Urban mobility with a focus on gender: the case of a middle-income Latin American city

Cecilia Olivieri[1] & Xavier Fageda[2]

Abstract: This study analyzes gender differences in travel patterns for the Metropolitan Area of Montevideo, Uruguay. By applying multilevel regression models, it provides estimates of the impact of individual and contextual factors on travel behavior. The paper's findings lend support to the household responsibility hypothesis, which claims that women's travel patterns are affected by the type of household in which they live and the consequent responsibilities or roles they assume. Furthermore, gender differences in travel patterns are reinforced across census tracts. The results indicate that policy makers need to consider gender differences when seeking to enhance urban planning decisions.

Keywords: Urban mobility, Travel behavior, Built environment, Gender, Household responsibility hypothesis

[1] Universidad de la República, Uruguay

[2] University of Barcelona, Spain

1. Introduction

People's commuting patterns are influenced and limited both by their personal characteristics and factors related to place of residence (Hanson, 1982; Hanson & Johnston, 1985). These elements can operate in different ways depending on gender and the type of household in which the individual lives (Silveira Neto et al., 2015).

In this regard, several studies claim that gender differences in travel behavior arise from differences in the way women and men participate in household- related activities. The household responsibility hypothesis (Johnston-Anumonwo, 1992) relies on the notion that women – owing perhaps to perceptions of values and roles – tend to take greater responsibility for childcare and household chores than men. Furthermore, women have to reconcile these activities with paid work. As space and time are constrained, competing demands for time result in a reduction of women's mobility (Crane, 2007).

While there is a broad consensus that women's travel patterns are different from men's, explanations as to how the household responsibility operates vary in the literature. Indeed, there is no consensual understanding of the influence of the presence of children or the marital status and partner's employment.

Dimensions of travel behavior that has been examined in previous literature include the distance and time spend on trips, number of daily trips and gender differences in car use. It is generally accepted a higher number of trips for those individuals who make multiple-purpose daily trips including commute to work, home and care duties. On the other hand, findings about gender differences on car use are not conclusive.

This paper seeks to illustrate the factors that influence travel patterns in the Metropolitan Area of Montevideo (MAM), with a specific focus on social gender roles and relations. Accounting for the interactions between the individual and their zone of residence, it specifically analyzes whether there are differences between male and female travel patterns that can be linked to the household responsibility hypothesis. Our results show the importance of family structure in accounting for gender differences in commuting patterns. Specifically, the interaction between the presence of a partner and the presence of children in the household appear to be key factors in accounting for these differences, pointing to the validity of the household responsibility hypothesis.

The methodology we adopt is based on multilevel regression models to provide accurate estimates of both individual and contextual effects on travel behavior. Its adoption allows us to contribute to the extant literature by providing a link between research on commuting gender differentials and research on the impacts of neighborhood environment on travel behavior.

Most studies of urban mobility have been undertaken in developed countries and, so, there is little evidence on this subject for the middle-income economies. This study seeks to fill this gap by conducting a case study of Montevideo, the capital city of Uruguay. Interestingly, while the sociodemographic characteristics of Montevideo are similar to those of developed countries, its transport infrastructure and the characteristics of its built environment are more similar to those of a city in the developing world.[3]

Furthermore, the study undertakes a joint consideration of the various attributes or dimensions of urban mobility, including trip time, trip distance, mode choice and trip count. In contrast, most previous studies have focused on just one specific aspect of urban mobility. Third, the study analyzes in detail the interaction between gender, family organization and contextual factors while the previous literature has tended to focus on just one of these aspects in isolation.

The remainder of this study proceeds as follows. Section 2 provides a detailed description of the literature. Section 3 describes the variables included in the analysis and their data sources. Section 4 presents the empirical specification of the models and the econometric approach. Section 5 reports the results and section 6 discusses the main conclusions and policy implications.

[3] Uruguayan women have on average 10.2 years of schooling and their participation rate is 67%, whereas the Latin American averages are, respectively, 8.7 years and 55% (ECLAC, 2016; World Bank, 2016). Moreover, as the ageing process is more advanced in Uruguay, there is a relatively high incidence of one person households (mostly elderly) as well as couples without children. In contrast, average annual investment in the road subsector in Latin America was 0.7% in 2008-2015, while road investment in Uruguay was just 0.4% of GDP (OECD, 2016). In this same period, dividing annual road investment by a country's total population yields an average for Latin America of US$ 64 per capita (at 2010 constant prices); in the case of Uruguay, this figure fell below US$ 50 per capita

2. Literature review

Empirical papers have sought to provide evidence in support of the household responsibility hypothesis by focusing on the time and distance dimensions of travel behavior. As mentioned above, there is a broad consensus that women’s trips are shorter than men’s, but the influence of the household responsibility differ depending on the context and period analyzed.

For United States, evidence in favor of the household responsibility hypothesis is mixed. Some early studies do not find evidence that gender differences in travel time and distance can be explained by the household responsibility hypothesis (Gordon et al., 1989, Hanson & Johnston, 1985).

In contrast, Johnston-Anumonwo (1992) finds that traditional gender roles are only important in understanding women’s shorter trips in the case of married women where both they and their partners work. Results in Crane (2007) suggest that married women have shorter trips than single women although the presence of children has a smaller influence. Finally, Fan (2017) shows that gender differences in work travel do not react solely to partner presence or parenthood but also to household structures in which partner presence interacts with parenthood.

Out of United States, Lee & McDonald (2003) analyze the case of Seoul. They find that while the presence of children negatively affects women’s travel time, the presence of parents or parents-in-law in the household reduces women’s household responsibilities and increases women’s commuting substantially. Furthermore, they show that being married negatively affects women’s travel time regardless of whether the spouse works or not. Silveira Neto et al. (2015) test the household responsibility hypothesis in the São Paulo Metropolitan Region, Brazil. The results suggest that marital status exerts a strong influence on the commuting time of working women, while the presence of dependents (children and elderly) has a smaller influence. Additionally, gender differences are observed for single and formerly married working females, which suggest other cultural or environmental factors not fully captured by the household responsibility hypothesis.

The number of daily trips has also been studied as a relevant dimension of travel behavior (Best & Lanzendorf, 2005 for Cologne, Germany; Hanson, 1982 for Uppsala, Sweden; Kim & Wang, 2015 for Hamilton county-Ohio, US, Prevedouros & Schofer, 1991 for Chicago, US) on the assumption that it will highlight differences related to typical gender roles and the presence of children in the household. Individuals reporting fewest trips are usually those who make single-purpose daily trips, such as the commute to work. In contrast, a greater number of trips are reported by those who perform other types of activities, such as home and care duties.

Several quantitative studies have identified significant gender differences in car use as well. The more infrequent use of cars and the more frequent use of slower modes of transport by women have been associated with women’s time poverty (Turner &

Grieco, 2000). However, findings about gender differences on car use are not conclusive either. For example, Gordon et al. (1989) find for US that women have shorter worktrips than men regardless of mode of travel, while that the analysis of Best & Lanzendorf (2005) for Cologne (Germany) suggests that parenthood reduces the car use by women but labor participation intensifies car use for both genders.

The evidence suggests that men had the first choice in households, but the increasing availability of licenses and cars during the 1990s have led to a convergence over time (Beckmann et al., 2006 for Germany; Crane, 2007 for the US; Frändberg & Vilhelmson, 2011 for Sweden; Hjorthol, 2008 for Norway; Noble, 2005 for the UK). However, some differences still remain (see for example, Scheiner & Holz-Rau, 2012 for Germany).

In the analysis of gender differences in urban mobility patterns, the attributes of the built environment are recognized as being important contributors to household activity-travel decisions (see Ewing & Cervero, 2010 for an in-depth review).[4] The built environment can be described in terms of various dimensions: density, diversity, design and destination accessibility (eg; Cervero, 2013; Sun et al., 2017; Kim & Wang, 2015; Zahabi et al., 2015). While it is generally recognized the importance of the contextual environment, very few studies consider the interactions between individual and

[4] It is worth stressing that the concepts of the built environment, urban form and neighborhood environment characteristics are used interchangeably in the literature.

neighborhood factors. A number of more recent analyses, however, show the effectiveness of incorporating multi-level models so as to control for level interactions (Bottai et al., 2006; Silveira Neto et al., 2007; Mercado & Paez; 2009; Antipova et al., 2011; Ding et al., 2014; Ding et al., 2017; Sun et al., 2017).

The interactions between the built environment and travel patterns have been little explored in middle-income economies (Sun et al., 2017, in an analysis for Shanghai, China, is an obvious exception). Clearly, the characteristics of urban areas and the built environment differ according to a city's level of development. Indeed, in many middle-income countries, the scope for catching up in terms of their urban planning is broad and constitutes something of a challenge in the medium and long terms. In this process, smaller cities, which find themselves in the 'growth' stage, can obtain huge benefits from the effective coordination of transport and urban development. For instance, built environments can be expected to have a stronger influence on travel decisions in such contexts (Cervero, 2013).

Overall, empirical evidence on how it works the household responsibility hypothesis in the different dimensions of trips (travel time and distance, number of trips and mode choice) is scarce for middle-income countries. In this study, we examine the interaction between gender, family organization and contextual factors in those dimensions of trips using data for Uruguay, a mid-size city from a middle-income country.

3. Data sources and variable specification

This study focuses on the Metropolitan Area of Montevideo which comprises the entire *departmento* of Montevideo and parts of the border *departmentos* of San José and Canelones (see Figure 1).

Figure 1. Census tracts of the Metropolitan Area of Montevideo.

Source: Own elaboration

The main data source is the household mobility survey for the MAM (*Encuesta de movilidad del Área Metropolitana de Montevideo*) carried out in 2016. The purpose of the survey is to record information about all the daily trips made by each individual in every sampled household. In addition, it records the household's income and socioeconomic information about the individual members over the age of three.

The survey includes a total of 535 census tracts for the MAM. The overall sample comprises 2,230 households (that expands to 655,558), 5,946 individuals (1,806,989) and 12,546 trips (4,201,184). Some observations were eliminated in order to ensure that every census tract incorporated had at least 5 individuals[5].

[5] We apply the same criterion that has been used in the cited literature. However, the minimum of 5 observations per census tract may induce a weakness in the statistical sampling process. As a robustness check, we use an alternative census delimitation in which the total number of areas is 41 (see Annex).

Secondary sources of data used included the 2011 National Census and the Montevideo Municipality Open Data catalogue, which provide information about population density, aggregate educational attainment, number of bus stops and land use categories for calculating a land use mixture index, all of them referenced by census tract.

The last national census, conducted in 2011, recorded a total population of 3.3 million people, of whom around 1.9 million resided in the MAM, with 1.3 million residents in the capital. The population of the MAM is widely unevenly distributed over its territory. The areas with the highest population density are those closer to the center of the capital city and along the coastline on the Río de la Plata. These are also medium-high income segments; the lower-income population is located further from the coast and the city center, in sparsely populated areas. The small portion of rural population living in the MAM (4%) is also located on the periphery (see Figure 2).

Figure 2. Population density in the Metropolitan Area of Montevideo's census tracts.

Source: Own elaboration

The MAM public transport network is based primarily on bus services, provided by private companies but regulated by the government (about 1 million trips a day in 2016). This urban transport system comprises about 1500 buses, 4718 stops and 3 exchange stations. It is organized around 145 lines that include several variants in both directions and of shorter coverage. The total number of bus lines, when each variant is considered separately, rises to 1383 (Massobrio, 2018). In addition, there are three railroad lines operated by the state railways administration which connect Montevideo primarily with other regions in the country, but demand is marginal (fewer than 1000 passengers a day in 2016).

A key feature of Montevideo's bus network is that the city center acts as a hub with most of the lines converging on that area. In fact, the density of bus stops is greatest in the city center, with more than one bus stop per block along some of the main avenues. Moreover, the average length of the bus lines (16.7 km with a standard deviation of 7.1) is high with respect to the area of the city (the densest urban area in Montevideo occupies only about 100 km2 of its total area).

According to data from the 2016 mobility survey of the Metropolitan Area of Montevideo, on average, each household in the study area has 0.53 automobiles, 0.17 motorcycles and 0.64 bicycles. Of the total trips reported, the participation of the private car is relatively high (32.2% either as a driver or as a passenger) compared to 25.2% of journeys made by bus. The survey data shows that travel time by bus is double that of travel time by private car. The percentage of trips on foot is also high (33.5%) but this probably reflects the fact that it is not filtered by type of mobility, for example, short trips. Among the less frequent trips are those on motorcycle (4.2%) and on bicycle (2.6%), this is not surprising given that the priority of cyclists on the total extension of the roads is 0.5% (a total extension of 10 km of cycle paths). In 2015, as a pilot, the Municipality installed a public bicycle system covering a small part of the city center. The system is called “Movete” and has 8 stations for the provision of the service. Although the high rate of motorization may have an impact in terms of traffic congestion, there are no local statistics and no data for Montevideo in TomTom or Inrix, which are the two main sources at the international level for congestion statistics.

Dependent variables

We focus on four dimensions of trip behavior: 1) *Trip time* is measured as the average overall travel time spent by an individual on trips made with a frequency greater than 1 or 2 days a week; 2) *Trip distance* is measured as an individual’s average travel distance (trips made with a frequency greater than 1 or 2 days a week); 3) *Mode choice* is a binomial logit variable (1: automobile; 0: bus, walk, bicycle or combined) and 4) *Trip count* is the sum of the number of trips that are made with a frequency greater than 1 or 2 days a week. The descriptive statistics of the dependent variables differentiated by type of household are shown in Table 1.

Explanatory variables

Table 2 outlines the explanatory variables used in the analysis, which are nested in two levels: that is, the individual and census tract levels. The individual attributes included in the study are gender, age, income (included in the survey as a socioeconomic index), employment status, purpose of the trip and household type. We attempted to include other characteristics of an individual's economic activity but they were found to distort the model's fit.

As the specific focus of our study is to capture gender differences, we classified households on the basis of the employment status of their members and the presence of children below the age of 15. The "Male breadwinner" category includes households (with or without children) in which only men work; around 25% of individuals live in this type of household. The "Female breadwinner" category includes households in which only women work; around 18.7% of individuals live in this type of household. The "Dual earner" type corresponds to households in which both men and women work. This category is the most frequent, accounting for 36.8% of individuals. Households without workers are classified as "Non-employed" and account for 19.7% of the sample. In line with previous studies, mobility is associated with the working population and it is reflected in the lower mobility of the non-employed households, which present greater differences in their mobility patterns in relation to those of the other categories.

The study includes the following census tract level attributes: population density, the percentage of people educated to *baccalaureate* or higher level (as a proxy of the socioeconomic level of the area), the total number of bus stops (as an indicator of accessibility) and an entropy measure representing the evenness of distribution of several land use types.

4. Methodology

We use multilevel regression models as proposed in geographical research to provide accurate estimates of the effects of individual and contextual factors on travel behavior (eg; Kim & Wang, 2015; Duncan & Jones, 2000; Paez & Scott, 2004; Mercado & Paez, 2009). The primary motive for using multilevel models is to be able to take into account the hierarchical structure of the data, in order to model their spatial heterogeneity.

In this context, we assume that individuals within a zone of residence (census tract) have certain characteristics in common and that these attributes differ from those residents in other zones. Thus the data are nested, that is, individuals (level 1) are grouped into zones (level 2).

In modes of this type the analysis is carried out in stages (Raudenbush & Bryk, 2002; Rabe-Hesketh & Skrondal, 2012). In the first stage, we estimate a null or "empty" model, with no explanatory variables included. We then gradually incorporate the different explanatory variables. In a second stage, we include the level-1 variables and, finally, incorporate the level-2 variables. The models detailed above are known as "random intercept" models because only the intercept has a random component.

Several indicators can be employed to evaluate and compare multilevel models. The most widely used are the intraclass correlation coefficient, which determines the proportion of the total variability that is attributable to differences between zones and the likelihood-ratio test, which compares the log-likelihoods of the models with and without the random components.

5. Results

In this section we present the outcomes of our application of multilevel models to the analysis of urban mobility in the MAM. The table below shows the estimated coefficients of each dependent variable. All the specifications include a random intercept across census tracts. To compare the models, we present the intraclass correlation coefficient (ICC) and the likelihood-ratio test (-2LL) results. For the goodness of fit, we present the typical statistics (AIC and BIC).

Multilevel regression analysis for trip time

Table 3 shows the estimated results of the multilevel regression analysis for trip time (column I). Each model was estimated using the maximum likelihood method. The specification includes the individual-level and the contextual variables described above.

The estimation results indicate that, on average, commuting time is differentiated by gender. The variable *Female* is positive and significant, which means that women's travel times are longer than men's, given the same individual characteristics. Below, we show that this result can be explained by the fact that men make more frequent use of faster modes of transport.

The model's specification also incorporates eight dummy variables that distinguish four types of family organization, each broken down between "with children" and "without children" categories. Table 3 reports the estimated coefficients of *Household type* corresponding to the "Dual earner without children" category. It can be seen that, on average, households with children present shorter travel times. A comparison of the four main types of family organization shows that the presence of children reduces the travel time in all categories. However, the effect is stronger for the female breadwinner type; moreover, it maintains the significant effect when controlling for the mode of transport in the alternative model.

Households with children are particularly relevant for understanding gender inequalities in mobility patterns. To refine our analysis, we examine the interaction between the variables *Female* and *Household type*. A comparison of the four main household categories indicates that the presence of children significantly reduces women's travel time in all household types, with the exception of the non-employed. The changes in men's trip times are not significant. This pattern is considered as being evidence in support of the household responsibility hypothesis (Fan, 2017; Lee & McDonald, 2003; Silveira Neto et al., 2015) and may indicate that women in such households take on additional family responsibilities that foster relocation strategies that seek a greater proximity between work and home.

Figure 3 (square a) shows the expected gender difference (contrast of prediction if *Female* equals 1 minus prediction if *Female* equals 0) in trip time by household type. The gray bar shows the *Model* estimation and a straight line indicates the 95% confidence interval. In this figure, only the male breadwinner with children type presents a negative and significant difference in travel time. In other words, women's trip times are shorter than male's when they live in households with children and in which only men work. Male breadwinner types are represented primarily by the traditional family of a working man and a woman who does not go out to work (82%), which contrasts with the female breadwinner types composed primarily by single mothers (55%). This distribution of household types is evidence of the continuing existence of traditional gender roles in Uruguayan society.

In contrast, dual earner without children households present a positive and significant difference in travel time. This result can be attributed to the use of different transport modes by women and men from the same household (women traveling on public transport and men in their own vehicles).

Figure 3. Differences between women and men (prediction of Female - prediction of Male), by household type.

Source: Authors' estimations based on Encuesta de Movilidad del Área Metropolitana de Montevideo, 2016. Note: Contrast of predictive margins, the straight line indicates the 95% confidence interval

According to the estimates, of the contextual factors only *Transportation accessibility* cannot explain the significant zone-level variation. In general, most of the areas with high population density and high land-use diversity are close to jobs, shopping centers and educational establishments, which cuts trip times. Thus, women's options in terms of access to public transport are likely to be poorer when they live away from the city center; this aspect of social inequality leaves them especially vulnerable. Moreover, the educational attainment of residents in an area is highly correlated with their socioeconomic status. The negative coefficient presented by the variable *Baccalaureate or higher level* is not in line with the literature, since in general the richest people make longer commutes from residential areas to the city center. However, the results do reflect the polycentric urban-territorial structure described above. In this same region, Silveira Neto et al. (2015) evidence the same pattern for Brazilian cities, in this case due to centralization of income.

Multilevel regression analysis for trip distance

Table 3 (column II) shows the estimated results of the multilevel regression analysis for trip distance. The variable *Female* presents a negative and significant sign. Thus, in line with previous research and unlike trip time, women on average travel less distance than men.

The table also reports the estimated coefficients of *Household type* relative to the "Dual earner without children" category. The presence of children only significantly reduces travel distance in the female breadwinner category. Given that the presence of children reduces travel times in all household types but does not reduce travel distance, it could be argued that the strategy of households is based, at least in part, on a shift towards faster means of transport. The exceptions are the female breadwinner households.

If we examine gender roles in each category (that is, by analyzing the interaction between the *Female* and *Household type* variables), in the presence of children, the women in female breadwinner households reduce their trip distance while men in male breadwinner households increase this distance. As the household responsibility hypothesis argues, in households with children, the gender difference in trip distance is sensitive to spouse/partner presence. In households where the woman does not work, the presence of children increases the distance travelled by the man. In contrast, in households with a single female breadwinner, the presence of children could lead to a relocation of the residence or workplace towards zones of greater proximity to that household's daily activities.

Figure 3 (square b) shows the expected gender difference (contrast of prediction if *Female* equals 1 minus prediction if *Female* equals 0) in trip distance by household type. The figure shows that women travel shorter distances in the male breadwinner with children and dual earner with children households. This evidence reinforces the argument presented above that females in dual earner with children households seem to prefer working nearer to home or opt for part-time jobs.

In the case of the level-1 control variables, years of education, job type and trip purpose are significant factors in explaining travel distance on weekdays. The signs of these impacts, moreover, are as expected.

At the zone level, transport accessibility, population density and land-use seem to impact on the distance travelled by MAM residents. The level-2 results show that individuals residing in the most densely populated zones, with the greatest public transport accessibility and land-use diversity, travel shorter distances. This evidence is consistent with findings in the literature related to travel distance (eg; Kim & Wang, 2015).

Here again, the evidence presented in this section suggests that more densely populated areas with greater accessibility to public transport and greater diversity of land use are associated with shorter trips. Therefore, women's options in terms of access to public transport are likely to be poorer in less central areas, making them especially vulnerable to this aspect of social inequity. Similarly, it is more likely that female breadwinner with children and dual earner with children households are located in more densely populated areas, while male breadwinner with children households are more likely to be located in less central areas, where women's travel distances are shorter and men's are longer.

Multilevel regression analysis for trip count

We assume that the number of trips can be explained by both family structure and gender roles. In general, trips made on weekdays are not solely single-purpose (for example, trips just to undertake household-related activities) but are likely to be multiple-purpose (for example, work, school run, or shopping). If the household responsibility hypothesis holds, women can be expected to complete more multiple-purpose trips.

According to our estimations (Table 3, column III), the variable *Female* presents a negative coefficient which means fewer trips, on average, for women. This outcome runs contrary to expectations but is in line with findings published elsewhere, including Bottai et al. (2006). However, if we consider the presence of children under 8 years old at home and the purpose of the trips made – in particular, those to complete household-related activities – then we can see that they are associated with a greater number of trips. Indeed, small children and trips associated with household-related activities are important in explaining the trip count. Moreover, as expected, the presence of children is related to a significant increase in the number of trips made in the "Dual earner" category.

As for gender roles within each household category, the presence of children is significant in explaining the greater number of trips made by women in all household types. In the case of men, we document a significant increase in the number of trips in the dual earner and non-employed households. Our evidence suggests that in traditional family units only the mobility of women increases in the presence of children, albeit with a reduction in travel time. In contrast, in male breadwinner households the travel distance of men increases but not the number of trips.

Figure 3 (square c) shows the differences (contrast of prediction if *Female* equals 1 minus prediction if *Female* equals 0) in trip count between women and men by household type. Trip frequency is significantly higher for women only in male breadwinner households with children. In contrast, in male breadwinner and dual earner households without children the number of trips is significantly lower for females. This result reinforces our previous findings: that is, women are more likely to present a lower frequency of mobility with the exception of those in “Male breadwinner with children” households. This higher number of trips can probably be attributed to their specific purposes, i.e. an association with activities of care and/or domestic chores.

As shown in Table 3 (column III), transport accessibility and population density are associated with a greater frequency of trips, though the impact is very small. As expected, the most densely populated residential areas with better supplies of public transport enable residents to access a greater diversity of services and activities, which may be associated with a greater number of trips.

Multilevel regression analysis for mode choice

The probability of an individual traveling by car (*Mode choice* equals 1 when automobile and 0 if other means of transport) is estimated using a binomial logit multilevel model. In non-linear multivariate models, such as logit, the impact of the independent variables can be analyzed using alternative measures. We display the estimated coefficients, whose signs allow us to analyze the positive or negative association with the individual's car use, that is, it shows the direction of the change but not its size. In addition, we examine the marginal effects, which show the effect on the probability of traveling by car when changing exogenous variables. Finally, we perform the likelihood-ratio test to compare each model using ordinary logistic regression, and find high statistical significance in all cases.

Table 3 (column IV) reports the fixed effects estimated coefficients and the estimated variance components of the binomial logit multilevel models. According to our results, women are about 25% less likely, on average, than men to travel by car.

Household types also play an important role in determining the individual's mode choice. Controlling for all other variables, the "Male breadwinner with children", "Dual earner with children" and "Female breadwinner with children" households are more likely to use an automobile than their counterparts without children, a finding that is in line with the literature. In the case of "Non-employed with children", the expected difference is not statistically significant, but as discussed above these households present a number of atypical characteristics in relation to the other categories.

When we interact the household type with gender, no differences are found in the behavior of males and females. The presence of children suggests that both women and men are more likely to travel by car, with the exception of non-employed households.

As for gender differences by household type, women present a significantly lower probability of travelling by car in “Male breadwinner”, “Dual earner” and “Female breadwinner” households with and without children and in “Non-employed” households without children (see Figure 3, square d).

As Table 3 (column IV) shows, the likelihood of using a private vehicle increases with age and full-time job. Moreover, and as expected, the probability of traveling by car is significantly and positively related to years of education and socioeconomic status.

Regarding the contextual variables, only the estimated coefficient of the *Population density* variable is statistically significant, indicating that an individual’s mode choice is not so strongly influenced by the attributes of their zone of residence. This result is in line with previous studies; in general, the need of those living in the most densely populated areas to use a car is not so great because of the greater service supply within the same neighborhood.

6. Concluding remarks

Overall, our evidence points to the existence of differences in the commuting patterns of males and females resident in the MAM. However, it is worth to note that these differences, while significant, are not always very pronounced.

On average, women travel shorter distances and make fewer trips. Women’s lower mobility may be associated, among other factors, with the unequal internal distribution of domestic chores within households (corresponding to the household responsibility hypothesis). Women, who traditionally spend more time undertaking domestic work than do men are obliged to adopt a strategy: either they choose to live close to their workplace or, in cases where the residential choice is made jointly with other members of the household, they choose to work closer to home. In either case, however, the outcome is the same: women's mobility is not as great as men's.

Households with children are particularly important for understanding gender inequalities related to mobility patterns. The results show that women in all types of household with children tend to have shorter commute times than those of their counterparts in households without children. Similarly, the presence of children increases the frequency of trips for women in all households, while the probability of travelling by car increases with the presence of children in all household types and for both genders. Meanwhile, men present higher travel distances in male breadwinner households with children.

Besides the presence of children, the presence of a spouse/partner in the household also has an effect on mobility patterns. Our findings indicate that the behavior of women in dual earner households is similar to that of women in male breadwinner households, regardless of the fact that in the former they participate in the labor market. In couple households, the presence of children has a marked effect on the mobility of women, who tend to reduce their travel time by incorporating faster means of transport (increased car use), increase the number of trips by assuming a greater number of tasks associated with care, while maintaining their total travel distance (probably reflecting the net effect of a decrease in distance associated with the relocation of their workplace, compensated by an increase in distance due to their taking on more domestic chores and activities related to care).

In households where the presence of couples is lower and women undertake paid work (i.e. female breadwinner type), the relocation strategy of daily activities takes on considerable relevance insofar as trip and total travel time both fall. This behavior occurs despite the greater use of faster means of transport and an increase in trip frequency.

In the case of expected gender differences within each household type, our results reinforce the above findings: women are less mobile than men above all in couple households with children. We should also stress that the probability of travelling by car is significantly lower for females in all household types.

As for the specific zone of residence, while most of the contextual variables provide a significant explanation of the variation between census tracts, the estimates indicate that the case of Uruguay is very similar to that of developed countries. Socioeconomic issues appear to be more relevant than infrastructure development in explaining gender differences in commuting patterns.

According to our results, women’s options in terms of access to public transport are likely to be poorer in less centrally located areas of residence, an aspect of social inequality to which they are especially vulnerable. Overall, our evidence suggests that women make more intensive use of public transport; thus, in residential areas with less access to public transport, women's mobility in particular will be affected. This finding has obvious implications for public policy, given that the promotion of public transport in less central areas could help reduce the negative consequences of gender inequality.

A limitation of this study is the possible omission of relevant variables in the analysis, which may cause endogeneity in the estimates. There would appear to be broader cultural and environmental factors that lie outside the scope of enquiry of the present study that might help explain commuting patterns, in particular the lower probability of women to travel by car. Finally, the results are obtained through a survey with its own typical biases. Even though it is designed to represent the total population of the MAM, a richer analysis could have been carried out with a larger sample.

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TABLES AND FIGURES

Table 1

Descriptive statistics of dependent variables, all households and household types.

Household type	Trip time	Trip distance	Trip count	Trip mode
All households	29.9	7171.0	2.7	0.3
	(26.4)	(9423.6)	(1.4)	(0.4)
	2943	2904	2943	2937
11 Male breadwinner	29.3	7511.3	2.6	0.3
	(26.7)	(10630.2)	(1.2)	(0.5)
	442	432	442	441
12 Male breadwinner with children	28.0	7157.9	2.9	0.3
	(25.5)	(9520.5)	(1.6)	(0.5)
	303	299	303	303
21 Female breadwinner	35.0	8162.4	2.6	0.2
	(27.8)	(9468.7)	(1.2)	(0.4)
	288	286	288	287
22 Female breadwinner with children	28.6	5905.6	2.9	0.2
	(25.6)	(7783.6)	(1.5)	(0.4)
	250	249	250	250
31 Dual earner	34.1	8645.1	2.6	0.3
	(26.9)	(10201.1)	(1.1)	(0.5)
	566	560	566	564
32 Dual earner with children	32.2	8236.9	2.9	0.4
	(27.7)	(9388.1)	(1.7)	(0.5)
	680	669	680	679
41 None employed	19.4	3084.6	2.4	0.2
	(18.6)	(5868.8)	(1.0)	(0.4)
	348	343	348	347
42 None employed with children	19.3	3406.1	3.1	0.1
	(23.5)	(7138.7)	(1.6)	(0.3)
	66	66	66	66

Source: Own elaboration. Note: descriptive statistics are mean, standard deviation and number of observations.

Table 2

Explanatory variables.

Level	Variable name	Description
Individual	Female	1 for female ; 0 for male
	Age	mean: 43.9; sd: 16.57
	Income (socioeconomic index)	1 Low 2 Medium-low 3 Medium high 4 High
	Years of Education	mean: 10.22; sd: 4.06
	Children up to 7	1 if at least one children up to 7 in the household
	Full-time	1 for full-time employee; 0 for part-time employee, unemployed or inactive
	Household type	11 Male breadwinner 12 Male breadwinner with children 21 Female breadwinner 22 Female breadwinner with children 31 Dual earner 32 Dual earner with children 41 None employed 42 None employed with children
	Purpose of the trip	1 Return to home 2 Work 3 Study 4 Household related activities 5 Leisure
Zone	Population density	Population per square kilometer (in hundreds)
	Baccalaureate above percent	Percentage of adults (> 18 years old) who acquire baccalaureate´s or above degrees
	Transportation accessibility	Total number of bus stops

Land use mixture	Diversity index expressed by entropy (0-100)

Source: Own elaboration

Table 3

Estimated coefficients

	(I) Trip time	(II) Alternative	(III) Trip distance	(IV) Trip count	(V) Mode choice
Fixed effects					
Intercept	39.45***	29.76***	9026.27***	1.74***	-3.25***
	(4.16)	(3.47)	(1478.80)	(0.23)	(0.52)
Level-1 variables					
Age	-0.18	0.04	11.79	0.03***	0.09***
	(0.16)	(0.13)	(55.35)	(0.01)	(0.02)
Age2	0.00	0.00	-0.29	-0.00***	-0.00***
	(0.00)	(0 .00)	(0.60)	(0.00)	(0.00)
Female	1.73*	-1.17	-761.36**	-0.11**	-1.15***
	(0.98)	(0.81)	(342.54)	(0.05)	(0.12)
Education	0.55***	0.345***	358.08***	0.012	0.07***
	(0.14)	(0.12)	(50.67)	(0.01)	(0.02)
Full time	3.54***	1.73	1494.92***	-0.05	0.36**
	(1.20)	(0.98)	(426.21)	(0.07)	(0.15)
Income					
Low	1.36	3.91***	-859.05	-0.06	-2.13***
	(1.65)	(1.36)	(583.79)	(0.09)	(0.22)
Medium-low	0.38	0.94	-463.42	-0.09	-1.18***
	(1.32)	(1.08)	(467.10)	(0.07)	(0.15)
Medium-high	#	#	#	#	#
High	-3.16**	-0.67	-677.06	0.09	0.65***
	(1.47)	(1.19)	(522.77)	(0.08)	(0.15)
Children_7	-0.18	-0.15	-323.56	0.26***	0.37**
	(1.56)	(1.26)	(551.28)	(0.09)	(0.18)
Purpose					
Home return	4.20***	1.87**	612.54	0.03	-0.35***

	(1.11)	(0.90)	(393.85)	(0.06)	(0.13)
Work	#	#	#	#	#
Study	8.18***	1.03	3136.89***	0.20	-0.87**
	(2.53)	(2.05)	(892.84)	(0.14)	(0.35)
HH related activities	-16.83***	-6.93***	-4651.18***	0.48***	0.30*
	(1.41)	(1.17)	(495.75)	(0.08)	(0.16)
Leisure	-10.19***	-4.66***	-1955.18***	0.35***	0.82***
	(1.88)	(1.53)	(669.52)	(0.10)	(0.21)
Mode of transport					
Foot (less than 10 blocks)		-11.59***			
		(1.18)			
Foot/bike/motorbike		-7.07***			
		(1.22)			
Payed vehicle		14.97***			
		(3.42)			
Car		#			
Bus		26.81***			
		(1.03)			
Household type					
MaleBreadwinner	-1.47	-0.62	144.92	-0.05	0.03
	(1.51)	(1.22)	(533.51)	(0.09)	(0.17)
MaleB_children	-4.59	-2.77	155.40	0.11	0.91***
	(2.23)	(1.80)	(787.68)	(0.12)	(0.26)
FemaleBreadwinner	2.63	-1.01	1244.90**	0.02	-0.09
	(1.72)	(1.39)	(607.07)	(0.10)	(0.20)
FemaleB_children	-5.55**	-4.06***	-1695.43**	0.19	0.46*
	(2.19)	(1.77)	(774.21)	(0.12)	(0.28)
DualEarner	#	#	#	#	#
DualE_children	-2.30	-1.60	42.90	0.16*	0.58***
	(1.71)	(1.38)	(604.77)	(0.09)	(0.20)
NoneEmployed	-1.49	0.48	-130.48	-0.26**	-0.22
	(2.11)	(1.71)	(746.71)	(0.12)	(0.26)
NoneE_children	-5.14	-2.60	-1289.98	0.09	-1.16
	(4.40)	(3.56)	(1544.69)	(0.24)	(1.09)
Level-2 variables					
Transport_access	0.13	-0.19	-332.49***	0.01*	-0.01
	(0.16)	(0.12)	(57.40)	(0.01)	(0.02)

Bachelor_above	-13.03***	-9.42***	-2208.81	-0.05	-0.00
	(3.69)	(2.94)	(1351.09)	(0.21)	(0.41)
Pop_density	-0.03***	-0.04***	-31.315***	0.00**	-0.00***
	(0.01)	(0.01)	(3.88)	(0.00)	(0.00)
Land_use mixture	-6.57**	-5.10**	-2095.62**	0.10	0.24
	(2.84)	(2.25)	(1047.74)	(0.16)	(0.32)
Random effects					
var(Intercept)	45.69***	26.26***	7329022***	0.14***	0.48***
	(9.15)	(3.47)	(1341799.88)	(0.03)	(0.13)
var(Residual)	532.69***	349.23***	64672247***	1.64***	
	(15.10)	(9.92)	(1869199.54)	(0.05)	
ICC	7.90%	6.99%	10.18%	8.08%	12.85%
-2LL	-13339	-12690	-29986	-4935	-1349
AIC	26733	25443	60026	9925	2750
BIC	26894	25628	60187	10087	2906
N	2,906	2,900	2,869	2,906	2,900

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo,* 2016. Note: Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1, # indicates the reference category

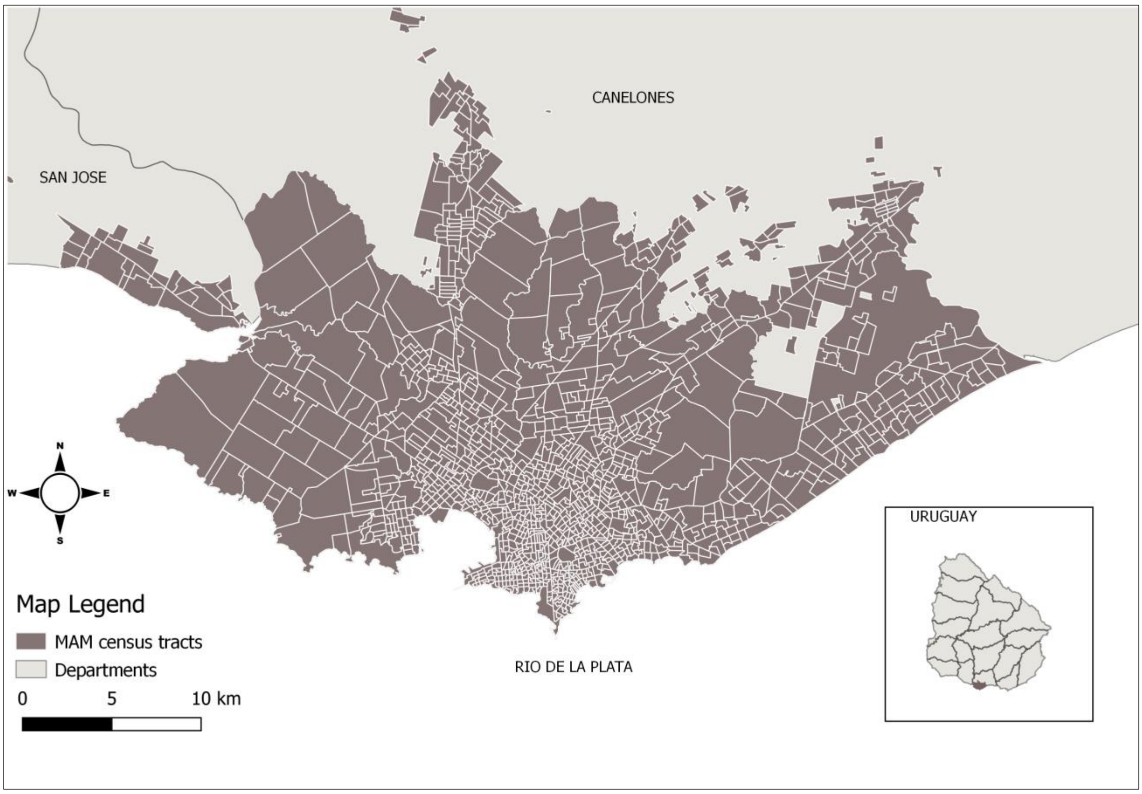

Figure 1. Census tracts of the Metropolitan Area of Montevideo.

Source: Own elaboration

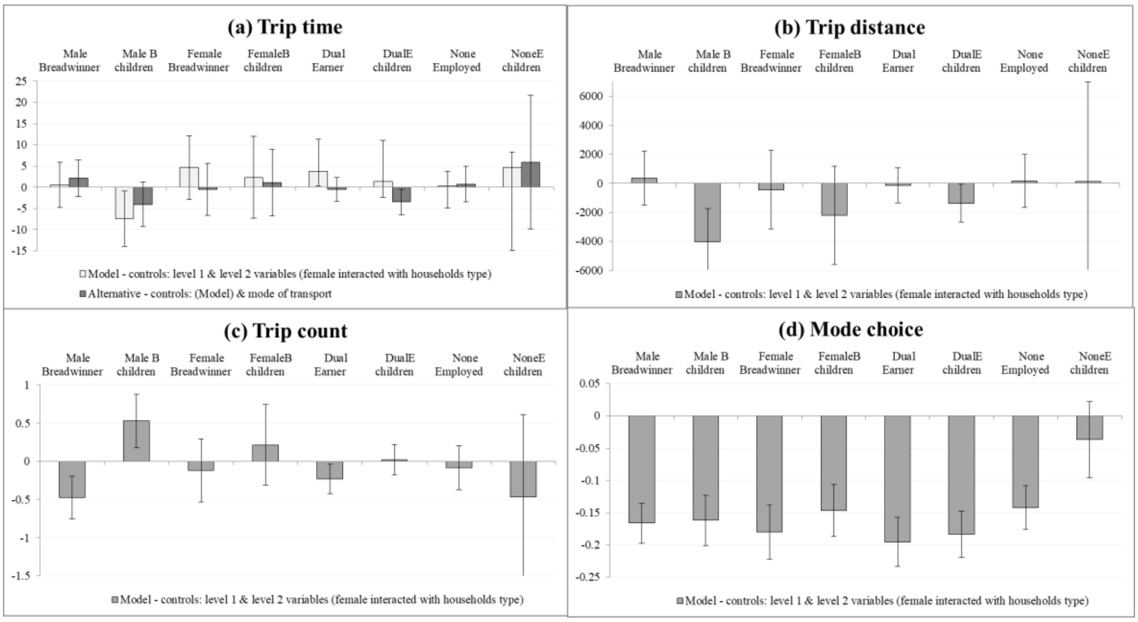

Figure 3. Differences between women and men (prediction of Female - prediction of Male), by household type.

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: Contrast of predictive margins, the straight line indicates the 95% confidence interval

Annex

Estimated coefficients using alternative census tract delimitation (41 areas)

	(I) Trip time	(II) Trip distance	(III) Trip count	(IV) Mode choice
Fixed effects				
Intercept	38.42***	8765.17***	1.84***	-3.85***
	(5.41)	(1970.46)	(0.29)	(0.55)
Level-1 variables				
Age	-0.17	9.84	0.03***	0.09***
	(0.16)	(55.82)	(0.01)	(0.02)

Age2	0.00	-0.26	-0.00***	-0.00***
	(0.00)	(0.60)	(0.00)	(0.00)
Female	1.44	-795.88**	-0.11**	-1.08***
	(0.99)	(347.35)	(0.05)	(0.11)
Education	0.47***	357.61***	0.01	0.06***
	(0.14)	(49.65)	(0.01)	(0.01)
Full time	3.65***	1539.50***	-0.06	0.34**
	(1.21)	(427.65)	(0.07)	(0.14)
Income				
Low	1.61	-495.92	-0.06	-1.97***
	(1.61)	(565.80)	(0.09)	(0.20)
Medium-low	0.33	-411.07	-0.08	-1.14***
	(1.29)	(454.27)	(0.07)	(0.14)
Medium-high	#	#	#	#
High	-3.58**	-481.71	0.11	0.57***
	(1.44)	(510.27)	(0.08)	(0.14)
Children_7	-0.83	-500.17	0.28***	0.37**
	(1.52)	(534.82)	(0.08)	(0.17)
Purpose				
Home return	4.47***	694.13*	0.02	-0.31***
	(1.11)	(393.24)	(0.06)	(0.12)
Work	#	#	#	#
Study	8.11***	2639.78***	0.19	-0.91**
	(2.53)	(894.08)	(0.14)	(0.34)
HH related activities	-16.53***	-4593.10***	0.49***	0.31*
	(1.41)	(496.69)	(0.08)	(0.15)
Leisure	-10.35***	-2095.95***	0.36***	0.89***
	(1.88)	(667.10)	(0.10)	(0.19)
Household type				
MaleBreadwinner	-1.13	100.50	-0.06	0.04
	(1.48)	(521.41)	(0.08)	(0.15)
MaleB_children	-3.89*	-40.24	0.14	0.85***
	(2.19)	(769.91)	(0.12)	(0.24)
FemaleBreadwinner	2.66	1042.74*	0.02	-0.04
	(1.69)	(593.13)	(0.09)	(0.19)
FemaleB_children	-4.89**	-1441.16*	0.15	0.40
	(2.15)	(757.09)	(0.12)	(0.26)

DualEarner	#	#	#	#
DualE_children	-1.77	48.19	0.16*	0.52***
	(1.67)	(587.95)	(0.09)	(0.18)
NoneEmployed	-1.06	-222.32	-0.28**	-0.15
	(2.07)	(730.14)	(0.12)	(0.24)
NoneE_children	-5.04	-1588.75	0.11	-1.23
	(4.39)	(1536.91)	(0.24)	(1.06)
Level-2 variables				
Transport_access	0.01	-7.44***	0.00	0.00
	(0.01)	(1.97)	(0.00)	(0.00)
Bachelor_above	-8.86	-2450.03	-0.15	1.54**
	(9.8)	(3659.17)	(0.49)	(0.73)
Pop_density	-0.03	-42.31***	0.00	-0.01***
	(0.04)	(13.60)	(0.00)	(0.00)
Land_use mixture	-17.56**	-2394.48	0.05	0.91
	(7.27)	(2695.93)	(0.37)	(0.59)
Random effects				
var(Intercept)	19.33***	2820847***	0.04***	0.07
	(6.30)	(912605)	(0.02)	(0.05)
var(Residual)	559.22***	68499006***	1.74***	
	(14.75)	(1819527)	(0.05)	
ICC	3.34%	3.95%	2.45%	2.08%
-2LL	-13338	-29976	-4944	-1354
AIC	26729	60006	9943	2760
BIC	26890	60167	10104	2915
N	2,906	2,869	2,906	2,900

Source: Authors' estimations based on *Encuesta de Movilidad del Área Metropolitana de Montevideo*, 2016. Note: Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1, # indicates the reference category