Work-trip mode choice in Germany – Affected by individual constraints or by partner interaction?

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Abstract: Individuals with young children have additional responsibilities, and tend to have different patterns of work trip mode choice. In this regard, the purpose of the study is to determine if individuals' commuting mode decisions vary with gender and the presence of young chil-dren. In doing so, we develop four separate models for women and men with and without children, respectively. We explore the associations between work trip mode choice and five key elements: i) personal socio-economic status; ii) household attributes, iii) spatio-temporal fixity, iv) partner interaction and v) working hours preferences. We use the Ger-man National Time Use Survey 2012 and adopt multinomial logit analysis. In general, our results suggest that the direction of coefficients is more similar than different for both men and women. For respondents without young children, the spatial and temporal fixity attrib-utes strongly predict men's (also women's) driving, whereas for working in market/non-market sectors, partner attributes significantly decrease men's driving. For respondents with young children, increase in personal income positively and significantly predicts women's (also men's) driving, whereas high levels of education, increase in household income and partners' time spent on unpaid work strongly decrease women's driving. For both the groups, men or women with more egalitarian or reverse working hours preferences are more likely to use sustainable modes.

Keywords: Commuting; Mode choice; Gender roles; Spatio-temporal fixity; Partnership; Preference

1 Introduction

Considerable research on gender and transport has shown evidence for gender differences in travel mode availability and mode choice. These have been linked to multiple reasons, in-cluding inequalities in economic power and access to labour markets, the gender division of paid and unpaid work, access to individual and household resources, differential preferences and attitudes

towards travel modes and the environment, different levels of habitualisation, and the general system of patriarchy (Nobis and Lenz, 2005; Hanson, 2010; Lanzendorf, 2010; Scheiner and Holz-Rau, 2012a).

In a longitudinal perspective, considerable convergence in mode choice has been observed over the past few decades in various countries. This again may be attributed to various rea-sons such as women's increasing labour force participation, the associated decline in the normative male-breadwinner-female-housewife model, and increasing levels of licensing and personal car ownership with women catching up with men over time (Beckmann et al., 2006; Konrad, 2016). Despite this convergence, the gender/travel nexus has remained on the agenda in research and policy. From a research perspective, there are several reasons why this nexus is still relevant.

Firstly, women's travel behaviour continues to be different from men's in various respects, as can be seen in their shorter commutes, lower participation in business travel, long-distance trips and driving, their more complex trip chains and their larger number of trips.

Secondly, these observations can be linked to a significant extent to gender inequalities in economic power, the attribution of social roles and space-time constraints at the possible expense of gender equity and, thus, fairness and social sustainability.

Thirdly, despite the bulk of past research and existent knowledge about gender inequalities in mode choice, the reasons underlying this inequality are not yet adequately understood. For example, the most important variable for a study of personal economic power would be personal income but this is included in hardly any study in the field due to a lack of availa-ble information in most travel surveys (see Boarnet and Hsu, 2015).

Fourthly, while there is abundant research on intra-household interactions between partners in terms of travel behaviour (e.g. partners' out-of-home activities on sharing on joint trips by Schwanen et al., (2007); partners' car use on respondents' car use by Scheiner, 2020), such interactions have rarely been systematically included in gender/travel studies. For in-stance, less is known about how partners' work sharing (e.g. real time use on unpaid work/travel) influence respondents' mode choices.

This paper studies commute mode choice from a gender perspective using multinomial logit modelling based on the German Time Use Survey 2012/13. The model explores five key factors that may affect mode choice: i) personal socio-economic status; ii) household attrib-utes; iii) spatio-temporal constraints, iii) interpersonal interactions between partners in ac-tivity and travel behaviour and v) working hours preferences. Feminist researchers have long pointed out that the gendered character of travel behaviour can only be adequately under-stood by looking at a broader set of 'mobilities', including care trips and household mainte-nance trips, or non-realised trips, rather than just commuting (Law, 1999; Scheiner, 2016; de Madariaga and Zucchini, 2019). Nonetheless, the commute is the economic nexus of house-hold travel, thus reflecting to no small extent economic power in couple households in travel behaviour.

The novelty of the paper lies in the simultaneous consideration of diverse variables that re-flect social (gender) roles, preferences, individual and household resources, and interperson-al interaction to better understand work-trip mode use. In particular, personal income has rarely been considered in related research. The same is true for time-use preferences (rather than realised time-use), and for interactions in two partners' activity and travel behaviour. In the following section, we briefly review the gender gap in mode choice in the literature be-fore conceptualising the determinants of work trip mode choice. Section 3 introduces the data and methods used, and Section 4 provides results. Section 5 draws conclusions.

2 Previous research

2.1 The gender gap in mode choice

Early gender studies on travel focused mainly on assessing the gender differences in mode access, especially car access and car use (Pickup, 1984; England, 1993; Hanson and Pratt, 1995; Pazy et al., 1996; MacDonald, 1999). It is in those early years that the gender gap in car access yawns widest due to low car availability and economic disparities. Later studies still tended to find that men have more car access than women and hence drive more, whereas women on the other hand walk more and tend to use cars as passengers, with less gender gap in public transport and cycling, although the findings vary with geographical and social context (Vance and Iovanna, 2007 for Germany; Simma and Axhausen, 2003 for Austria; Hamilton, 2005 for the UK; Nobis and Lenz, 2005 for Germany; Limtanakool et al., 2006 for the Netherlands). Over the decades, studies observe a pattern of gender convergence in car access and mode use: from 1985 to 2005 in the USA (Crane, 2007); from 1992 to 2005 in the Netherlands (Hjorthol, 2008), from 1978 to 2006 in Sweden (Frändberg and Vilhelmson, 2011), from 1976 to 2002 in Germany (Scheiner, 2006), and from 1976 to 2008 in Germany (Konrad, 2016). This gender convergence is attributed to many factors such as evolving gender roles, women's improved socioeconomic status and labour status, women catching up with men in license holding and car availability due to decreases in the cost of driving, and the general decline in transit use.

Both men and women confront various forms of constraints on mode choice in their daily travel. At the same time, mode choices may be shaped by preferences, rather than just constraints. We discuss the following elements: 1) personal socioeconomic status, 2) household resources and constraints, 3) spatio-temporal fixity constraints; 4) partner interactions and 5) preferences for gendered work-sharing. Figure 1 provides a graphical representation of our classification. It should be noted that these elements and their underlying hypotheses are typically discussed in concert and considered to be complementary rather than competitive; no author champions one hypothesis to the exclusion of all others.

2.2 Personal socio-economic status

Gender studies commonly claim that men's and women's unequal contributions to the household budget due to the persistent gender hourly wage gap and unequal hours of employment make women more dependent on public transport and walking (Rosenbloom, 2006; Hanson, 2010). Occupational segregation between typical women's and men's jobs, and women's 'spatial entrapment' in certain spatial contexts may contribute to their lower income (England, 1993; Hanson and Pratt, 1995; MacDonald, 1999; Svanfelt, 2018), and at the same time in itself contribute to their lower car use.

Additionally, partnered men tend to show higher educational attainments than their female partners (Skopek et al., 2011), which further boosts income inequality. However, results concerning mode use are inconsistent. While Scheiner and Holz-Rau (2012a) find no empirical evidence to suggest a relationship between economic power and the gender gap in car use, Scheiner and Holz-Rau (2012b) do find such a relationship when using duration of car access as an indicator.

What is more, type of economic sector generates significant effects on mode use. For instance, Schwanen (2011) finds that men working in the service sector and health sector are less likely to commute by car while women working in the health sector tend to be car-dependent due to irregular and non-conventional working hours.

Some studies extend this economic power hypothesis to include wider ‘access to resources’, such as time, the private car, and mobility in general. For instance, Prashker et al. (2008) find that

women are more sensitive than men to distance in residential choice. Some researchers argue that time poverty disproportionately affects women (Turner and Grieco, 2000). A number of studies find lower levels of car availability among women (Simma and Axhausen, 2001; Cao et al., 2007), while others show gender as having no significant effect on car availability (Scheiner, 2010; Van Acker and Witlox, 2010). The divergent findings may be due to differences in the socio-spatial context and/or measurement.

2.3 Household resources and constraints

Mode choices are also affected by household attributes. It is consistently found that household income is positively related to car use (Cao et al., 2006; Best and Lanzendorf, 2005 for maintenance and commuting trips; Reichert and Holz-Rau, 2015 for long-distance trips; Eisenmann and Buehler, 2018 for daily distance and long-distance trips).

The same is true for household car ownership (Cao et al., 2006; Best and Lanzendorf, 2005; Reichert and Holz-Rau, 2015). Vance and Iovanna (2007) find that having fewer cars than drivers reduces women's car use for maintenance more than men's, supporting the notion of gender inequality in access to household cars.

The presence of children has been found to have negative effects on driving alone compared to ride sharing (Rajamani et al., 2003). Best and Lanzendorf (2005) found that the presence of children reduces only women's car use. Conversely, Vance et al. (2005) report that children tend to increase women's but decrease men's car use.

2.4 Spatio-temporal fixity constraints

For both working men and women, daily commuting between home and work is not always straightforward as they need to cope up with various household maintenance activities and travel (Jarvis, 1999; Kwan, 1999; Skinner, 2005). Drawing on Hägerstrand's time geography, individuals' activities are affected by spatio-temporal constraints (Kwan, 1999). Accordingly, paid activities, most in-home activities and escort are typically fixed in space and time and act as 'pegs' around which other activities are scheduled. By contrast, time spent on shopping and leisure tends to be more flexible (Schwanen et al., 2003; Schwanen et al., 2008).

The implications of this for daily life are particularly challenging when several fixity constraints intersect, such as when someone needs to juggle employment and child escort. Such combinations over-proportionally affect women (Schwanen et al., 2008). Despite the convergence in traditional gender roles, mothers still retain the burden of childcare-related chauffeuring trips besides commuting (Heine et al., 2001; Nobis and Lenz, 2004; Vance et al., 2005; Scheiner, 2016), and the same is true for other care trips such as caring for the elderly (Hanrahan, 2018; de Madariaga and Zucchini, 2019; Dardas et al., 2020).

Past activity and travel time studies address the role of such constraints on car use (Pickup, 1988; Rosenbloom and Burns, 1994; Dobbs, 2005; Lanzendorf, 2010). These studies repeatedly claim that working women tend to drive cars to juggle the time-budget constraints arising from non-work obligations and that taking responsibility for household- and family-serving trips increases the chance of getting access to the household car in couples sharing a car, although perhaps less so than contributing to household income (Scheiner and Holz-Rau, 2012b).

In terms of the interpretation of variables, things may not be straightforward. Time spent on employed work strongly correlates with personal income and is sometimes used as a proxy for personal income (Scheiner and Holz-Rau, 2012b). Personal income, however, reflects economic power, whereas time spent on employed work reflects a temporal constraint.

There are other space-time constraints than just those arising from activity patterns. The length of the commute has often been found to impose stress on commuters and impair their quality of life (Stutzer and Frey, 2008; Chatterjee et al., 2020). Hence, commute distance may be considered a spatio-temporal constraint that affects mode choice over and above time spent on employment. Men's above-average commute distances are likely to contribute to their higher car use (Chidambaram and Scheiner, 2020).

The spatial environment a household lives in may also play a role. Urban areas have been recognised to feature more gender-egalitarian attitudes and models of work sharing than more suburban or rural areas (Bastian and Börjesson, 2018; Nisic, 2017; Lo and Houston, 2018). Findings in this vein need to be interpreted with care because the residential area is not necessarily a constraint but is shaped by residential self-selection.

2.5 Interpersonal interaction within partnerships

In partner households, partners allocate time and other household resources, share income generation and divide their labour to meet household needs under social, spatial and temporal constraints. They tend to negotiate the constraints and opportunities that are highly interdependent (also referred to as coupling constraints). Such interpersonal interaction characterises partners' daily life and may affect both partners' mode use.

The transition to parenthood may create a shift in partner interaction (Lanzendorf, 2010; Scheiner, 2020). For example, in one-car couples, one partner may commute by public transport to free the car for their partners escorting their children, grocery shopping and errands (Schwanen et al., 2007; Scheiner, 2020). If both partners are equally busy in their professional careers, partners negotiate the division of tasks based on their tight time budgets.

In travel research, studies have analysed household interactions in various ways: i) as key household structure variables, i.e. by the effects of cohabitation and shared resources on travel (Elliott and Joyce, 2004; Zolnik, 2010; Boarnet and Hsu, 2015), these studies importantly include the household and family context, but with little emphasis on working out the details of interpersonal interaction; ii) by modelling actual interactions between household members in terms of activity-travel decisions, job choice, residential choice, time allocation and holiday travel (Timmermans and Zhang, 2009; Ho and Mulley, 2015; Kroesen, 2015); and iii) by looking at intra-household interactions in travel over the life course, either quantitatively (Scheiner, 2020) or qualitatively (Rau and Sattlegger, 2017).

A few studies address the effects of interpersonal interaction on commuting, for instance, i) by including the effect of a partner’s childcare and housework on individual commuting time (Roberts et al., 2011), ii) by analysing joint participation in discretionary activities between partners (Schwanen et al., 2007). However, little is known about the direct effects of the partner's time use and travel behaviour on individual commuting from a gender perspective.

2.6 Preferences for gendered work-sharing

Social psychologists and some sociologists study the importance of gender attitudes and norms based on preference (e.g. Hakim, 2000). Preferences are attitudes towards an alternative, typically conceived of as shaping individual or household decisions and actions (Mas-Colell et al., 1995). Several recent studies in the transport field also make an explicit empirical distinction between the binary variable sex and gender attitudes (Ettema and van der Lippe, 2009; Sivasubramaniyam et al., 2020). The findings support the preference hypothesis that even women with easy access to a car use public transport more than men, and they are more inclined to reduce their car use than men (Matthies et al., 2002; Polk, 2004). This has been traced back to

women's more prevalent ecological norms and sustainability goals and to their less ingrained car habits (Matthies et al., 2002; Hjorthol, 2008).

Similarly, a couple's realised gendered social role preferences may shape gender divisions of work. Couples are formed based to some extent on such preferences, and the latter may align between partners over time (Arránz Becker, 2013; Arránz Becker and Lois, 2010; Kalmijn, 2005). In turn, they may shape mode choices.

It is important to note that the notion of preference assumes individual freedom of choice, but preferences may have their roots in societal traditions and may hence operate based on patriarchy, inequality and culturally defined social roles. Thus, preferences may mirror societal power relationships rather than having much explanatory power in themselves. On the other hand, given the relatively high level of individual freedom in modern western societies, preferences are likely to drive inter-personal (and, thus, societal) relationships.

In Germany, recent research has shown disparities between actual and preferred working hours and that men increasingly want to reduce their working hours (Pollmann-Schult, 2008; Abendroth, 2018). Another study reports that nearly half of fathers who work full-time or overtime would prefer to reduce their working hours, while mothers prefer a working week between 25 and 35 hours (BMFSSFJ 2015). In particular, women would prefer to work longer if they work less than 20 hours a week while those who work more than 35 hours a week would prefer to reduce working hours (BMFSSFJ, 2015, p.55).

The interconnectedness between preferred social roles and mode choice is still unknown. We assume that traditional preferences increase the male partners' use of powerful, fast, time-saving, expensive, 'male' transport modes (e.g. cars), and female partners' use of slower modes. For egalitarian or reverse preferences, the opposite should be true.

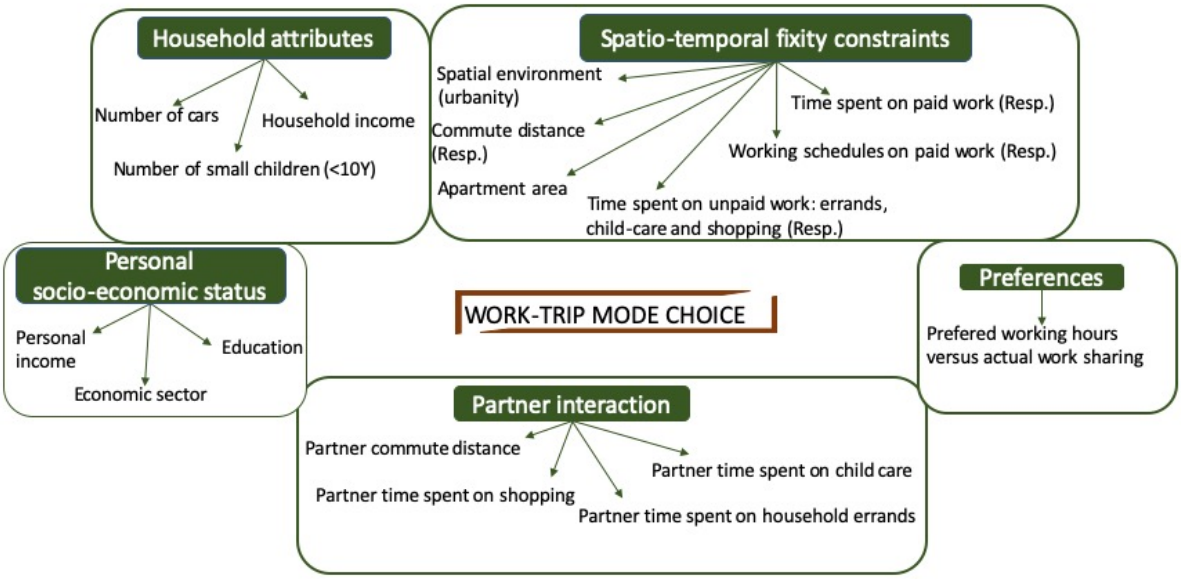

Figure 1: Factors affecting work-trip mode choice

Source: author's compilation.

2.7 Present study

Using the cross-sectional data, we explore the gender differences in factors that affect work-trip mode choice across four groups (partnered men and women, with and without young children) by investigating its association with the five key factors. We developed a set of hypotheses gathered from the concepts and theories discussed in the literature mentioned above:

First, we expect that an increase in personal income and education level tends to increase both men's and women's driving over other modes (H1).

Second, we hypothesised that having cars and having young children tend to increase women's driving (H2).

Third, we look at spatio-temporal fixity constraints. We expect that living in rural settlements highly determines the probability of men's driving (H3), as men tend to commute longer and rural areas offer less well-paid jobs. Then, we expect that long-distance commuting tends to increase women's public transport usage more than driving (H4), as women are highly sensitive to commuting stress and safety. Other factors such as long working hours and work schedules with fixed start and end times may increase both men's and women's driving (H5). Furthermore, we expect that time spent on shopping may increase men's driving over other travel mode choices (H6), based on the previous findings that men increase car use for maintenance trips (Best and Lanzendorf, 2005; Scheiner, 2020). As women are efficient in organising the fixed trips, we expect that time spent on childcare or household errands positively affects their driving over other travel modes (H7).

Fourth, we posit that partner's time spent on shopping and errands may negatively impact men' s/women's commuting by car (H8), building on the previous findings about partner negotiation concerning car use – an increase in the number of trips made by a respondent's partner decreases the respondent's car use (Scheiner, 2020).

Finally, we expect male partners with traditional working hours preferences may most likely drive, while those with egalitarian attitudes may be more likely to use other modes; for women, we expect the opposite (H9).

3 Methods

3.1 Data

The study uses a subsample of data from the German Time Use Survey (GTUS), conducted by the Federal Statistical Office in 2012/2013 (Forschungsdatenzentren, 2013). It is a cross-sectional survey, repeated once in ten years, after 1991/1992 and 2001/2002. The data is representative for the German population. It comprises sociodemographic variables of private households, as well as three-day activity, travel and mode-use patterns of all household members. Similar to other time use surveys (e.g. UK Time Use Survey, General Social Survey for Canada, American Time User Survey for US), the respondents self-report the daily activity and travel mode in the activity diary for a continuous 24 hours (i.e. from 4:00 AM to 4:00 AM next day) over three random days (two weekdays and one weekend day), with ten-minute intervals. For simplicity, we classified the primary modes into four: 1. cars, (car, motorbike), 2. public transport -PT (bus, train, tram), 3. walking, and 4. cycling.

3.2 Sample setting

The activity diary comprises of a sequence of episodes of varying lengths, starting at 4 am, with a total duration of 1440 minutes, leading to 144 episodes per day. Each episode has information on the respondent's primary activity (e.g., work, education, personal care, household, sport, voluntary, travel) and primary travel mode used, if applicable. Using the code identifier, we retained two activities: primary work (coded as 21) and primary work-related travel (coded as 921). We then generated travel mode-based work trips (*to work* trips stages and *from work* trips stages) per person per day. Here, we count trips with more than one stage as separate trips. For instance, Figure 2 shows the generation of work trips from activity episodes. Case 1 denotes a

work trip using a single mode of transport, i.e. car, whereas case 2 shows the trip stage denoted by multimode, i.e. walking and public transport. In case 1, the respondent has 2 car trips *(to and from work)*, whereas in case 2 the respondent has trip stages: *walking-PT-walking (to and from work)* that have been converted to 2 PT trips and 4 walking trips.

In travel surveys, the single trip aggregates the trip stages with its primary travel mode, as the respondents self-report the entire mode used for one trip in yes/no type questions (Gerike at al., 2015). However, in time use surveys, respondents self-report the travel modes they used for each ten-minute interval. They are not instructed on how to report trips and trip stages, which leads to more single trips in the data. Accordingly, we generated 14219 work trips from the data. Out of these work trips, about 91% of work trips are the single-stage trips generated by single travel mode (car trips: 67%, PT trips: 9.6%, cycle trips: 8.6%, and walk trips: 6.2%). About 6% of work trips are two-stage trips generated by two travel modes (car + walk trips: 2.2%, PT+walk trips: 1.6%, car+PT trips: 1.2%, car+cycle trips: 0.8%, and PT+cycle trips: 0.2%). The remaining 3% of total work trips have more than two stages.

Our analysis includes work trips made by the partnered respondents. Hence, our sample was narrowed down to 9438 work trips (M:5455; W:3983). Compared to individuals with older children (over ten years) or childless couples, those with younger children have additional responsibilities with non-mandatory activities and trips like childcare and escort. Hence, we believe that partnered respondents with young children may have different patterns of work-trip mode choice than those without. To investigate this, we split the sample into two groups: partnered respondents with one or more young children below 10 years and those without young children[1].

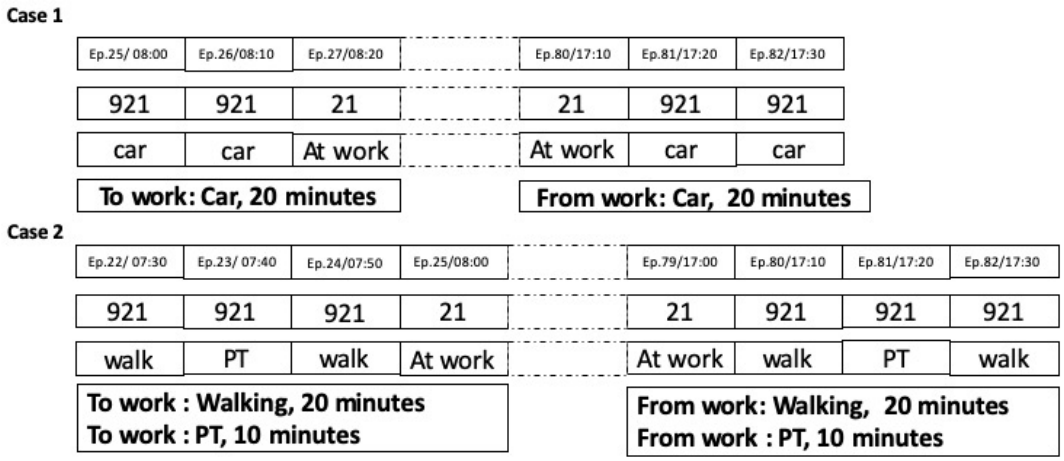

Figure 2: Generation of work trips from activity file

Source: author's compilation.

3.3 Determinants of work-trip mode choice

We categorise the variables in five groups, as discussed in Section 2.

Personal socio-economic status

In personal socio-economic status, we include three variables: personal income, education and type of economic sector. The direct information on personal monthly income is ranked in order

[1] Here the households without young children include childless respondents, and respondents with at least one child over ten years of age, while households with young children include the respondents with at least one child below 10 years

from poorest to richest and divided into four income quartiles. For education, we combine the categorical variables of German school and professional education and convert this into years of education. In the data, the economic sector is classified into 21 categories which we summarise in three categories: industry, market and non-market, as described in Table 2. Other demographic variables, such as age and working status, are excluded due to the lack of significant effects.

Household attributes

Similar to the personal income, we categorise household income into four quartiles. In terms of children in the household, the presence of young children (either at pre-school or primary school) is primarily relevant for the respondents' commute mode choice. Hence, we include the number of young children below ten years of age as a variable for the model *partnered respondents with young children*.

Spatio-temporal factors

For spatial attributes, we include three variables: urban size, commute distance and apartment area. Regarding urbanity, the municipality size according to the Bundesamt für Bau-, Stadt- und Raumforschung (BBSR, 2016) has been classified into four categories in the data: large cities, semi-urban, high density rural and low density rural (see Table 2 for details). We categorise commute distance into three groups: short (less than 10km), medium (from 10 to 25km), and long-distance commuting (over 25km). We included the apartment area as a proxy for the respondents' residential location as we do not have better local-scale information. Large apartment areas are typically associated with more remote locations within a city.

The temporal attributes of work schedules are classified by three dummy variables: fixed, flexible and free organisation (see Table 2 for details). For time spent on paid and unpaid work, we use the direct metric variable from the data, measured in hours per day. The time spent on paid work denotes the number of working hours per day. The time spent on unpaid work (shopping, childcare and errands) indicates the time spent on the activity and travel as some of the travel can be considered care work in itself (e.g. escort).

Partner interactions

We expect mode choice to be affected by the partner's behaviours, resources and social roles. Hence, we include the variables that represent the partner's monetary resources and responsibilities such as partner's monthly income, partner's commute distance, and partner's time spent in unpaid variables (shopping, childcare and errands). We tested the partner's income in various forms (categories, continuous scale), but finally excluded it due to its strong correlation with household monthly income. Also, we excluded partner's time spent on paid work, due to the lack of significance with mode choice for both men and women.

Working hours preferences

Our data include a direct measurement of preferred working hours per week and actual working hours per week. Based on the match between the two, we measure male and female preferences for additional work. We combine this preference variable with the realised type of work-sharing between partners to draw conclusions on preferred work-sharing.

Male/female preference for working hours	Actual work-sharing of paid work		
	Traditional M>F	Egalitarian F=M	Reverse F>M
Male preferences for working hours			
Prefer additional working hours (preference > actual working hours)	prefer traditional role	prefer traditional role	prefer egalitarian role
No difference (preference = actual	prefer traditional	prefer egalitarian role	prefer reverse role

working hours)	role		
Prefer less working hours (preference < actual working hours)	prefer egalitarian role	prefer reverse role	Prefer reverse role
Female preferences for working hours			
Prefer additional working hours (preference > actual working hours)	prefer egalitarian role	prefer reverse role	prefer reverse role
No difference (preference = actual working hours)	prefer traditional role	prefer egalitarian role	prefer reverse role
Prefer less working hours (preference < actual working hours)	prefer traditional role	prefer traditional role	prefer egalitarian role

Table 1: Working hours preferences versus actual work sharing of paid work

Source: author's compilation.

Theoretically, if a man from a traditional household would like to increase his working hours, he prefers an even more traditional role distribution. If there is no gap between his actual working hours and his preference, this implies that he is still satisfied with the traditional role. Conversely, if he would like to reduce his working hours, he prefers a more egalitarian or even reverse-role pattern. In contrast, if a woman from a traditional household would like to reduce her working hours further, she prefers a more traditional pattern of household income generation, while if she would like to increase her working hours, she prefers a more egalitarian or even reverse-role pattern, depending on her preference relative to her husband's working hours. Table 1 shows the information on how we generated this variable.

3.4 Analysis

We employed multinomial logistic regression[2] to examine the association between each work trip mode and the explanatory variables listed in Table 2. As there are repeated observations (trips) for each respondent, the multinomial logit model addressed the problem of clustering of measures and correlation of error by observation unit. We treated the personal identification number as the clustering variable. We checked multicollinearity between independent variables using the variance inflation factor. All independent variables were included in the model except partner income and partner's time spent on employment. All resulting variance inflation factor values are smaller than 3 (ranges from 1.12 to 2.27).

Also, we performed the Wald test[3] to assess if the outcome variables are different from each other. Our results reject the null hypothesis (associated p values are significant), which implies that all four categories of our dependent variables are distinguishable.

To search for a better fit model, we calculated Goodness-of-Fit (GoF) statistics for all models. Log pseudo-likelihood is the probability the parameters maximize value of likelihood function on the basis of best estimate of coefficients. Pseudo R2, Cragg and Uhler's R2 explain the overall fit of the model. Additionally, lower values of Akaike information criterion and lower Bayesian information criterion scores indicate the preferred and better fitted model (Williams 2018).

[2] Also, we employed fractional multinomial logit model with the same set of variables to predict the work trip mode choice for men and women (with and without children). The coefficients and significance do not vary much, however the variance (adj.R2) explained by factors in the multinomial logit model was much better than in the fractional logit model. Hence, we decided to use multinomial logit model for the analysis.

[3] Due to the robust nature of the models, we could not perform the Hausman test for IIA (Independence from Irrelevant Assumption). We instead used the Wald test that computes if the alternatives are indistinguishable. The null hypothesis is that alternatives are indistinguishable or identical to each other.

In addition, we estimated the average marginal effects (AME) as dy/dx to enable an intuitive interpretation. AMEs are expressed as percentage points (pp) that denote the average of predicted changes in probabilities of dependent variable for one unit increase in the independent variable, and the effects are compared to the rest of the categories. In travel research, AMEs are used to summarise relationships between travel outcomes and explanatory variables. The marginal effects representing the change in the choice probabilities must sum to zero, thus representing a net zero change over all alternatives.

4 Results

4.1 Descriptive analysis

Table 2 provides a descriptive summary of the variables used in the analysis. We classified the respondents into two groups: partnered respondents without young children and partnered respondents with young children. We performed the independent sample t-tests and chi-square independence tests, as appropriate, to examine gender differences. The results indicate the following.

Firstly, driving appears as the most popular commute mode choice among men and women from both the groups. We observe some changes in mode shares between groups. Compared to women without young children, those with young children accounted for a higher proportion of work trips by cars (73%) and a lower proportion of trips by public transport, cycling and walking. On the other hand, men with young children have a slightly lower commuting share by cars (74%) and a higher share of public transport (11%) and walking (7%) compared to those without young children.

Secondly, a large gender gap in monthly income is observed between male and female respondents with (€1412 gap) and without young children (€1406 gap). Also, in the highest quartile income group, men dominate more than women (without young children: 56% vs 11%; and with young children, 58% vs 12%). In terms of economic sector, men across groups are more or less equally distributed among industry, market and non-market, whereas women (nearly 60%) across groups predominantly work in the non-market sector such as health, education and public administration.

Thirdly, men commute considerably longer distances than women in both groups. Further, both men and women with young children commute longer than those without. A possible explanation could involve the fact that partnered men with young children are less likely to take care of the dependent children, as the childcare burdens mostly fall on women. In such cases, we can expect that men with young children commute longer. What is more, women with young children are more likely to escort children to school or day-care via trip chaining or men with young children rationally accept the longer commute as a trade-off to locate near better schools. The gender gap between men and women is equally large among the groups (6.44 km gap and 6.99 km gap).

Fourthly, the number of working hours explains a substantial part of the gender gap in income. A similar pattern of the gender differences found for actual working hours is also seen in working hours preferences. Importantly, men would prefer to reduce their working hours, while women seem to be more satisfied with their contribution to paid work time. The higher gap in working hours also implies that the burden of household work may be falling solely on women. Women across both groups have higher means of time spent on unpaid activities than men. In particular, the gender gap in total unpaid activities between men and women with young children is more significant (-2.23h/day) than for those without, the substantial part of this gap is attributed to the time spent on childcare. Women with dependent children are most likely to devote their time to

primary childcare and escort. Boarnet and Hsu (2015) claim that such a chauffeuring gap becomes smaller when the woman's earning power increases. Notably, respondents without young children spend slightly more time on shopping and errands than those with young children.

Variables and Levels	Respondents -without young children			Respondents with young children		
	Male	Female	χ2/Gap	Male	Female	χ2/Gap
	% / mean(SD)	%/ mean(SD)		% / mean(SD)	% / mean(SD)	
Mode shares (%):						
By car	75.44	68.61	[c]	73.59	73.41	[b]
By public transport	8.73	9.29		10.59	7.42	
By bicycle	10.03	10.41		8.79	10.31	
On foot	5.81	11.69		7.03	8.86	
A. Personal socio-economic						
Personal monthly income (€)	2701(1260)	1295(827)	**1406*** **	2700(1227)	1287(850)	**1412.95*** **
Personal income level (%):						
(Poor) less than or equal to €800/month	3.97	38.53		3.60	16.20	
(Low) - €800 to €1600/month	11.49	29.55		8.92	30.31	
(Middle) - €1600 to €2450/month	28.94	20.65		29.20	18.32	
(High) - greater than or equal to €2450/month	55.60	11.27		58.29	11.60	
Years of education	14.1 (2.8)	13.3 (2.4)	**0.72*** **	14.5 (2.93)	14.3 (2.59)	**0.24***
Type of economic sector (%):						
(Industry)mining, manufacturing, energy, construction	35.36	12.44	[c]	33.19	10.62	[c]
(Market)wholesale/retail trade, goods, hospitality, bank	33.05	33.13		33.25	30.41	
(Non-market) public admin., education teaching, health	31.59	54.43		33.56	58.97	
B. Household attributes						
Household monthly income (€)	4083(1502)	3940 (1424)	na	3824 (1385)	3870 (1358)	na
Household income level (%):						
(Poor) less than or equal to €2750/month	22.11	24.55	na	28.02	25.44	na
(Low) - €2750 to €3800/month	17.42	18.97		20.94	21.05	
(Middle) - €3800 to €4750/month	28.48	27.35		23.28	26.51	
(High) - greater than or equal to €4750/month	31.99	29.13		27.76	27.00	
Number of cars per household	1.8 (0.8)	1.8 (0.7)	na	1.6 (0.6)	1.6 (0.6)	na
Number of children below 10 years	na	na		1.56 (0.64)	1.41 (0.53)	
Children's age	13.4 (2.2)	13.2 (2.1)	na	4.6 (2.7)	5.14 (2.5)	na
C. Spatio-temporal fixity						
Spatial environment (%):						
(Large) cities with populations of at least 100,000	23.09	24.20	na	25.17	25.53	na
(Semi-urban) districts pop. density at least 150 inhab./km^2	44.08	41.80		42.79	39.69	
(High dense rural) districts with pop. density below 150 inhab./km^2	18.81	18.95		17.62	19.46	
(Low dense rural) districts with pop. density below 100 inhab./km^2	14.02	15.05		14.42	15.32	
Respondent's commute distance (km)	17.5 (23.7)	11.0 (11.9)	**6.44*** **	19.8 (25.1)	12.8 (15.8)	**6.99*** **
Respondent's commute distance category (%):						
(< 10km) short-distance commuting	53.53	62.92	[c]	46.30	54.30	[c]
(10-25km) medium-distance commuting	24.10	26.15		28.13	36.04	
(>25km) long-distance commuting	22.37	10.93		25.57	9.67	
Apartment area (sqm)	128 (39.4)	123 (36.4)	na	127 (37.8)	125 (35.3)	na
Respondent's working hours (h/day)	8.4 (1.8)	5.5 (2.3)	**2.87*** **	8.3 (1.8)	5.1 (2.2)	**3.26*** **
Respondent's work schedule (%):						
(Fixed-time) fixed start and end time	40.5	57.00	[c]	39.66	51.36	[c]
(Flexi-time) flexible start and end time - adhere to some period	32.7	28.28		37.40	31.48	
(Free schedule) free organisation of working hours	26.6	14.72		22.94	17.15	
Respondent's time spent on shopping activity and travel (h/day)	0.5 (0.5)	0.8 (0.7)	**-0.33*** **	0.4 (0.4)	0.7 (0.6)	**-0.27*** **
Respondent's time spent on childcare activity and escort (h/day)	0.1 (0.3)	0.2 (0.4)	**-0.09*** **	1.0 (0.8)	1.9 (1.0)	**-0.93*** **
Respondent's time spent on household activity and travel (h/day)	1.1 (1.0)	2.3 (1.2)	**-1.19*** **	1.0 (0.9)	2.1 (1.0)	**-1.05*** **
D. Partner interaction						
Partner's commute distance (km)	8.8 (11.8)	14.6 (22.3)	**-5.85*** **	10.7 (17.0)	16.9 (22.8)	**-6.16*** **
Partner's time spent on shopping activity and travel (h/day)	1.0 (0.9)	0.7 (0.9)	**0.39*** **	0.9 (0.7)	0.52 (0.7)	**0.41*** **
Partner's time spent on childcare activity and escort (h/day)	0.2 (0.5)	0.1 (0.3)	**0.13*** **	2.4 (1.5)	1.1 (0.9)	**1.30*** **
Partner's time spent on household activity and travel (h/day)	2.9 (1.5)	1.5 (1.4)	**1.41*** **	2.6 (1.3)	1.3 (1.2)	**1.32*** **
E. Working hours preferences						
Preferred working hours (h/day)	7.3 (2.0)	5.4(2.0)	**1.9*** **	7.4 (1.9)	5.0 (1.9)	**2.4*** **
Preferences for gendered work-sharing (%):						
(Traditional) working hours preference vs. traditional household (M>F)	32.7	34.3	[c]	9.1	24.0	[c]
(Egalitarian) working hours preference vs. egalitarian household (M=F)	47.9	38.0		40.0	50.2	
(Reverse) working hours preference vs. reverse household (F>M)	19.2	27.6		50.8	25.6	
n	3372	2729		1862	997	

Table 2: Description and composition of the variables used in the analysis

Values in bold are significant: gap (2-tailed t-test): *** -p<0.001, **- p<0.01, and *- p<0.05;
Chi-square independence test (**χ2**): : [a]- p<0.05; [b]- p<0.01, and [c] -p<0.001; na-not applicable; Source: authors' calculations.

Fifthly, regarding partner variables, the partners of male respondents across both groups have less income, lower commute distances and spend more time in unpaid activities than the partners of female respondents. This is because partner variables include not only the working male/female respondents but also the non-working/stay-at-home partners of single-earner respondents.

Both the households (with and without young children) commonly exhibit a strong traditional division of labour, with men mostly driving to commute, working longer hours, earning more and hence bearing primary responsibility for financial well-being. In contrast, women primarily drive to commute but are also responsible for a multitude of unpaid tasks (for more details see Chidambaram and Scheiner, 2020). Additionally, the presence of young children increases the total time spent on unpaid activities for women.

Taken overall, male respondents on average have higher mean scores than women in commute distance, personal income, working hours and working hours preferences, and have lower mean scores in unpaid work: shopping, childcare and errands. The extent of the gender gap is larger between male and female respondents with young children than between those without.

In the following section, we discuss the results of the multinomial logistic regression analysis to explore further the mechanisms between commute mode choice behaviour of men and women and other attributes: economic, spatial, temporal attributes and preferences.

4.2 Regression analysis

Using multinomial logit regressions, we estimated coefficients for four models: partnered men and women without young children (Table 3) and with young children (Table 4) respectively. The McFadden pseudo R2 and Cragg & Uhler's R2 values presented in Table 3 and Table 4 indicate a reasonable overall fit for the model explaining about 22% (Model 1) to 33% (Model 4) of the variance in the data. The probability of obtaining the chi-square statistic is significant for all models, indicating the effect of all explanatory variables, taken together on the dependent variable. The difference between the null model (without independent variables) and the full model for AIC and BIC values is significant for both male and female respondent models.In the following sections, we discuss only the significant associations between variables and work trip mode choice.

Between men and women without young children

Both men and women tend to have a similar association with personal socioeconomic attributes, although there are slight differences in the marginal effect. Compared to poor income groups, women from low-income groups have a significant negative association with public transport. For men, the income levels are not significant. Turning to industry type, working in market sectors or non-market sectors compared to industry increases public transport usage for both men and women. Besides, the non-market sectors positively predict men's cycling. Also, working in the market or non-market sectors is negatively associated with both men's and women's driving, but is significant only for men.

Considering household income[4], compared to the poorest quartile, the highest quartile is positive-

[4] We tested the endogeneity between household income and respondent's personal income by excluding personal income and vice versa in the model. When checked separately, the coefficients for respondent's personal income and household income remain the same in all models and also there was no change in signs. Also, VIF values were less than 3. Hence, we included both of them in the models in order to get a clearer picture of how these two variables jointly influence individual mode choice.

	Male (N=3372) –Model 1							Female (N=2729) –Model 2						
	Car	**PT**		**Cycle**		**Walk**		**Car**	**PT**		**Cycle**		**Walk**	
	dy/dx	Coef.	dy/dx	Coef.	dy/dx	Coef.	dy/dx	dy/dx	Coef.	dy/dx	Coef.	dy/dx	Coef.	dy/dx
1. Respondent's income class: Ref: Poor	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Low	0.04	-0.21	-0.01	0.35	0.02	-0.79	-0.05	0.05	**-0.95***	**-0.06**	-0.04	0.00	0.00	0.01
Middle	0.00	-0.39	-0.03	1.21	0.08	-0.68	-0.05	0.02	-0.24	-0.02	-0.32	-0.03	0.22	0.03
High	0.05	-0.81	-0.06	0.99	0.07	-0.89	-0.05	0.07	-0.56	-0.03	-0.84	-0.06	0.06	0.02
2. Years of education	-0.04	0.30	0.01	0.49	0.03	0.04	-0.00	0.08	-0.48	-0.02	0.09	0.02	-0.98	-0.08
3. Respondent's economic sector: Ref: Industry	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Market sector	**-0.10**	**1.39*** **	**0.08**	0.36	0.01	0.37	0.01	-0.08	**1.46***	**0.08**	0.15	0.00	0.06	-0.01
Non-market	**-0.14**	**1.17*** **	**0.05**	**1.11*** **	**0.07**	**0.63*** **	**0.02**	-0.06	**1.01***	**0.05**	0.16	0.01	0.15	0.00
4. Household income Ref: Poor	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Low	-0.04	0.24	0.01	0.54	0.03	0.12	0.00	0.04	-0.28	-0.01	0.18	0.02	-0.48	-0.04
Middle	-0.05	0.18	0.00	0.53	0.03	0.44	0.02	-0.05	0.30	0.01	0.61	0.05	0.00	-0.01
High	**-0.11**	0.57	0.02	**1.03***	**0.06**	0.82	0.03	-0.06	**0.83***	**0.06**	**0.69***	**0.05**	-0.43	-0.05
5. Cars per household (Nos.)	**0.14**	**-1.16*** **	**-0.06**	**-0.76*** **	**-0.04**	**-1.05*** **	**-0.04**	**0.11**	**-1.08*** **	**-0.07**	**-0.62** **	**-0.04**	-0.29	-0.01
6. Children below ten years (Nos.)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)	(ni)
7. Settlement type: Ref: Large cities	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Semi urban	**0.08**	**-0.83** **	**-0.06**	-0.20	-0.00	-0.36	-0.01	**0.11**	**-0.75***	**-0.06**	**-0.78** **	**-0.06**	-0.18	0.00
High dens. rural	**0.09**	**-1.69*** **	**-0.10**	0.16	0.03	-0.40	-0.01	**0.18**	**-2.60*** **	**-0.13**	**-0.92***	**-0.06**	-0.25	0.01
Low dens. rural	**0.09**	**-1.15***	**-0.08**	0.19	0.03	**-1.41***	**-0.05**	0.10	**-1.20** **	**-0.09**	-0.23	-0.01	-0.23	-0.01
8. Respondent's com. distance (km) Ref: < 10km	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10-25km	**0.13**	0.40	0.05	**-2.00*** **	**0.14**	**-0.94***	**-0.04**	**0.13**	**0.79** **	**0.08**	**-1.41*** **	**-0.10**	**-1.69*** **	**-0.11**
>25km	**0.14**	**0.66***	**0.08**	**-3.00*** **	**-0.16**	**-1.45*** **	**-0.05**	0.07	**1.40*** **	**0.15**	**-2.65** **	**-0.13**	**-1.18** **	**-0.10**
9. Apartment area (sqm)	0.00	0.03	0.00	**-0.07***	**-0.01**	-0.01	-0.00	**0.02**	**-0.16*** **	**-0.01**	0.02	0.00	**-0.14** **	**-0.01**
10. Respondent's time spent in paid job (h/day)	**0.02**	-0.15	-0.01	**-0.30** **	**-0.02**	0.06	0.01	0.01	-0.03	-0.00	-0.05	-0.00	-0.05	-0.00
11. Respondent's work schedules: Ref: Fixed time	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Flexi-time	**-0.07**	**1.03*** **	**0.08**	-0.01	-0.01	0.32	0.01	**-0.08**	**1.05*** **	**0.07**	0.08	-0.01	0.34	0.02
Free	**0.06**	-0.74	-0.03	**-0.80***	**-0.05**	0.23	0.02	-0.03	-0.03	-0.01	-0.06	-0.01	0.52	0.05
12. Respondent's shopping incl.travel (h/day)	**0.06**	**-0.46***	**-0.02**	-0.34	-0.02	**-0.42***	**-0.01**	0.04	**-0.42***	**-0.03**	-0.24	-0.02	0.01	0.01
13. Respondent's childcare incl.travel (h/day)	**0.11**	**-1.17***	**-0.07**	-0.49	-0.02	**-0.56***	**-0.02**	0.05	-0.20	-0.01	-0.40	-0.03	-0.26	-0.02
14. Respondent's errands incl.travel (h/day)	-0.00	-0.01	-0.00	-0.01	-0.00	0.10	0.00	-0.01	0.02	0.00	0.08	0.01	0.08	0.01
15. Partner's com. distance (km)	0.08	-0.81	-0.05	-0.52	-0.03	-0.42	-0.01	0.02	-0.79	-0.06	-0.56	-0.05	0.85	0.09
16. Partner's shopping incl.travel (h/day)	**-0.03**	**0.23***	**0.01**	0.20	0.01	0.13	0.00	-0.02	0.14	0.01	0.10	0.01	0.04	0.00
17. Partner's childcare incl.travel (h/day)	**-0.06**	**0.65** **	**0.04**	0.14	0.00	**0.60***	**0.02**	-0.03	0.37	0.02	-0.30	-0.03	0.42	0.04
18. Partner's errands activities incl.travel (h/day)	0.01	-0.05	-0.00	0.00	0.00	-0.10	-0.00	0.01	0.12	0.01	-0.09	-0.01	-0.19	-0.02
19. Preference for working hours: Ref: Traditional	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Egalitarian	-0.02	-0.26	-0.02	**0.86** **	**0.07**	-0.38	-0.02	-0.03	-0.09	-0.01	0.17	0.01	0.35	0.03
Reverse	-0.03	-0.01	-0.01	0.59	0.04	0.02	-0.00	0.06	-0.58	-0.03	-0.46	-0.03	0.00	0.01
Constant		-0.13		0.28		-0.41			1.56		-0.17		2.01	
Goodness of fit measures		**Full model**		**Null model**					**Full model**		**Null model**			
Log likelihood		-2109.81		-2696.24					-2134.17		-2594.46			
McFadden's pseudo R^2		0.22							0.18					
Cragg & Uhler's R^2		0.37							0.34					
AIC		4393.61		5804.61					4442.33		5703.34			
BIC		4926.34		5823.11					4956.65		5721.31			

Table 3: Estimated coefficients for partnered/cohabiting respondents (without young children) – Comparison with car

Reference category: Car; Values in bold are significant: * p<.05; ** p<.01; *** p<.001; aBIC(null) – BIC(full) > 0 indicates that the full model is better than the null model; ni – not included.

	Male (N=1862) –Model 3							Female (N=997) –Model 4						
	Car	**PT**		**Cycle**		**Walk**		**Car**	**PT**		**Cycle**		**Walk**	
	dy/dx	Coef.	dy/dx	Coef.	dy/dx	Coef.	dy/dx	dy/dx	Coef.	dy/dx	Coef.	dy/dx	Coef.	dy/dx
1. Respondent's income class: Ref: Poor	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Low	**0.28**	**-2.51***	**-0.14**	-0.12	0.04	**-2.06***	**-0.18**	**0.13**	**-1.53***	**-0.07**	-0.82	-0.03	-0.80	-0.03
Middle	**0.26**	**-1.80***	**-0.11**	-0.77	-0.01	-1.63	0.15	0.11	-1.82	-0.08	-0.86	-0.04	-0.27	0.01
High	0.21	-0.96	-0.05	-0.03	0.04	**-2.15***	**-0.19**	**0.17**	**-2.00***	**-0.08**	-1.95	-0.09	-0.64	-0.00
2. Years of education	**-0.23**	1.07	0.05	**1.80****	**0.08**	**2.15*****	**0.10**	-0.12	-0.49	-0.05	**2.78****	**0.19**	-0.03	-0.03
3. Respondent's economic sector: Ref: Industry	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Market sector	-0.04	0.52	0.03	-0.30	-0.03	0.66	0.04	**-0.12**	0.60	0.01	1.45	0.06	1.05	0.05
Non-market	**-0.09**	**1.11****	**0.07**	-0.04	-0.02	0.73	0.03	-0.07	-0.07	-0.02	1.22	0.06	0.77	0.03
4. Household income Ref: Poor	-----	-----	-----	-----	0.02	-----	-----	-----	-----	-----	-----	-----	-----	-----
Low	-0.02	0.09	0.00	0.32	0.01	0.08	0.00	-0.04	0.81	0.01	0.62	0.03	0.07	-0.00
Middle	0.04	-0.30	-0.02	0.06	0.01	-0.70	-0.04	**-0.16**	**2.44****	**0.07**	**1.54***	**0.07**	0.80	0.02
High	-0.01	0.15	0.01	0.11	-0.09	-0.08	-0.01	**-0.25**	**4.03*****	**0.18**	**1.62***	**0.05**	1.02	0.01
5. Cars per household (Nos.)	**0.20**	**-1.40*****	**-0.08**	**-1.73*****	**0.00**	**-1.02*****	**-0.03**	**0.23**	**-2.30*****	**-0.08**	**-1.45*****	**-0.06**	**-2.03*****	**-0.10**
6. Children below ten years (Nos.)	0.02	-0.18	-0.01	0.02	-0.01	-0.21	-0.01	-0.03	-0.32	-0.03	-0.42	-0.04	**1.29****	**0.09**
7. Settlement type: Ref: Large cities	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Semi urban	0.04	-0.29	-0.02	-0.28	-0.01	-0.23	-0.01	0.08	-1.27	-0.06	-0.74	-0.04	-0.06	0.02
High dens. rural	-0.05	0.82	0.08	-0.07	-0.01	-0.18	-0.02	0.05	-1.03	-0.06	-0.16	-0.00	0.01	0.01
Low dens. rural	-0.07	-0.22	-0.03	0.96	0.07	0.55	0.03	0.05	-2.82	-0.10	0.04	0.02	0.27	0.04
8. Respondent's com. distance (km) Ref: < 10km	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10-25km	0.04	**1.00****	**0.09**	**-1.48*****	**-0.10**	-0.62	-0.03	**0.13**	0.68	0.06	**-2.61*****	**-0.14**	**-0.97***	**-0.05**
>25km	**0.09**	0.71	0.07	**-3.34*****	**-0.14**	-0.66	-0.03	**0.15**	0.65	0.07	**-2.88****	**-0.14**	**-1.48***	**-0.07**
9. Apartment area (sqm)	0.01	-0.08	-0.01	-0.05	-0.00	0.01	0.00	**0.01**	**-0.23***	**-0.01**	-0.05	-0.00	-0.09	-0.00
10. Respondent's time spent in paid job (h/day)	0.00	0.04	0.00	-0.09	-0.01	0.01	0.00	**-0.03**	0.22	0.01	**0.26***	**0.01**	0.19	0.01
11. Respondent's work schedules: Ref: Fixed time	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Flexi-time	-0.07	**0.87***	**-0.06**	-0.07	-0.02	0.58	0.02	-0.05	0.82	0.04	-0.48	-0.05	**0.93***	**0.06**
Free	0.05	-0.68	-0.03	**-0.97***	**-0.06**	0.53	0.04	0.03	-0.87	-0.03	-0.24	-0.01	0.10	0.01
12. Respondent's shopping incl.travel (h/day)	0.06	**-0.91****	**-0.06**	-0.02	0.01	-0.19	-0.00	0.01	-0.01	0.00	-0.24	-0.02	0.13	0.01
13. Respondent's childcare incl.travel (h/day)	-0.01	0.11	0.01	0.30	0.02	-0.20	-0.02	0.02	0.04	0.01	-0.26	-0.02	-0.11	-0.01
14. Respondent's errands incl.travel (h/day)	0.01	-0.04	-0.00	0.08	0.01	-0.36	-0.02	**-0.05**	**0.68***	**0.03**	0.26	0.01	**0.48****	**0.02**
15. Partner's com. distance (km)	0.04	-0.08	0.00	-0.96	-0.06	0.16	0.02	-0.06	-1.18	-0.08	0.32	0.01	**1.72***	**0.12**
16. Partner's shopping incl.travel (h/day)	-0.04	**0.38***	**0.02**	0.11	0.00	0.21	0.01	-0.03	-0.07	-0.01	**0.55***	**0.04**	0.16	0.01
17. Partner's childcare incl.travel (h/day)	0.00	0.11	0.01	**-0.28***	**-0.02**	0.08	0.01	-0.01	0.55	0.03	-0.21	-0.02	0.09	0.01
18. Partner's errands activities incl.travel (h/day)	-0.01	0.20	0.01	-0.15	-0.01	0.13	0.01	-0.01	0.05	0.00	0.25	0.02	-0.18	-0.02
19. Preference for working hours: Ref: Traditional	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Egalitarian	0.01	-0.36	-0.03	0.24	0.02	0.09	0.01	-0.03	0.35	0.01	-0.84	-0.07	**1.18****	**0.08**
Reverse	0.01	-0.30	-0.02	0.34	0.03	-0.22	-0.01	-0.09	1.08	0.04	0.12	-0.01	**1.14***	**0.06**
Constant		-1.54		0.42		**-2.50***			-0.10		**-4.82***		-3.81	
Goodness of fit measures		**Full model**		**Null model**					**Full model**		**Null model**			
Log likelihood		-1196.98		-1584.91					-562.46		-838.55			
McFadden's pseudo R^2		0.25							0.33					
Cragg & Uhler's R^2		0.42							0.52					
AIC		2573.96		3348.81					1320.25		1809.80			
BIC		3071.61		3365.52					1761.68		1824.64			

Table 4: Estimated coefficients for partnered/cohabiting respondents (with young children) – Comparison with car

Reference category: Car; Values in bold are significant: * p<.05; ** p<.01; *** p<.001; aBIC(null) – BIC(full) > 0 indicates that the full model is better than the null model; ni – not included.

ly associated with men's commuting by bicycle, and women's cycling and public transport usage. Additionally, the highest household income quartile has a negative marginal effect on driving for both men and women. Undoubtedly, having cars significantly increases the probability of commuting by car for both men and women.

Most of the spatio-temporal variables are significantly associated with work trip modes for both men and women. Compared to large cities, semi-urban or rural settlements positively predict commuting by car for both men and women. In particular, the rural settlement compared to large cities predicts a decrease in both men's and women's public transport usage and women's commuting by bicycle.

Longer commuting increases the probability of commuting by car and public transport but decreases the probability of commuting by bicycle and walking for both men and women. Compared to short-distance commuting, women with medium (10-25km) or long-distance commuting (>25km) are more likely to commute by public transport (also for men). Besides, the magnitude of long-distance commuting by car is slightly larger for men, producing a marginal effect of 14 percentage points (versus 7 percentage points for women). Increase in apartment area significantly decreases men's cycling and women's public transport usage.

Concerning the temporal fixity attributes, the time spent on paid work is significantly negatively associated with men's cycling. Men and women with flexi-time work schedules are more likely to commute by public transport and are less likely to drive. In contrast, men with free work schedules are less likely to commute by public transport and bicycle and are more likely to drive.

Respondent's time spent on unpaid activities and time spent on shopping (both travel and activity) has a significant negative association with both men's and women's public transport usage. Also, the time spent on childcare (both escort and activity) is negatively associated with public transport usage, cycling and walking, but only significant for men. Household errands remain insignificant for both men and women. In addition, both shopping and childcare increase the likelihood of driving for both men and women.

In terms of partner variables, partner's time spent on shopping increases the probability of using public transport for men. The partner's time spent on child escort significantly increases the likelihood of men's public transport usage and walking. Besides, the partner's time spent on unpaid activities decreases the probability of both men's and women's driving. Partner's time spent on household errands has no considerable effect on either men's or women's mode choice.

Regarding working hours preferences, men with a preference for equal working hours to their partners (i.e. egalitarian work roles) have a strong positive association with cycling with the marginal effect of 7 percentage points. For women, this remains non-significant.

Between men and women with young children

Here, we describe the significant association between predictor variables and mode choice of men and women with young children (see Table 4 for Model 3 and Model 4); these are quite different from previous sections (Table 3 - Model 1 and Model 2).

Certain economic attributes are more significant for men and women with young children than for those without. For instance, with an increase in income level, both men and women are less likely to commute by public transport or walking. Also, increase in the level of education has a positive and statistically significant association with men's cycling and walking, and women's cycling. Besides, education has relatively large and negative marginal effects on both men's and women's driving (23 pp and 12 pp respectively). This suggests that highly educated parents are aware about the negative effects of car use. With reference to economic type, we find that the likelihood

of men's public transport usage is higher with non-market sectors than with industry, but for women this remains insignificant.

Some of the household attributes are more significant for women than for men. For instance, an increase in household income significantly increases the probability of women's public transport usage. Moreover, an increase in the number of young children is significantly positive for women's walking, with an average predicted increase of 9 percentage points. This indicates that maternal responsibilities (e.g. escort to school) influence women's walking. In contrast, an increasing number of cars tends to strongly predict women's (also men's) driving, with a larger marginal effect (by 23 pp and 20 pp respectively) than in the previous models (by 14 pp and 11 pp respectively). Perhaps this suggests that young mothers in multicar households drive to juggle various activities and responsibilities.

Unlike previous models, settlement type is not significant for either men or women. Both medium and long-distance commuting are significantly positive on men's public transport usage and are significantly negative on their (also women's) cycling and walking. Increase in working hours increases the likelihood of women's cycling but is not significant for men. Flexi-time or free work schedules are significant for men, and the direction is quite similar to previous models, while for women they remain insignificant, unlike previous models.

Of unpaid variables, time spent on shopping negatively predicts men's public transport usage, but other variables remain insignificant. The partner effect predicts both men's and women's mode choices much better than previous models. For instance, the coefficients of partner's shopping positively predict men's public transport usage and women's cycling. Also, partner's commute distance increases the probability of women's walking, but partner's time spent on household errands reduces the probability of their walking. This supports the notion that partners' sharing of unpaid care work allows the respondents to drive less and use other travel modes.

Regarding working hours preferences, women with egalitarian (also reverse) working hours preferences are more likely to walk than those with traditional role attitudes.

Summary of the findings

Our findings concerning personal socioeconomic status partly support hypothesis (1) and are highly significant for respondents (both men and women) with young children. Personal income positively influences both men's and women's driving compared to other modes (in line with H1), whereas education level has a large and negative marginal effect on their driving (contrary to H1). For respondents without young children, working in the market/non-market sector has a significant negative relationship with the choice of driving over other modes for both men and women (contrary to H1).

In contrast to personal income, increase in household income significantly increases the probability of women's public transport usage for both the groups (with and without young children). Least surprisingly, possessing cars strongly increases the likelihood of commuting by car for both men and women in both groups (in line with H2). An increase in the number of young children is significantly positive for women's walking (contrary to H2).

The spatial attributes determine the mode choice better for respondents without young children than for those with. For instance, living in semi-urban or rural districts compared to large cities is negatively associated with public transport usage for both men and women (in line with H3). Conversely, a longer commute compared to shorter commute distance is positively associated with public transport use for both men and women (in line with H4).

In terms of temporal attributes, the gender dimension is observed slightly between men without young children and women with young children. For instance, longer working hours are positively associated with women's commuting by bicycle (contrary to H5) but have a negative relationship with men's commuting by bicycle in contrast to car driving.

The time spent on flexible unpaid work like shopping (in line with H6) and childcare tends to increase men's (without young children) driving and reduces public transport usage. The time spent on household errands increases women's (with young children) public transport usage and walking (contrary to H7). For both the groups, working in flexi-time work schedules means both men and women are more likely to commute by public transport (and also walking), whereas free work schedules means they are less likely to commute by public transport.

The findings concerning the effects of partner interaction on male respondents suggest that the partner's sharing of unpaid work, to some extent, reduces men's driving (also women's), especially for those without young children. For instance, the time spent on partner's shopping and childcare positively influences both men's and women's public transport usage (in line with H8). Other temporal attributes, such as the partner's commute distance and partner's time spent on household errands, are significant for women with young children. The increase in partner's commute distance increases the probability of women's walking, while the increase in partner's time spent on household errands reduces the possibility of their walking.

Male partners with preferences for working hours equal to their partners are significantly more prone to commuting by bicycle than those with traditional attitudes (in line with H9), and the egalitarian and reverse working hours preferences increase the likelihood of women walking.

5 Conclusion and discussion

This study explored the possible gender differences in the work-trip mode choice decisions of men and women across four groups (with and without young children). Initial descriptive analysis showed the significant gender gap between men and women in economic, work and non-work related factors, and demonstrated how the presence of young children additionally widens the gender gap in economic and work attributes between men and women.

Comparison between the two groups (with and without young children) and the results of the multinomial logit analysis revealed that the estimated coefficients of the factors associated with work-trip mode choice are more similar than different between men and women. Moreover, we found no striking differences in directions of coefficients between the groups except for the level of significance. For instance, personal socioeconomic status, household attributes, partner variables and working hours preferences strongly influence the work-trip mode choice of partnered respondents with young children. For respondents without young children, besides a few other variables, the spatial and temporal fixity attributes strongly influence the mode choice of men and women. Based on the summary of the findings, we draw five main conclusions.

- First, we conclude that an increase in personal income increases the probability of both men and women driving, whereas an increase in the level of education and working in market or non-market economic sectors strongly predicts public transport usage for work trips. The positive correlation between income and car usage has been well documented in much of the transport literature (O'Fallon et al., 2004; Buehler and Pucher, 2012; Böcker et al., 2017). The negative correlation between education and car use has been previously acknowledged in the literature (Beckmann et al., 2006; Scheiner, 2006; Scheiner and Holz-Rau, 2012a). In line with Heinen et al. (2013), men (with or without young children) working in non-market sectors are more likely to exhibit high levels of commuting by bicycle.

- Second, except for car availability, other household attributes predict a decrease in driving. Having a higher household income positively predicts women's public transport usage and walking, which is in contrast to the findings of Dargay and Hanly (2007). Moreover, having young children decreases women's driving, in line with Polk (2004), and increases walking, which could be linked to the proximity of workplace and childcare facilities.
- Third, living in a rural settlement and having a free work schedule increase both men's and women's driving. In semi-urban or rural type settlements, reduced access to public transport supply increases the probability of commuting by car, whereas in large urban areas the difficulties and costs associated with car use probably reduce the likelihood of driving, which is in line with the findings of Pucher and Buehler (2008) and Zolnik (2011). Other spatio-temporal fixity variables such as longer commutes and flexible work schedules positively predict public transport usage for both men and women. This is because flexible working hours may enable car commuters to switch to public transport as they can adjust their working patterns to suit the schedules. This could encourage transport planning authorities to develop sustainable travel patterns allowing juggling between homework, childcare and workplace.
- Fourth, the effects of individual constraints versus partner constraints on mode usage are an important finding of this study. Individuals, men in particular, increase driving for commuting if they combine it with shopping or childcare, which is line with the findings of Schwanen (2004). At the same time, they increase public transport usage (or decrease driving) if their partners spend time on unpaid work.
- Fifth, men with egalitarian attitudes are more likely to commute by bicycle. Similarly, women with egalitarian/reverse attitudes for working hours preferences are more likely to walk. This suggests that men/women who prefer to work as much as their partners and believe in equal values, roles and opportunities tend to reduce driving and use sustainable modes.

Overall, the results reflect that a variety of factors influence both men and women in their commute mode choice. Only personal income and car availability increase men's and women's driving, while other personal economic and household attributes are positively associated with public transport usage. Spatial and temporal characteristics positively influence men's (women's) driving, and some variables like long commuting and flexible work schedules increase their public transport usage. For men without young children and women with young children, interpersonal interaction between partners and egalitarian working hours preferences positively influence the use of sustainable modes.

The study contributes to gender studies in transport research by including factors such as time spent on in-home activities, personal income information, partner interaction and preferences/ attitudes towards working hours in mode choice analysis. While the data used in this study have provided an excellent opportunity to analyse the work trip mode choice, our data cannot provide all the pieces necessary to understand the mode choice behaviour of men and women in a geographical context. It is essential to bear in mind that the data do not include information on geocodes or postal codes of residences or workplaces, proximity to public transport bus stations or preferences of mode usage. Due to these limitations, it is not possible to understand why an individual chooses particular modes instead of other modes. For instance, an individual's choice of driving for long commutes can also be expected to be preceded by other attributes, influenced by proximity to bus stations, lack of connectivity, or preferences over other modes.

The paper suggests various directions for future research. Firstly, with more time spent on unpaid work, women occupy more complex activity spaces (shopping, errands, childcare) than men. This is because the gender difference does not primarily lie in the number of different activities but in the distribution of time spent on different activities, as pointed out by Scheiner (2014). This

necessitates measuring the complexity of activity patterns for various groups of men and women. Secondly, consideration of the interpersonal interaction between partners could be extended to analyse the mode choice behaviour of leisure and non-work trips, which could widen the target groups to include the unemployed, househusbands (housewives), students and older people. Lastly, individual versus partner travel preferences on commute mode choice could be analysed to extend existing literature on travel well-being towards taking intra-household dimensions into account.

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