, highlights the need to promote more sustainable and energy-efficiency strategies for daily mobility. One approach involves changing the behavior of drivers towards an eco-driving style, which includes such fuel-efficient practices as accelerating moderately, anticipating traffic flow and signals, avoiding sudden starts and stops, maintaining an even driving pace, driving at or safely below the speed limit, and eliminating excessive idling. Barkenbus (2010) indicates that eco-driving can reduce fuel consumption by 10% on average and over time in the US, thereby reducing CO2 emissions from driving by an equivalent percentage. However, because driving in an eco-fashion still has many cultural, technical, and educational barriers to overcome, more policies designed to trigger behavioral changes are needed. In relation to this, Schall, Wolf and Mohnen (2016) indicate that theoretical eco-driving training shows neither short-term nor long-term effects, highlighting the necessity to introduce practical training. Their results suggest the difficulty of changing engrained behavior.

Another strategy focuses on the use of electric vehicles and plug-in hybrids. For example, Jenn, Springel and Gopal (2018) study the incentives for the adoption of electric vehicles in the US and find that every $1,000 offered as a rebate or tax credit increases average sales of electric vehicles by 2.6%, while high-occupancy vehicle lane access is a significant contributor to adoption. Further, the authors indicate that raising consumer awareness is critical to the success of electric vehicle incentive programs. However, and despite efforts from automakers and governments to foster the use of electric vehicles, adoption rates remain low because of relatively high prices, technical limitations, and the sparse availability of charging infrastructure (Jang and Choi, 2021).

Researchers and policy makers have also paid special attention to the promotion of alternative modes of personal transportation as a promising approach to decarbonize mobility. These include public (Stanley and Watkiss, 2003) and active mobility (e.g., walking or cycling), which is, ultimately, 'zero carbon' and environmentally friendly (Chapman, 2007; Gôssling and Choy, 2015). Other more recent modes involve electric bikes, scooters, and bike/scooter sharing services, where users can access those vehicles for short trips. In China, Cherry, Weinert and Xinmiao (2009) find that electric two-wheelers emit several times lower pollution per kilometer than do motorcycles and cars, and have comparable emission rates to buses but higher emission rates than bicycles.

Within alternatives modes of transportation, carpooling emerges as an alternative energy-saving mode, which allows individuals to share a ride by car to a common destination. Carpooling provides considerable gains in terms of reductions in fuel consumption, along with other societal benefits, such as reductions in greenhouse gas emissions, air pollution, and monetary costs. For example, Minett and Pearce (2011) estimate that casual carpooling in San Francisco, understood as a system of carpooling without trip-by-trip pre-arrangement, conserved an equivalent of 200-400 liters of gasoline per year for each participant. Jacobson and King (2009) estimate potential fuel savings of 0.80 to 0.82 billion gallons of gasoline per year, in the US, if one additional passenger is added t o every 100 vehicles, and of 7.54 to 7.74 billion gallons if one additional passenger is added to every 10 vehicles. In the same vein, Liu et al. (2019) find for the city of Beijing that carpooling leads to considerable fuel savings of about 1.23 liters on average per trip.

Besides the savings in energy consumption, the chosen mode of transport by an individual may be positively or negatively related to his/her subjective well-being -understood as happiness/enjoyment/satisfaction - through the activities accessed from mobility, and through the actual travel itself (Ettema et al., 2010, Friman et al, 2013; De Vos et al., 2013). A body of research has documented that public transit is associated with lower levels of well-being during travel (Ettema et al., 2011; Eriksson et al., 2013), while walking and cycling are associated, in comparison to driving a car, with higher levels of well-being (Morris and Guerra, 2015; Zhu and Fan, 2018). Similar evidence has been found in specific cases of travels to/from work (Friman et al., 2013, Gatersleben and Uzzell, 2007; Páez and Whalen, 2010). However, little is known about the level of well-being experienced by individuals when riding in a car with someone else, in comparison to riding alone. Smith (2017) examines the well-being of individuals during commuting, using a web-based survey in Portland (Oregon, US) gathered in 2012, and finds that those who carpool to work have higher well-being than those who drive alone.

3. Data and Variables

Our analysis relies on the United Kingdom Time Use Survey (UKTUS), which covers the period April 2014 to December 2015, and the Well-Being Module of the American Time Use Survey (ATUS) for the years 2010, 2012, and 2013. Both surveys are the official time use surveys of the UK and the US. The Well-Being Module is fielded from January through December each year, and aims to capture how individuals feel during their daily activities.

The main instrument of these surveys is the time use questionnaire, that respondents fill out on selected days, recording information on their main activity. Other information that may be gathered in time use questionnaires is that of secondary activity (i.e., carried out simultaneously with the primary activity), whether the activity was performed in the company of another person, the location of the activity, and the mode of transport. Prior literature has shown the superiority of diary data over other time-use information based on stylized questions, which asks respondents to estimate time on different activities on a ‘typical day’ (Robinson and Godbey 1985; Juster and Stafford 1985).

In time use surveys, respondents report the main purpose of the activity, which allows for an accurate measure of travel time in comparison with other datasets. For instance, we can distinguish between real commuting episodes and other episodes that are intertwined, such as picking up children from school. Time use surveys provide information on duration, departure and arrival times, location, and mode of transport, and the use of time-use surveys in transportation research has become common (Gimenez-Nadal and Molina, 2014; 2016; Jara-Díaz and Rosales-Salas, 2015; Gimenez-Nadal, Molina and Velilla, 2018a, 2018b).[4]

Our sample consists of individuals between the ages of 21 and 65 (inclusive) to restrict the sample to working-age individuals (Aguiar and Hurst,2007; Gimenez-Nadal and Sevilla, 2012; Gimenez-Nadal and Molina, 2019; Gimenez-Nadal, Molina and Velilla, 2018a, 2018b; Molina et al., 2020). In addition, we restrict the analysis to working days, defined as those days where individuals devote at least 60 minutes to market work activities (Gimenez-Nadal and Molina, 2019; Gimenez-Nadal, Molina and Velilla, 2018a, 2018b; Molina et al., 2020) and with positive time devoted to commuting (i.e., work-related travels to/from work). Our final sample amounts to 1,869 individuals and 4,556 commuting episodes from the UKTUS, and 2,147 individuals and 2,425 commuting episodes from the ATUS.[5]

To explore the profile of individuals travelling to/from work by carpooling, we compute the proportion of time commuting by carpooling, which constitutes our dependent variable. Carpooling is a mode of transport defined as sharing a car ride with someone else (either as a driver or passenger). Then, we sum the commuting time by car with presence of others engaged by the individual in his/her diary, and divide it by the total time spent in all commuting episodes. Carpooling, along with public ridership and walking/cycling, are considered "green" modes of transport, compared to driving a car alone.

We consider several socio-demographic and employment characteristics included in the UKTUS and the ATUS to build the profile of carpoolers. Specifically, we include age, gender, native status, the highest level of formal education achieved (primary education,

[4]Time use surveys gather information on daily activities and travel undertaken by individuals and households, and prior literature has relied upon this type of data to analyze commuting (Gimenez-Nadal and Molina, 2016, Gimenez-Nadal, Molina and Velilla, 2018a, 2018b) and travel behaviors (Kitamura et al., 1997, Axhausen et al, 2002; Gerike, Gehlert and Leisch, 2015; Rosales-Salas and Jara-Díaz, 2017; Harms, Gershuny and Olaru, 2018; Aschauer et al., 2019). Gerike, Gehlert and Leisch (2015) compare travel behavior and activity participation using the German National Travel Survey (NTS) and Time Use Survey (TUS), finding that the number of trips per person is higher in the TUS when changes in location without a trip are included. The daily travel time is consistently higher in the TUS. Thus, time use surveys are an alternative to national travel surveys, and allow for the analysis of travel behavior determinants, including the relationship to non-travel activities (Giménez-Nadal and Molina, 2019). One caveat of these surveys is that they do not include information on travel distance.

[5] We have eliminated observations of respondents with missing information on mode of travel, feelings, and/or socio-demographic characteristics.

secondary education, higher education), the presence of a partner (either married or cohabitating), family size, and the number of children under 18 years old. Prior studies suggest that these socio-demographic characteristics, including household composition, are traditionally related to individual commuting behavior in general (Aguiar and Hurst, 2007; van Ommeren and van der Straaten, 2008; Sevilla, Gimenez-Nadal and Gershuny, 2012; McQuaid and Chen, 2012; Gimenez-Nadal and Molina, 2016; Gimenez-Nadal, Molina and Velilla, 2018a, 2018b) and to carpooling for commuting in particular (Molina et al., 2020).

Regarding labor characteristics, we include the number of market work hours during the day. Prior evidence indicates that daily commuting and market work hours are positively related (Schwanen and Dijst, 2002; Gutierrez-i-Puigarnau and van Ommeren, 2010; Gimenez-Nadal and Molina, 2014), and not considering the time devoted to market work could lead to an omitted variable bias. We also include the occupation of the individual. The UKTUS recodes occupation into 7 categories: 1) large employers and higher managerial occupations; 2) higher professional occupations; 3) lower managerial and professional occupations; 4) intermediate occupations; 5) lower supervisory and technical occupations; 6) semi-routine occupations; and 7) routine occupations. The ATUS considers 10 categories: 1) management, business, and financial; 2) professional and related; 3) services; 4) sales and related; 5) office and administrative support; 6) farming, fishing, and forestry; 7) construction and extraction; 8) installation, maintenance, and repair; 9) production; and 10) transportation and moving.

To analyze the relationship between carpooling and the feelings experienced during commuting, we exploit the information on instant enjoyment/happiness contained in the UKTUS and ATUS, where individuals report their feelings during their various activities (Kahneman et al. 2004). The UKTUS collects information on hedonic experience in real time during all daily episodes. In particular, the question used in the survey is "how much did you enjoy this time?", with answers ranging from 1, "not at all", to 7, "very much". In the Well-Being Module of the ATUS, three episodes from the preceding day, lasting at least five minutes, are randomly selected and diarists are asked to rank on a 7-point scale the extent to which they felt happy during the activity, with "0" indicating "did not experience the feeling at all" and "6" indicating "feeling was extremely strong". For our analysis, self-reported levels of enjoyment (UK) and happiness (US) are our dependent variables of interest.

Tables 1 and 2 report summary statistics of the sample of individuals for the UK and the US, respectively. Panels A describe the main characteristics of commuting episodes. In the UK (US), the average duration of each commuting episode is 21.9 (25.5) minutes, while the average time spent in non-commuting activities is 1,273.2 (1,385.7) minutes per day. 48% (76.4%) of commuting episodes correspond to a weekday. Additionally, the proportion of commuting time engaged incarpooling amounts to 16.8% (10.1%). Hence, less than 20% of the time devoted to commuting is done by carpooling. Panels B report the levels of subjective well-being or feelings during commuting episodes. On a 7-point scale, the average level of enjoyment experienced during commuting in the UK is 4.6, while in the US the average level of happiness is 4. These values are similar to those reported in prior studies (Kahneman et al., 2004; Kahneman and Krueger, 2006, Knabe et al., 2010; Gimenez-Nadal and Molina, 2019).

Panels (C) present the socio-demographic and employment characteristics of individuals in our sample. We observe that commuters in the UK (US) are on average 40 (37) years old, while 50% (58%) of the sample are men, 86% (80%) are native, 31% (24%) have attained secondary education, and 66% (69%) have higher education. Regarding family structure, 70% (56%) of the sample live in couples, and families are composed, on average, of 3 members, including 1 child.

Employment characteristics of the sample indicate that commuters in the UK work on average 7.7 hours a day, while the US number is 8.6 hours a day. The most frequent occupation categories in the UK sample are lower managerial and professional (29%) and intermediate (21%), followed by semi-routine (17%), higher professional (13%), routine (11%) and lower supervisory and technical occupations (7%). Only a small proportion of commuters work in occupations related to large employers and higher managerial occupations (3%). In the case of the US, 24% of commuters in our sample work in professional and related occupations, 19% in management, business and financial, 16% in services, 11% in sales and related occupations, and 10% in office and administrative support occupations. Only small proportions work in construction and extraction, installation, maintenance and repair, production, and transportation and material moving occupations (5%), with less than 1% working in farming, fishing, and forestry.

4. Empirical Strategy

We first analyze the personal characteristics related to a higher likelihood to carpool while commuting to or from work. To that end, we estimate Ordinary Least Squares (OLS) models at the individual-level, with the proportion of commuting time done by carpooling as the dependent variable. We estimate, for both the UK and the US, the following specification:

$$P_i = \alpha + \beta X_i + \eta E_i + \delta W_i + \gamma FE + \varepsilon_i \qquad (1)$$

where P_i is the proportion of commuting time spent in carpooling. X_i is a vector of socio-demographic variables that include age (and its square), gender, native status, education level (ref.: elementary education), the presence of a partner in the household (either married or cohabitating), household size, and number of children. E_i is a vector of employment variables, including daily hours of work and the occupational category of the individual. W_i controls whether the diary corresponds to a weekday or weekend. FE are region/state of residence, year and month fixed effects, and ε_i are unmeasured factors. Standard errors are robust, and error terms are clustered at the individual level. Observations are weighted at the individual-level using the survey weights.[6]

Because our sample includes a non-negligible proportion of individuals not carpooling (see Table 1 for the UK, and Table 2 for the US), a Tobit model could be implemented to account for the censoring. However, prior studies have found similar results when comparing OLS models to Tobit models with time-use data (Frazis and Stewart, 2012; Gershuny, 2012; Foster and Kalenkoski, 2013; Gimenez-Nadal and Molina, 2014, 2016). As a consequence, and for the sake of simplicity, we rely on OLS regressions to estimate Eq. (1), but we have estimated Tobit regressions for the three specifications of interest, and find

[6]Given that for the UK there may be individuals with two diaries, we take the unobserved heterogeneity of individuals by clustering the error term at the individual level. In the case of the US, given that we have only one diary per individual, clustering at the individual level has no effect on standard errors.

that our results are robust in magnitude and sign to the estimation method. (Estimates of the Tobit regressions are available upon request.)

In order to analyze the relationship between carpooling and the experienced well-being of individuals during commuting, we estimate Ordinary Least Squares (OLS) models at the individual-level, for both the UK and the US, as follows:

$$WB_{ij} = \alpha + \theta CP_{ij} + \varphi P_{ij} + \beta X_i + \eta E_i + \delta W_{ij} + \gamma FE_i + \varepsilon_{ij} \qquad (2)$$

where WB_{ij} is the experienced well-being of individual i in commuting episode j. In the UK sample, the respondent's well-being is captured by the level of enjoyment experienced in each commuting episode. In the US sample, the respondent's well-being is captured by the level of happiness. We standardize WB_{ij} (i.e., z-score) so that each estimated coefficient can be interpreted as the change in terms of one standard deviation of the well-being measure.

CP_{ij} indicates whether the individual commutes by carpooling, while P_{ij} is a vector of indicator variables of commuting by public and physical transport. These indicators are compared to driving a car alone (reference category), and capture "green" modes of transport. θ is our main parameter of interest. Then, if $\theta > 0$, carpooling is associated with higher levels of experienced well-being, in comparison to driving alone.

As in Eq. (1), X_i is a vector of socio-demographic characteristics, and E_i is a vector of employment controls. W_{ij} are variables used to control for differences at the episode level, and we control for the (log of) duration of the episode (and its square), and an indicator variable if the commuting episode took place on a weekday or weekend. FE_i are region/state of residence, year and month fixed effects, and ε_i are unmeasured factors. Standard errors are robust, and error terms are clustered at the individual level. Observations are weighted at the individual level using original survey weights.

We also analyze changes in the level of experienced well-being, depending on with whom the trip is shared. To this end, we estimate a similar specification to Eq. (2) but instead of CP_{ij}, we include a set of indicators to capture whether the individual engages in carpooling with either the spouse, parents, children, other household member, or non-household member. Then, we estimate the following equation:

$$WB_{ij} = \alpha + \sum_k \vartheta_k CP_{ijk} + \varphi P_{ij} + \beta X_i + \eta E_i + \delta W_{ij} + \gamma FE_i + \varepsilon_{ij} \qquad (3)$$

where CP_{ijk} are variables indicating if individual i shared a drive to work with individual k in commuting episode j, with k being the spouse, parents, children, other household member, or non-household member.

The use of a scale to measure self-reported well-being is subject to different interpretations across individuals of what the scale of measurement really refers to, leading to a lack of independence across measures (Kahneman and Krueger, 2006). To further consider the scaling effect of individuals, we augment the specification of Eq. (2) and Eq. (3) to control for unobserved heterogeneity and account for fixed individual traits. Thus, we allow for an individual-specific interpretation of the well-being question. The inclusion of the heterogeneity of individuals in scales is important, because individuals reporting higher well-being while commuting by carpooling could also report higher levels of well-being during their non-commuting activities. Then, the relationship between carpooling and well-being could be mediated by personal unobserved characteristics (i.e., differences in scale).

To account for differences in scale across individuals, we estimate two alternative specifications. First, we include as a control variable the average level of enjoyment/happiness for each individual during all non-commuting activities. Second, we interact this variable with total time (minutes per day) spent in all non-commuting episodes. In the case of the UK, the average level of enjoyment in non-commuting activities (5.2) is slightly higher in comparison to commuting activities. The same is observed in the US sample regarding happiness (4.2):

5. Results

5.1. Profile of carpooling users

We first explore the profile of individual commuters who carpool, estimating Ordinary Least Squares regressions separately for the UK and the US, where our dependent variable is the proportion of time commuting by carpooling (vs. non-carpooling). Regressions are performed at the individual level, and estimated coefficients are multiplied by 100 to directly express the change in percentage points of the time proportion of carpooling associated with a change in the covariates of interest.

Tables 3 and 4 report the results of estimating Equation (1) for the UK and US samples, respectively. In the case of UK (Table 3), we find that only some socio-demographic and employment characteristics are significant. Specifically, being male is negatively associated with the proportion of time commuting by carpooling, while living with a partner and household size is positively associated. In addition, individuals working more hours per day spend a significantly lower proportion of time carpooling. The occupation of the individual also plays a role in describing who chooses to share a car ride with someone else. A positive conditional correlation with the fraction of time carpooling is found for individuals in lower managerial and professional occupations (a 6-point increase with respect to large employers and higher managerial occupations), intermediate occupations (an 8.4-point increase), semi-routine occupations (an 11-point increase), and routine occupations (a 12.6-point increase).

In the case of the US (Table 4), being native is the only socio-demographic characteristic significantly and negatively related to the proportion of time spent carpooling. Differing from the estimated changes for the UK, the amount of daily hours of market work is negatively related to the proportion of time carpooling. In addition, the proportion of time carpooling in the case of individuals working in construction and extraction occupations is 24% larger than individuals from management, business, and financial operations (the reference category).

In sum, we find that characteristics at the work level (number of work hours, occupation) are related to the proportion of carpooling, although results are not homogeneous across countries. Furthermore, only a few personal characteristics are relevant to carpooling behavior in the UK, while in the US, personal characteristics are not significant in carpooling. These results are consistent with Molina et al. (2020), who show that socio-demographic characteristics of individuals are not significant in the carpooling behavior of individuals. Furthermore, our results indicate that carpooling behavior is country-specific.

5.2. Feelings during carpooling

We now analyze the relationship between carpooling and the feelings experienced during commuting. Tables 5 and 6 present Ordinary Least Squares regressions for enjoyment, in the case of the UK, and happiness in the case of the US, respectively. In each of these tables, Column (1) reports results from Equation (2), while Column (2) presents results from Equation (3). Additionally, in each of these tables, Panel (A) shows the estimates of the baseline specifications (Equations (1) and (2)), while Panels (B) and (C) control for individual scaling differences. Specifically, Panel (B) includes the individuals' average level of enjoyment/happiness in all non-commuting episodes as a control variable in the estimation, and Panel (C) includes the interaction between individuals' average level of enjoyment/happiness in all non-commuting episodes with total time (minutes per day) spent in all non-commuting episodes.[7] This suggests the need to control for heterogeneity of individuals in scales.

We are interested in the parameters of carpooling as a "green" mode of transport, which compares the average level of enjoyment/happiness felt during carpooling compared to driving alone. Regressions are performed at the episode-level. All regressions include additional episode controls (e.g., log of time duration and its square, and an indicator for commuting on a weekday), and socio-demographic and employment characteristics.

Results for the UK indicate that carpooling, in comparison to driving alone, is related to a comparatively higher level of enjoyment, around 0.09 of a standard deviation of enjoyment, on average. A similar but more pronounced result is observed in the case of happiness for the US (Table 6). Carpooling is associated with a higher level of happiness, around 0.24 of a standard deviation.[8] In both countries, commuters sharing the ride with their spouses reported higher levels of enjoyment/happiness, in comparison to driving alone (reference category), indicating that carpooling is beneficial for the well-being of individuals. In sum, our evidence

[7]Note that the average level of enjoyment/happiness in all non-commuting episodes is positively and (statistically) significantly related to the level of enjoyment/happiness experienced during commuting, indicating that individuals who report higher levels of enjoyment/happiness in non-commuting activities also report higher levels of enjoyment/happiness when commuting. This relationship could be due to a "cheering" effect of carpooling on non-travel activities (Gimenez-Nadal and Molina, 2015). That is, those individuals who use carpooling could enjoy other non-travel activities more, because the positive effects of carpooling on enjoyment spread to other, non-travel activity. We cannot analyze causality issues with the data at hand, and thus we cannot test these hypotheses.

[8] In the US WBM, other feelings are available, such as stress, fatigue, and pain. Applying the same strategy of analysis as for the happiness measure, we estimate Equations (2) and (3) for stress, fatigue, and pain, and we find that, in comparison to driving alone, carpooling is related to lower levels of stress, pain, and fatigue. Results are available upon request.

reveals a positive relationship between carpooling and the enjoyment/happiness dimensions of well-being.

Furthermore, alternative modes of "green" mobility (e.g., public transit, walking/cycling) are also related to enjoyment in the UK, in line with prior evidence (Echeverría, Giménez-Nadal and Molina, 2021). The physical modes of transport (walking and cycling) are significantly related to higher levels of enjoyment, while public transit is significantly related to lower levels of enjoyment, in comparison to driving alone. However, we find no robust evidence of a significant relationship between happiness and physical or public modes of transport in the US.

6. Conclusions

Millions of individuals travel every day in cities and regions worldwide, and the private car is the dominant mode of transport chosen. Increasing levels of fuel consumption in recent decades has made cities and regions consider how to change the daily mobility of the population, in order to reduce fuel and energy consumption These considerations include eco-driving, the adoption of electric vehicles and plug-in hybrids, and alternative modes of transportation. As a part of shared mobility, carpooling to a common destination represents an important alternative. In this paper, we analyze a profile of individuals engaging in carpooling during their commuting. We first show that individuals with certain socio-demographic characteristics and occupations are more likely to carpool, but this profile seems to be country-specific. Furthermore, our evidence reveals a positive relationship between sharing the ride with someone else and enjoyment/happiness during commuting.

Our results have several policy implications. Understanding how individuals feel during their travels may help to identify factors that encourage - or discourage - the use of green modes of urban mobility. If individuals are more satisfied during carpooling in comparison to driving alone, more effort should be made by local authorities to build the necessary infrastructure that will increase carpooling, such as the development of high-occupancy-vehicle (HOV) lanes. On the labor demand side, employers could implement policies to promote more flexible times of beginning and ending the workday to allow individuals to make their schedules compatible with those of other family members. In addition, to implement efficient policies aimed at decreasing the consumption of energy, GHG emissions, and improving management of the environment, policymakers need to identify the groups of the population that have a less-friendly behavior towards the environment, in order to design policies oriented to such groups, or identify those groups who may, comparatively, encounter more problems in the use of green modes of transport.

One limitation of our analysis is that we cannot control for the unobserved heterogeneity of individuals, which is important in this context, since unobserved factors (e.g., preferences, previous experience, parents' background) may condition decisions about what kind of transport individuals use, and the enjoyment/happiness levels reported by individuals. One way to overcome this limitation is to use data with a panel structure.

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Table 1. Descriptive statistics, UK

	Mean	Std. Dev.
Panel (A): time use data		
time in commuting episodes (in minutes)	21.9	18.6
time in non-commuting episodes (in minutes)	1273.2	206.2
commuting during weekday (%)	48.0	50.0
proportion of commuting time by carpooling (%)	16.8	34.1
individuals not engaging in carpooling (%)	75.8	
Panel (B): enjoyment in commuting episodes		
enjoyment	4.6	1.5
number of episodes	4,556	
Panel (C): individual information		
socio-demographic characteristics		
age	40.2	11.6
male	0.50	0.50
native	0.86	0.35
secondary education	0.31	0.46
higher education	0.66	0.47
presence of a partner	0.70	0.46
household size	3.0	1.3
number of children	0.7	0.9
employment characteristics		
daily hours of work	7.7	2.6
large employers and higher managerial occupations	0.03	0.18
higher professional occupations	0.13	0.34
lower managerial and professional occupations	0.29	0.45
intermediate occupations	0.21	0.40
lower supervisory and technical occupations	0.07	0.25
semi-routine occupations	0.17	0.37
routine occupations	0.11	0.31
number of individuals	1,869	

Note: Sample consists of individuals aged 21 to 65 from the United Kingdom Time Use Survey 2014-2015, with commuting episodes, and with non-missing information on mode of travel. Commuting is defined as the time devoted to "travel to or from work". Carpooling is defined as driving/riding by car with others. The analysis is restricted to working days, defined as those with more than 60 minutes of market work, excluding commuting. The level of enjoyment experienced by individuals in each episode is scaled from 1 ("not at all") to 7 ("very much").

Table 2. Descriptive statistics, US

	Mean	Std. Dev.
Panel (A): time use data		
time in commuting episodes (in minutes)	25.5	22.2
time in non-commuting episodes (in minutes)	1385.7	47.6
commuting during weekday (%)	76.4	42.5
proportion of commuting time by carpooling (%)	10.1	29.9
individuals not engaging in carpooling (%)	79.1	
Panel (B): happiness in commuting episodes		
happiness	4.0	1.6
sadness	0.6	1.3
stress	1.7	1.8
fatigue	2.5	1.9
pain	0.7	1.4
number of episodes	2,425	
Panel (C): individual information		
socio-demographic characteristics		
age	37.1	7.5
male	0.58	0.49
native	0.80	0.40
secondary education	0.24	0.43
higher education	0.69	0.46
presence of a partner	0.56	0.50
household size	3.15	1.52
number of children	1.17	1.15
employment characteristics		
daily hours of work	8.6	2.6
management, business and financial operations	0.19	0.39
professional and related occupations	0.24	0.43
service occupations	0.16	0.36
sales and related occupations	0.11	0.32
office and administrative support occupations	0.10	0.30
farming, fishing, and forestry occupations	0.005	0.07
construction and extraction occupations	0.05	0.21
installation, maintenance, and repair occupations	0.05	0.22
production occupations	0.05	0.21
transportation and material moving occupations	0.05	0.22
number of individuals	2,147	

Note: Sample consists of individuals aged 21 to 65 from the American Time Use Survey 2010-2012-2013 with commuting episodes, and with non-missing information on mode of travel. Commuting is defined as the time devoted to "travel to or from work". Carpooling is defined as driving/riding by car with others. The analysis is restricted to working days, defined as those with more than 60 minutes of market work, excluding commuting. The level of happiness experienced by individuals in each episode is scaled from 0 ("not at all") to 6 ("very").

Table 3. Factors related to carpooling while commuting, UK

	proportion by carpooling	
socio-demographic characteristics		
age	-0.581	(0.640)
age squared	0.008	(0.008)
male	-3.235*	(1.712)
native	-2.432	(2.754)
secondary education	-2.990	(6.186)
higher education	-6.944	(6.126)
presence of a partner	3.568*	(2.014)
household size	1.749*	(0.945)
number of children	0.462	(1.299)
employment characteristics		
daily hours of work	0.584*	(0.335)
higher professional occupations	2.163	(3.790)
lower managerial and professional occupations	6.132*	(3.631)
intermediate occupations	8.476**	(3.873)
lower supervisory and technical occupations	6.476	(4.607)
semi-routine occupations	10.992***	(4.162)
routine occupations	12.659***	(4.717)
weekday	-0.624	(1.684)
constant	35.920**	(16.454)
Region FE	Yes	
Year FE	Yes	
Month FE	Yes	
R-squared	0.063	
Number of individuals	1,869	

Note: Sample consists of individuals aged 21 to 65 from the United Kingdom Time Use Survey 2014-2015 with commuting episodes. Commuting is defined as the time devoted to "travel to or from work". Carpooling is defined as driving/riding by car with others. The analysis is restricted to working days, defined as those with more than 60 minutes of market work, excluding commuting. Dependent variable is the proportion of time commuting by carpooling. Estimated coefficients are multiplied by 100. Regressions include region, month, and year indicators. Robust standard errors clustered at the individual level in parentheses.
* Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 4. Factors related with carpooling while commuting, US

	proportion by carpooling	
socio-demographic characteristics		
age	1.423	(1.120)
age squared	-0.019	(0.015)
male	-0.436	(2.209)
native	-6.696**	(3.119)
secondary education	-6.183	(5.479)
higher education	-8.650	(5.622)
presence of a partner	3.295	(2.427)
household size	0.267	(1.086)
number of children	0.513	(1.663)
employment characteristics		
daily hours of work	-1.586***	(0.455)
professional and related occupations	-1.864	(3.599)
service occupations	-3.369	(3.972)
sales and related occupations	-0.062	(4.013)
office and administrative support occupations	-3.512	(4.234)
farming, fishing, and forestry occupations	3.533	(18.557)
construction and extraction occupations	24.713***	(7.621)
installation, maintenance, and repair occupations	-4.270	(4.453)
production occupations	-5.798	(4.823)
transportation and material moving occupations	4.406	(7.449)
weekday	0.297	(2.668)
constant	7.652	(20.612)
State FE	Yes	
Year FE	Yes	
Month FE	Yes	
R-squared	0.153	
Number of individuals	2,147	

Note: Sample consists of individuals aged 21 to 65 from the American Time Use Survey2010-2012-2013 with commuting episodes. Commuting is defined as the time devoted to "travel to or from work". Carpooling is defined as driving/riding by car with others. The analysis is restricted to working days, defined as those with more than 60 minutes of market work, excluding commuting. Dependent variable is the proportion of time commuting by carpooling. Estimated coefficients are multiplied by 100. Regressions include state, month, and year indicators. Robust standard errors clustered at the individual level in parentheses.
* Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 5. Enjoyment in commuting, UK

	Panel (A)		Panel (B)		Panel (C)	
	(1)	(2)	(1)	(2)	(1)	(2)
carpooling	0.072		0.089*		0.093**	
	(0.057)		(0.047)		(0.047)	
carpooling with spouse		0.113		0.141**		0.150**
		(0.084)		(0.062)		(0.062)
carpooling with parents		-0.053		0.050		0.059
		(0.216)		(0.169)		(0.168)
carpooling with child		-0.196		-0.104		-0.101
		(0.159)		(0.113)		(0.112)
carpooling with other hh members		-0.021		0.017		0.015
		(0.128)		(0.116)		(0.116)
carpooling with non-hh members		0.122		0.095		0.096
		(0.077)		(0.069)		(0.069)
public mode of transit	-0.245***	-0.245***	-0.182***	-0.183***	-0.187***	-0.188***
	(0.062)	(0.062)	(0.051)	(0.051)	(0.051)	(0.051)
physical mode of transport	0.109*	0.108*	0.172***	0.172***	0.175***	0.175***
	(0.056)	(0.056)	(0.044)	(0.045)	(0.044)	(0.045)
av. enjoyment in non-commuting ep.			0.591***	0.591***	-0.273	-0.246
			(0.022)	(0.022)	(0.552)	(0.549)
total time in non-commuting ep. (log)					-0.761*	-0.746*
					(0.401)	(0.400)
av. enjoyment * time non-commuting					0.122	0.118
					(0.077)	(0.077)
constant	-0.267	-0.246	-4.335***	-4.317***	0.982	0.894
	(0.600)	(0.600)	(0.531)	(0.531)	(2.896)	(2.884)
episode controls	Yes	Yes	Yes	Yes	Yes	Yes
socio-demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
employment controls	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.080	0.082	0.305	0.306	0.307	0.307
Number of episodes	4,556	4,556	4,556	4,556	4,556	4,556

Note: Sample consists of commuting episodes with non-missing information on mode of travel of employees aged 21 to 65 from the United Kingdom Time Use Survey 2014-2015. Commuting is defined as the time devoted to "travel to or from work". Carpooling is defined as driving/riding by car with others. The analysis is restricted to working days, defined as those with more than 60 minutes of market work, excluding commuting. Dependent variable is the level of enjoyment experienced by individuals in each episode scaled from 1 ("not at all") to 7 ("very much"). Dependent variable is standardized (z-score rescaled). Regressions include additional episode controls (time duration -in log of minutes- and its square, and an indicator for commuting during a weekday); socio-demographic controls (age, and its square, gender, native, education level, living in couple, household size and the number of children in the household) and employment controls (indicator variables for full-time individual and occupation category). Regressions include region, month, and year indicators. Robust standard errors clustered at the individual level in parentheses.
* Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Table 6. Happiness in commuting, US

	Panel (A)		Panel (B)		Panel (C)	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
carpooling	0.341***		0.242***		0.248***	
	(0.089)		(0.080)		(0.081)	
carpooling with spouse		0.472***		0.296**		0.292**
		(0.140)		(0.123)		(0.121)
carpooling with parents		0.098		0.231		0.228
		(0.259)		(0.182)		(0.184)
carpooling with child		0.007		-0.020		-0.014
		(0.209)		(0.168)		(0.168)
carpooling with other hh members		0.363*		0.170		0.183
		(0.197)		(0.156)		(0.162)
carpooling with non-hh members		0.305**		0.206		0.211
		(0.139)		(0.132)		(0.133)
public mode of transport	-0.225	-0.230	-0.236	-0.243	-0.206	-0.215
	(0.156)	(0.156)	(0.151)	(0.152)	(0.157)	(0.158)
physical mode of transport	0.133	0.121	0.154	0.145	0.192*	0.181*
	(0.121)	(0.121)	(0.100)	(0.100)	(0.106)	(0.106)
av. happiness in non-commuting ep.			0.340***	0.341***	-2.816	-2.654
			(0.020)	(0.020)	(4.318)	(4.378)
total time in non-commuting ep. (log)					-0.614	-0.597
					(2.214)	(2.253)
av. happiness * time non-commuting					0.437	0.415
					(0.597)	(0.606)
constant	-0.489	-0.440	-2.750***	-2.746***	1.891	1.764
	(0.979)	(0.987)	(0.892)	(0.900)	(15.973)	(16.260)
episode controls	Yes	Yes	Yes	Yes	Yes	Yes
socio-demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
employment controls	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.137	0.136	0.333	0.332	0.335	0.334
Number of episodes	2,425	2,425	2,425	2,425	2,425	2,425

Note: Sample consists of commuting episodes with non-missing information on mode of travel of employees aged 21 to 65 from the American Time Use Survey 2010-2012-2013.Commutingis defined as the time devoted to "travel to or from work". Carpooling is defined as driving/riding by car with others. The analysis is restricted to working days, defined as those with more than 60 minutes of market work, excluding commuting. Dependent variable is the level of happiness experienced by individuals in each episode scaled from 0 ("not at all") to 6 ("very"). Dependent variable is standardized (z-score rescaled). Regressions include additional episode controls (time duration -in log of minutes- and its square, and an indicator for commuting during a weekday); socio-demographic controls (age, and its square, gender, native, education level, living in couple, household size and the number of children in the household) and employment controls (indicator variables for full-time individual and occupation category). Regressions include state, month, and year indicators. Robust standard errors clustered at the individual level in parentheses.
* Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.