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Abstract

In this paper, home-workplace trips of two-earner households are studied. Here, light is shed on those living and working in Paris region. To compare two-earner households trips to those of single earners and to study their locational choice in the city, many econometric models are regressed. In these models, some of the variables that have not been used so far in the literature are introduced and, at the opposit of the existing studies on the same topic, endogeneity issues are dealt with using instrumental variables and 3sls techniques. The results show that households trips are shorter than those of single-earner ones, that women adapt their trips to their spouses and that two-earner households don't adjust the W1-H-W2 triangle configuration in order to minimize the total commute distance.

1   Introduction

The steady increase in the proportion of working women has generated a growing interest in studying two-earner household home-workplace trips[1]. The main reason for this is that the proportion of these households is expected to keep on growing [2] and to provoke an upset of the overall demand for urban transport.

The interest of studying two-earner household trips separately from those of single-earner ones is that the two kinds of households have different demographic and economic characteristics. The practical consequence of this is that the trade-offs they make between housing surface and distance lead to different decisions regarding their home-workplace(s) spatial configuration.

Deriving theoretically a comparison between single and two-earner households home-workplace distance is not an easy task. The reason is that this distance is influenced by two factors pulling in opposite directions. On the one hand, the basic but well established Alonso-Mills-Muth model states that the

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[1]In the rest of the paper, the word "trip" refers to home-workplace trips.
[2]Cf. Clarck et al. (2003)

slope of the bid-rent function decreases with income[3]. Consequently, as two-earner households have higher incomes, they are more likely to choose to reside far from employment centers in order to enjoy larger houses. However, in these households two members must commute to their workplaces. So, since these trips entail time expenditures, and knowing that two-earner households have less time for leisure, residing in the city outskirts may be harmful for them.

Empirically, the papers dealing with the topic provide mixed results[4]. On the one hand this may be due to the diversity of the studied cities and that of the approaches chosen to deal with the issue, and on the other hand this by be the result of using econometric techniques that don't deal with endogeneity and estimation bias issues.

In this paper, light is shed on two-earner households living and working in Paris region. Firstly, it is shown if their trips are longer or shorter than those of single-earner households all the other things being equal. Secondly, it is demonstrated that when the distance traveled by a spouse increases that of the other increases too (complementarity) or decreases (substituability). And last but not least, it is shown if the two-earner households adjust the structure of the triangle whose summits are home and the two workplaces in order to minimize the total commute distance. This triangle is noted W1-H-W2[5] in the rest of the paper.

To do so, many econometric models are regressed. In these models, a number of variables that have not been used so far in the literature are introduced [6] and endogeneity issues are dealt with using instrumental variables and 3sls techniques[7]. The obtained results show that in Paris region two-earner household trips are shorter than those of single-earner ones, that women adapt their trips to their spouses and that two-earner households don't adjust the W1-H-W2 triangle in order to minimize the total commute distance.

The continuation of the article is as follows. In section 2, a review of the literature dealing with the home-workplace trips within two-earner households is presented. In section 3, the empirical strategy is detailed.. In section 4, Paris region, the data used in the paper are presented and some descriptive statistics are provide. And in section 6, the results of the econometric regressions are presented. In the conclusion, some remarks and research perspectives are discussed.

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[3]Mills has already pointed in 1972 that many empirical studies show that the earnings elasticity of housing demand for elasticity is larger that 1

[4]A detailed review of the literature dealing with the question is provided in section 2

[5]W1 refers to the male's workplace, H to home and W2 to the female's workplace.

[6]Among these variables : home occupancy status (owners or renters), possessing a private vehicle, having driving license, paying for public transport pass ...

[7]The empirical strategy is presented in section3.

2 Literature review

The literature has addressed in several ways the comparison of the trips made by women with those made by men, the differences between the trips made by single-earner households and those made by two-earner ones, and the residential locational choices of two-earner households in relation to the two spouses workplaces.

Concerning the comparison between men and women work trips, all the empirical studies show that the distances traveled by women are shorter than those traveled by men (Chaple and Weinberger 2000; Clarck and al. 2003; Erickson 1977; Fuchs 1971; Madden 1977; Sultana 2005; Sultana 2006; Surprenant-Legault et al. 2013; White 1977; White 1986). This result holds for both single and two-earner households (Madden 1981; Surprenant-Legault et al. 2013 ...). Two justifications are often put forward to explain this fact. The first is that women have generally greater household duties so they reduce their geographical job seeking scope (Johnson and Anumanwo 1992; Turner and Niemer 1997), and the second is that the wage gains they can enjoy by accepting jobs located further are much lower than what men can get[8]. However, the two justifications are not always supported empirically. Plaut (2005) shows that in the USA the wage sensitivity to home-workplace distance is the same for men and women. Also, the studies disscussnig the impact of children show opposit conclusions : Madden (1980) and Hanson and Johnson (1985) find that their presence affects significantly home-workplace distances, Singell and Lillydahl (1986) shows that it leads to an increase of both spouses travelling distances, White (1986) shows the opposite and Davis (1993) concludes that it increases the reference person spouse travelling distance.

The difference between single and two-earner households work trips has been treated theoretically and empirically in several papers. From a theoretical point of view, Curan and al. (1982) explains, thanks to a model of residency choice, that two-earner households bid-rent function is diffrent from single-earners'. As a result, there is a specific area in the city where two-earners reside. However, this area cannot be determined analytically. White (1986) states that two-earner households find it hard to optimize their residency location in relation to both spouses workplaces. Thus, their home-workplace trips should be longer. Van Ommeren (1999) shows, using a job-search model that includes the interactions between the spouses, that two-earner households search more intensely in the labor market than in the housing market.

For the empirical papers, Madden (1980) concludes that two-earner households behave identically to single-earner ones regarding the choice of their residency location and as a consequence, the observed differences between the two kinds trips is fully explained by the differences in income, fertility and jobs characteristics. Rouwendal and Rietvald (1994) comes to a close conclusion.

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[8]Numerous empirical studies show that, all the other thinks being equal, workers whose home-workplace trips are longer have greater wages.

It shows that two-earner households trips are neither longer nor shorter than single-earners'. Finally, Surprenant-Legault et al. (2013) shows that in Montreal, two-earner households have shorter work trips.

Additionally to the comparison between single and two-earner households trips, numerous studies focus on the trad-off occurring in two-earner households. The objective is mainly to determine whether the spouses trips are substituable or complementary. Singell and Lillydahl (1986) shows that the residency location choice depends more on the man workplace, the recent moving leading more often to a decrease of the man's home-workplace distance and to an increase of the woman's. This result is also found by Hanson and Pratt (1991), Davis (1993) and Rouwendal (1998). Tkoz and Kristensen (1994) finds that in Denmark, women take more advantage from moving than men. Van Ommeren (1997) shows that for two-earner households, the probability of moving is positively impacted by both spouses home-workplace distances and negatively by the distance between the two-workplaces. Clark and al. (2002) shows that for two-earner households who recently moved, home-workplace distances of both spouses decreased. Furthermore, Plaut (2005) shows that the spouses trips are complementary. This result is also found by Surprenant-Legault et al. (2013). The latest shows also that two-earner households tend to set the W1-H-W2 triangle in order to minimize the household total commute distance.

Finally, it is worth noting that to analyze the W1-H-W2 configuration, many measures are used in the literature. The most straightforward and thus the most used the is the home-workplace distance (or trip duration) of each spouse. The distance between the two workplaces is also used by some authors (particularly Van Ommeren). This measure is justified by the fact that the more the workplaces are close, the less the constraints on the residency location choice are strong.

Angles can also be used to better define W1-H-W2 configuration. In the monocentric city case, the angle of interest is the one formed by the intersection of CBD-Residency and CBD-workplace lines. In multicentric cities, using this angle is not relevant as their isn't a unique CBD. The angle that is used is W1-H-W2. If this angle is small this means that the spouses travel to work in the same direction and if it is big, this means that they travel in opposite directions (Van Ommeren 2000). Furthermore, W1-H-W2 angle contains the information concerning the distance between the two workplaces. Thus, it is better to use it if the data allows to do so.

3 Methodology

As stated in the introduction, this paper analyzes the home-workplace trips of two-earner households living and working in Paris region. Firstly, the existence of a difference between two and single-earner households home-workplace distances is tested and measured if existing. Secondly, the existence of com-

plementarity / substitutability between the spouses in two-earner households is tested and measured if existing. And finally, it is shown if two-earner households adapt the W1-H-W2 triangle configuration in order to minimize their total commute distance.

Comparing single and two-earner households work trips

To answer the first question, the following model is regressed using the observations related to all the workers, whether they belong to a single or a two-earner household :

$$
\begin{aligned}
\ln\left(D_i\right) \quad = \quad & cst + \alpha_1 \text{residency\_area}_i + \alpha_2 \text{Gender}_i + \alpha_3 \text{Housing\_occupancy\_status}_i \\
& + \alpha_4 \text{Income}_i + \alpha_5 \text{Contract}_i + \alpha_6 \text{Children}_i \\
& + \alpha_7 \text{Driving\_licence}_i + \alpha_7 \text{Public\_transport}_i + \alpha_8 \text{Number\_of\_vehicles}_i \\
& + \alpha_9 \ln\left(\text{Residency\_accessibility}_i\right) + \alpha_{10} \ln\left(\text{Workplace\_accessibility}_i\right) \\
& + \alpha_{11} \text{Age}_i + \alpha_{12} \text{Age}^2 + \alpha_{13} \text{Two\_earner\_household}_i + \epsilon_i
\end{aligned}
$$
$$(1)$$

Where D_i is the home-workplace distance, residency_area$_i$ indicates whether the worker resides in the city of Paris, in the inner suburb or in the outer suburb[9], Housing_occupancy_status$_i$ indicates whether the household to whom the worker belongs is a first-time homebuyer, a private renting sector tenant, a home owner or a social sector tenant, Contract$_i$ says if the worker has a full time or a part time job, Children$_i$ is a dummy variable informing if there are children in the worker's household, α_7Driving_licence$_i$ indicates whether the worker has a diving license or not, Public_transport$_i$ tells whether the worker has a public transport subscription or not, Number_of_vehicles$_i$ informs about the number of vehicles available to the household, Residency_accessibility$_i$ and Workplace_accessibility$_i$ measure respectively how easy the worker's residence and workplace municipalities residents have access to jobs, and Two_earner_household$_i$ is a dummy variable indicating whether the worker belongs to a single or to a two-earner household. Details about the accessibility to job index used here are presented in the appendix.

Controlling for the number of vehicles and for possessing a public transports subscription requires to address the problem of endogeneity. Here, endogeneity is caused by simultaneity. A long home-workplace distance can be the cause or the consequence of possessing a private vehicle or / and a public transports pass and vice versa. Thus, to correct the estimating bias which could result from such a specification, possessing a public transports subscription is instrumented by the house surface[10] and the workers' educational level and the number of vehicles is instrumented using the house type[11] and by a variable indicating if the

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[9] A detailed presentation of Paris region is given in section 4.

[10] Many regressions using the house surface as explanatory variable where made. In all these regressions the coefficients related to this variable were not statistically significant.

[11] Individual house or collective dwelling.

household pays domestic parking lot fees. Endogeneity, instruments efficiency and over-identification tests are presented in the appendix.

Complementarity / substitutability in two-earner households

The existence of complementarity / substitutability between two-earner households spouses is tested in two steps. Firstly the following equation is regressed using only the observations related to workers belonging to two-earner households :

$$
\begin{aligned}
\ln(D_i) \quad = \quad & cst + \alpha_1 \text{residency\_area}_i + \alpha_2 \text{Gender}_i + \alpha_3 \text{Housing\_occupancy\_status}_i \\
& + \alpha_4 \text{Income}_i + \alpha_5 \text{Contract}_i + \alpha_6 \text{Children}_i \\
& + \alpha_7 \text{Driving\_licence}_i + \alpha_7 \text{Public\_transport}_i + \alpha_8 \text{Number\_of\_vehicles}_i \\
& + \alpha_9 \ln(\text{Residency\_accessibility}_i) + \alpha_{10} \ln(\text{Workplace\_accessibility}_i) \\
& + \alpha_{11} \text{Age}_i + \alpha_{12} \text{Age}^2 + \alpha_{13} \ln(\text{D\_Spouse}_i) + \epsilon_i
\end{aligned}
\tag{2}
$$

Where D_Spouse_i is the home-workplace distance of the worker's spouse. This allows a comparison between the impact of different factors on single and two-earner households work trips.

The same equation is estimated using only workers belonging to single-earner households. This allows a comparison between the impact of different factors on single and two-earner households work trips.

Secondly, to better measure the complementarity / substitutability and especially to determine if both spouses make compromises or if one of them adapts his trips to the other's, the system of simultaneous equations 3 consisting of man's and the woman's home-workplace distance equations is regressed (DM is the distance traveled by the man and DW that traveled by the woman). In each one, the distance traveled by the spouse is included. This is done for two reasons. The first is that it allows to take account of the fact that two spouses belong to the same household, and the second is that their are within two-earner households some factors that impact the home-workplace distance of each spouse and for which no variable is devoted in the databases used here. As a consequence, the impact of these factors is absorbed by the residuals. And as these factors are likely to be common to the two spouses, there is a considerable chance that men related regression residuals are correlated to those of women related ones.

The question of endogeneity is addressed here by an instrumentation using

6

the 3 Stages Least Squares technique.

$$
\begin{cases}
\begin{aligned}
\ln\left(DM_i\right) \;=\; & cst + \alpha_1\text{residency\_area}_i + \alpha_4\text{Income}_i \\
& + \alpha_7\text{Driving\_licence}_i + +\alpha_7\text{Public\_transport}_i + \alpha_8\text{Number\_of\_vehicles}_i \\
& + \alpha_9\ln\left(\text{Residency\_accessibility}_i\right) + \alpha_{10}\ln\left(\text{Workplace\_accessibility}_i\right) \\
& + \alpha_{11}\text{Age}_i + \alpha_{12}\text{Age}^2 + \alpha_{13}\ln\left(DW_i\right) + \epsilon_i \\[1em]
\ln\left(DW_i\right) \;=\; & cst + \alpha_3\text{Housing\_occupancy\_status}_i + \alpha_6\text{Children}_i \\
& + \alpha_7\text{Driving\_licence}_i + +\alpha_7\text{Public\_transport}_i + \alpha_8\text{Number\_of\_vehicles}_i \\
& + \alpha_{10}\ln\left(\text{Workplace\_accessibility}_i\right) + \alpha_{13}\ln\left(DM_i\right) + \mu_i
\end{aligned}
\end{cases}
\tag{3}
$$

W1-H-W2 triangle configuration

To determine if two-earner households adapt the W1-H-W2 triangle configuration in order to minimize the total commute distance, the model in relation 4, whose the endogenous is the sum of the two spouses work trips distances is regressed. Are included among the exogenous variables the difference between the longest and the shortest home-workplace distance and a logistic transformation of W1-H-W2 angle[12]. This transformation is made to obtain a measure of the angle which is a variable whose values can be everywhere in $\mathbb{R}$ rather than a variable whose values are included between 0 and 180.

$$
\begin{aligned}
\ln\left(\textstyle\sum D_i\right) \;=\; & cst + \alpha_1\text{residency\_area}_i + \alpha_3\text{Housing\_occupancy\_status}_i \\
& + \alpha_4\text{Income}_i + \alpha_5\text{Contract}_i + \alpha_6\text{Children}_i \\
& + \alpha_7\text{Driving\_licence}_i + \alpha_7\text{Public\_transport}_i + \alpha_8\text{Number\_of\_vehicles}_i \\
& + \alpha_9\ln\left(\text{Residency\_accessibility}_i\right) + \alpha_{10}\ln\left(\text{Workplace\_accessibility}_i\right) \\
& + \alpha_{11}\text{Age}_i + \alpha_{12}\text{Age}^2 + \alpha_{13}\text{AVG\_Age}_i \\
& \alpha_{15}\ln\left(\triangle D_i\right) + \alpha_{16}\text{logit}\left(W1-H-W2\right) + \epsilon_i
\end{aligned}
\tag{4}
$$

Here Driving_licence_i / $\text{Public\_transport}_i$ indicate if the two spouses have a driving license / a public transport subscription, if only one of them has it or if no one does so, Age_i and $\text{Age}^2{}_i$ are those of the man. AVG_Age_i is the two spouses average age, and $\triangle D_i$ is the difference between the longest and the shortest home-workplace distance.

If the coefficient related to $\triangle D_i$ is positive, this means that the two spouses trips are complementary. On the other hand, if the coefficient related to the $\text{logit}\left(W1-H-W2\right)$ is negative, this means that the households adapt W1-H-W2 triangle configuration in order to minimize the total commute distance (Surprenant-Legault 2013).

Endogeneity tests reveal that $\text{logit}\left(W1-H-W2\right)$ is endogenous to the sum the two spouses traveling distances. It is instrumented using the house surface.

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[12]The logistic transformation of an angle α is $\log\left(\frac{\alpha}{180-\alpha}\right)$.

And as this variable can no longer be used as an instrument for possessing a public transports pass, the latest is only instrumented by the man and the women educational level.

Expectations concerning some control variables

Regarding the impact of control variables, it is expected to find that workers who reside in the city of Paris travel less far than those who reside in the "inner suburb" and that the latter travel less far than those who reside in the "outer suburb". Also, as mobility constraints are less strong for renters, their trips are likely to be shorter than those of owners. Furthermore, having a driving license, a private vehicle and a public transports subscription are expected to have a positive impact on home-workplace distance. Moreover, part-time workers are likely to travel less far than full time ones because they are more sensitive to traveling costs. Finally, given the existence of a much greater number of leisure activities in the city of Paris than in the suburbs, young people are expected to prefer to live close to the center, and thus to have shorter work trips.

Concerning accessibility to jobs, the one of residency area should impact negatively home-workplace distance while the workplace's should impact it positively. Even if it sounds counter-intuitive, the positive impact of workplace accessibility is due to the fact that a high concentration of jobs in some area leads firms to offer a high price for land in this area. This induces a lack of houses in the firms surroundings, and forces them to hire workers who reside far from their sites.

4 Presentation of Paris region, data sources and descriptive statistics

4.1 Brief presentation of Paris region

Paris region consists of 8 departments split into 1296 municipalities and districts. Figure 1a shows the departments of which the region consists. The city of Paris is located in the center, Seine-Saint-Denis, Hauts-de-Seine and Val-de-Marne form what is called the " Small crown" and Val-D'oise, Yvelines Essonne and Seine-Et-Marne form what is called the "Big crown".

Paris region is the second urban agglomeraion in terms of population [13] in Europe with 12 millions, and is its largest employment area with more than one million firms generating more than 6 million jobs.

Concerning transport infrastructures and services, Paris region has 16 subway lines, 5 RER[14] lines, many "TRANSILIENS"[15] lines, 4 Tramway lines, 64

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[13] Behind Moscow and its 12.6 million inhabitants

[14] RER for "Réseau Express Régional". The English translation is "Regional Express Network". It is a rail network serving Paris and its region. It has almost 250 stops and its length is about 590 km.

[15] It is an rail network connecting the city of Paris to rest of the region. The main difference between this network and the RER is that the "TRANSILIEN" trains cannot be taken to

buses and 47 night shuttles. Figure1b shows the metro and RER network of the region[16].

(a) Ile-France departments

(b) Ile-de-France metro and RER network
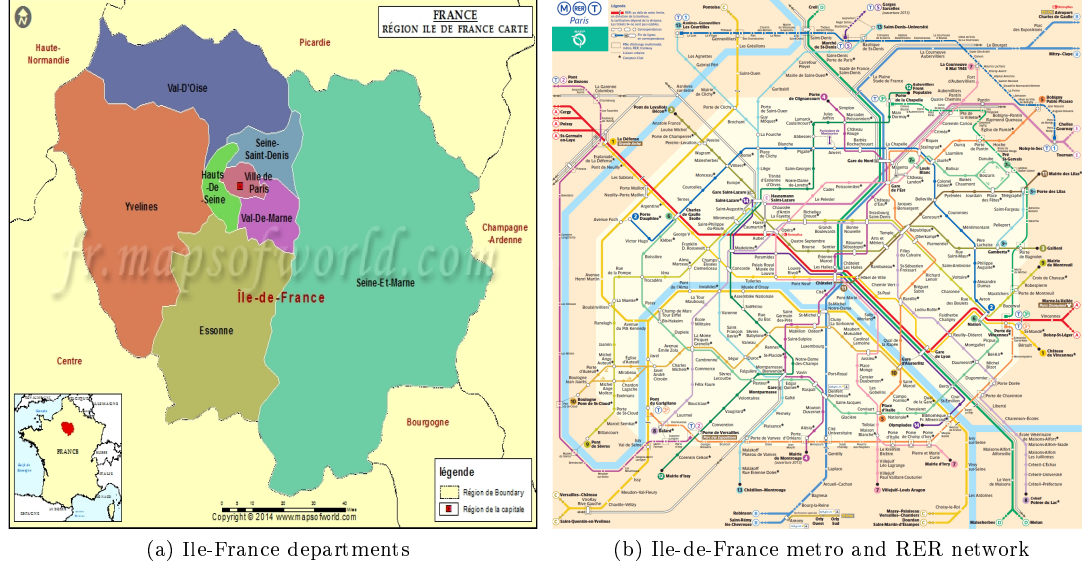
Figure 1: Ile-de-France departments and railway network

4.2 Data sources

In this paper, 3 data sources are used for the statistical analysis and the econometric estimations. The first is the "Employment and Labor Force" dataset resulting from the population census of 2012. The second is the set of databases resulting from the Global Transport Survey 2010 (GTS 2010), which is the main source of information on Paris region inhabitants trips. This data contains information about more than 143000 trips made for various reasons and using different transport means. Furthermore,the places of residence as well as the places of departure and arrival of each trip are marked using a grid of 100*100m[17]. And last but not least, the third source of data used here is a

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travel inside the city of Paris.

[16]The current subway and RER network is very extend geographically, but radial (thus very dense in the center) and not connecting effectively the peripheral municipalities between each other. Thus, in Order to enhance Paris region urban transport network and, particularly to allow the small and the big crowns inhabitants to travel from a suburban municipality to another suburban municipality without crossing the city of Paris, the French government decided to build a new urban transport infrastructure called the "GRAND PARIS EXPRESS" (GPE) whose the flagship aspect is the construction of two new automatic lines, one forming a loop through municipalities located in the east of the region and the other a loop through municipalities located in the west. Commissioning of the GPE will be done gradually between 2019 and 2030.

[17]This allows a fairly precise coupling between the data from GTS and those from other sources.

set of databases obtained exclusively from the "SOCIETE DU GRAND PARIS"
(SGP), a public industrial and commercial establishment created by the French
government in 2007. This data results from a classical 4-step travel model called
MODUS [18]. Among the given datasets, those used here are the matrix of trips
durations using private vehicle [19] and the matrix of trips durations using public
transport [20].

4.3   Descriptive statistics

4.3.1   Statistics on home-workplace trips

Descriptive statistics relating to home-workplace distance are presented in Table
1. They are broken down by household type, residency crown and gender.

In a general way, home-workplace distance increases the further we go from
the city of Paris, women's trips are shorter than men's, and those of two-earner
households are longer than those of single-earner ones.

4.3.2   Statistics on households characteristics

Descriptive statistics on households type, size, income, housing occupancy status
and number of vehicles are presented in Table 2. They are broken down by
household type and residency crown.

Over the region, the share of single-earner households is higher than that
of two-earner ones. However, breaking down by residency crown shows that
this is true only in the city of Paris. In fact, in the "Small Crown", single-
earner households account for 44.85% and in the "Big Crown" their share is
only 36.78%.

Concerning incomes, those of two-earner households are higher than those
of single-earner ones, regardless of residency crown. In addition, the households
living in the city of Paris have higher incomes than those of the households
living in the suburbs. And in the suburbs, the incomes in the "Small Crown"
are lower than the incomes in the "Big Crown".

Regarding housing occupation status, the owners share is significantly higher
for two-earner households that among for single-earner ones, regardless of resi-
dency crown. Moreover, in the city of Paris, the share of owners is greater than
in the suburbs and in the suburbs, their share is greater in the "Big Crown" than
in the "Small Crown". It is worth Noting that the "Small Crown" contains the
Seine-St-Denis (93) department in which there is a very high rate of poverty and
where social housing is important. This pulls down the statistics on households
incomes and housing ownership in the "Small Crown".

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[18]This model is estimated and used by the Ile-de-France Regional Direction of Equipment
and Planning to study the functioning of the transport system in the region and to evaluate
the impact of infrastructure projects and public policies affecting its transportation system.

[19]It provides for each pair departure-arrival (1296*1296 pairs) the trips duration in the
morning rush hour using a private vehicle.

[20]It provides for each pair departure-arrival the trips duration in the morning rush hour
using public transport . We can find the total duration of the trip and the time spent inside
and outside the vehicles.

	Region		City of Paris		Small Crown		Big Crown	
	Average	STD	Average	STD	Average	STD	Average	STD
All the households								
All	11.79	12.03	6.25	6.51	8.21	6.95	15.88	14.29
Women	10.70	11.34	5.63	5.98	7.31	6.91	14.74	13.70
Men	12.97	12.33	7.17	7.28	9.33	7.64	17.45	14.60
Single-earner households								
All	10.45	11.03	6.46	7.02	80.3	7.01	14.46	13.94
Women	9.04	9.76	5.62	6.3	6.98	5.84	13.27	13.03
Men	11.70	11.76	7.25	7.46	9.07	7.77	16.01	14.60
Two-earner households								
All	13.67	12.68	7.08	7.08	9.39	7.53	18.08	14.67
Women	10.93	11.43	5.54	5.21	7.54	6.52	14.54	13.68
Men	13.86	12.65	7.12	7.11	9.53	7.54	18.26	14.55

Table 1: Home–workplace distance in Km

Concerning the number of cars available to the household, two-earner households are more motorized than single-earner ones, and the rate of car ownership increases as we get further from the city of Paris.

Last but not least, regarding the possession of a public transport subscription, workers from two-earner households are less often subscribed than workers from single-earner ones, and the subscription rate decreases as we go further from the city of Paris.

The statistics on the number of vehicles in the household and the possession of a public transport subscription can be explained by the fact that the public transport offer is more dense in the city of Paris than in the suburbs and that the structures of the metro, the RER and the "TRANCILIEN" are radial, which makes commuting from a suburban area to another suburban area by public transport very time consuming.

5 Regressions results

5.1 Home-workplace trips length

Apart from age, all the quantitative variables are log-transformed. The relative coefficients can thus be interpreted as elasticities. Endogeneity and over-identification tests are presented in the appendix. In all the regressions, the coefficients relating access to employment and age are in line with the expectations. Moreover, the gender coefficient indicates that women move less far than men, regardless of household type.

All households and single-earner households trips

Table 3 presents the results of the regressions using all the workers and those of the regressions using the workers who belong to single-earner households.

The results show that the social sector tenants trips are the shortest, followed by those of private sector tenants, then by those of homeowners and then by those of first-time homebuyers.

Home-workplace distance increases with income and decreases if the worker moves from a full to a part-time contract.

Having a driving license, a public transport subscription[21] and one or more private vehicles incite home-workplace distance to increase.

Lastly, the regression on all the workers shows that, other things being equal, two-earner households trips are shorter than those of single-earners ones. This result is identical to that of Surprenant-Legault et al. (2013) devoted to workers residing in Montreal and its surroundings. It can be explained by the fact that two-earner households have less time for leisure and thus the value they give it is high enough to minimize the time spent traveling. Also, it is worth noting

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[21] The coefficient relating to the possession of a public transport subscription is not significant for single-earner households.

	Region		City of Paris		Small Crown		Big Crown	
	Single-earners	Two-earners	Single-earners	Two-earners	Single-earners	Two-earners	Single-earners	Two-earners
Single and two-earner households shares								
	54.5	45.5	51.49	48.51	44.85	55.15	36.78	63.22
Households average size								
	3.01	3.40	3.02	3.25	3.24	3.41	3.25	3.43
Share of households by monthly income bracket (In euros)								
< 1600	26.53	2.45	14.5	2.20	30.11	2.78	24.44	2.31
1600 to 3000	49.94	23.80	35.22	11.29	42.50	28.32	46.03	2.45
3000 <	23.47	7.74	50.43	86.51	27.39	68.90	29.53	74.24
Shares of home owners and tenants								
Tenants	37.49	20.64	24.78	14.37	44.63	28.56	34.32	16.61
Owners	62.51	79.36	75.22	85.63	55.37	71.44	65.58	83.39
Shares of households having no vehicle, having 1 vehicle, having 2 or more vehicle								
No vehicle	24.67	9.21	49.57	36.95	30.46	9.85	13.85	2.70
1 vehicle	54.06	43.15	44.35	55.13	54.07	56.55	56.31	31.38
2 or more	21.27	47.64	6.09	7.92	15.47	33.60	29.84	65.92
Share of workers having a public transport subscription								
No	53.41	59.93	31.22	37.24	49.19	54.24	66.32	68.78
Yes	46.59	40.07	68.78	62.76	50.81	45.76	33.68	31.22

Table 2: Descriptive statistics related to some characteristics of Paris region households

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that in Paris region the probability of having children is higher for two-earner households and thus their leisure time is even more valuable.

This result remains valid even by removing the single and childless workers from the regression sample.

	All workers		Single-earner households	
	Coefficient	STD	Coefficient	STD
Constant	22.14***	6.11	33.85***	10.29
Residency crown				
Big crown	0.45***	0.04	0.47***	0.07
Small crown	0.16***	0.03	0.17***	0.05
City of Paris	Ref		Ref	
Gender				
Female	-0.33***	0.02	-0.25***	0.03
Male	Ref		Ref	
Housing occupancy status				
First-time homebuyers	0.20***	0.03	0.24***	0.05
Private renting sector tenant	0.06**	0.03	0.11**	0.05
Homeowner	0.10**	0.03	0.11**	0.05
Social sector tenant	Ref		Ref	
Income				
more than 3000	0.22***	0.04	0.28***	0.06
1600 to 3000	0.17***	0.03	0.20***	0.04
Less than 1600	Ref		Ref	
Type of employment contract				
Part time worker	-0.08**	0.04	-0.12*	0.07
Full time worker	Ref		Ref	
Children in the household				
Yes	-0.03	0.02	-0.04	0.04
No	Ref		Ref	
Driving license				
No	-0.12***	0.03	-1.02	0.64
Yes	Ref		Ref	
Public transport subscription				
No	-1.08***	0.14	-	-
Yes	Ref		-	-
Vehicles available				
2 or more	0.34***	0.09	0.44***	0.11
1	-0.17	0.18	0.001	0.20
0	Ref		Ref	
Log residence accessibility	-51.86***	2.23	-46.02***	3.90
Log workplace accessibility	43.98***	2.05	33.49***	3.34
Age	0.02***	0.009	0.02**	0.01
Age squared	-0.0004	0	-0.0004	0
Two-earner household				
Yes	-0.17***	0.03		
No	Ref			

Table 3: Regressions on all the workers and workers of single-earner households using IV

Two-earner households trips

Table 4 contains the results of the regression performed on two-earner households without considering that two spouses belong to the same household, and the results of the simultaneous equations models using 3SLS.

The results show that two-earner households trips aren't affected by income, neither by employment contract type, nor by the number of vehicles available. It is worth noting that this is not the case for single-earner households.

Moreover, two-earner households are less sensitive to housing occupancy status than single-earner ones. This is shown by the fact that for two-earners, the coefficient related to accessing the property is the only one that is statistically significant.

Juxtaposing the results of Tables 4 and 3 allows a rough comparison between the sensitivity of single and two-earner households trips to the different factors. Firstly, the difference between the trips length of the workers living in Paris and those of the workers living in the suburbs is greater among single-earner households than among two-earner ones. Secondly, the absolute value of the coefficient related to gender is greater for two-earner households. This indicates that women belonging to two-earner households travel less far than those belonging to single-earner ones. Finally, two-earner households are more sensitive to home and workplaces access to employment than single-earner ones.

Moreover, in the single equation regression using two-earner households, the coefficient relating to the spouse home-workplace distance is positive and statistically significant. This indicates that the spouses trips are complementary.

The results obtained after regressing the simultaneous equations model provide important insights on the difference in sensitivity and on the spouses trade-offs in two-earner households[22]. First, the presence of children in the household positively impacts women but doesn't impact men. Second, women are more sensitive to possessing a public transport subscription and to the number of private vehicles than men. The coefficient related to possessing a public transport subscription is, by the way, not significant for men. Third, men's commuting distance is positively impacted by household income, while income has no impact on the distance traveled by women[23]. Fourth, women belonging to first-time buyers households travel farther than those who are part of a household with another tenure status. Regarding men, the housing occupancy status has no impact on the distance they travel. And last but not least, women adapt the length of their journeys to that of their spouses, but not men. This result appears only after the use of the 3SLS method. The SURE method gives a result that indicates that both members adjust the length of their trips.

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[22] Are considered here only two-earner households where the spouses are of different sex.

[23] This is consistent with the low sensitivity of women's wage to home-work distance is mentioned in the literature review section.

| | Simple equation | | Simultaneous equations | | | |
| | | | Male | | Female | |
	Coefficient	STD	Coefficient	STD	Coefficient	STD
Constant	6.22	7.97	11.04	11.91	-124.53***	19.61
Residency crown						
Big crown	0.36***	0.06	0.51***	0.09		
Small crown	0.13**	0.05	0.13	0.08		
City of Paris	Ref		Ref			
Gender						
Female	-0.43***	0.03				
Male	Ref					
Housing occupancy status						
First-time homebuyers	0.11***	0.04			0.36**	0.15
Private renting sector tenant	-0.007	0.04			0.15	0.16
Homeowner	0.08	0.05			0.03	0.19
Social sector tenant	Ref				Ref	
Income						
more than 3000	0.12	0.10	0.40**	0.16		
1600 to 3000	0.09	0.10	0.26	0.16		
Less than 1600	Ref		Ref			
Type of employment contract						
Part time worker	-0.03	0.05				
Full time worker	Ref					
Children in the household						
Yes	-0.03	0.03			0.005*	0.003
No	Ref				Ref	
Driving license						
No	-0.19***	0.05	-0.72*	0.40	-5.02**	2.52
Yes	Ref		Ref			
Public transport subscription						
No	-1.06***	0.14	-0.72*	0.40	-5.02**	2.52
Yes	Ref		Ref			
Vehicles available						
2 or more	0.17	0.13	0.43	0.41	3.68***	1.83
1	-0.35	0.25	-0.11	0.47	0.98	1.39
0	Ref		Ref			
Log residence accessibility	-51.65***	2.88	-54.31***	4.38		
Log workplace accessibility	49.90***	2.68	50.36***	3.75	48.07***	7.53
Age	0.03**	0.01	0.06***	0.02		
Age squared	-0.0005	0	-0.0009***	0.0002		
Log distance of the spouse	0.14***	0.01	-0.14	0.13	0.97*	0.54

Table 4: Two-earner households using IV and simultaneous equations using 3 SLS

5.2 Total commute distance

The results of the regressions whose the endogenous is the two-earner households total commute distance are presented in Table 5. They show that total commute distance increases as we go further from the city of Paris, that it is shorter for renters than for homeowners [24], and that it is not affected by income, by the presence of children in the household, or even by the number of vehicles available.

Concerning public transport, households whose both spouses have a subscription have the longest travel distance, followed by households where only one spouse has a subscription and by households where neither spouse has a subscription.

Regarding home and workplace areas accessibilities to employment, their impacts are consistent with expectations, with greater sensitivity to the woman's workplace accessibility to jobs.

Finally, concerning the spatial configuration of the triangle W1-H-W2, the coefficient related to the difference between the longest and the shortest distance is 0.33. This indicates that when this difference increases by 1%, the total commute distances increases by only 0.33%. This number is smaller than 1 and indicates that when the distance traveled by the spouse who moves the farthest increases by a certain percentage, that of his spouse increases by a percentage that is lower. This confirms the fact that the trips of the two spouses are complementary and that one of the spouses adapts his trips to the other's.

And last but not least, the coefficient related to W1-H-W2 angle is not significant. This suggests that two-earner households in Paris region do not use localization strategies to reduce their total commute distance[25]. This result only appears after instrumentation. Given the economic dynamism of the region, this result can be explained by the saturation of its real estate market.

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[24]Total commute distance of the private renting sector tenants is higher than that of the of the social sector tenants. On the other hand, first-times buyers total commute distance is higher than that of owners.

[25]W1-H-W2 angle distribution is available in the appendix.

	Total commute distance	
	Coefficient	STD
Constant	24.70***	7.27
Residency crown		
Big crown	0.30***	0.05
Small crown	0.11**	0.04
City of Paris	Ref	
Housing occupancy status		
First-time homebuyers	0.17***	0.03
Private renting sector tenant	0.10**	0.04
Homeowner	0.18***	0.043681
Social sector tenant	Ref	
Public transport subscription		
None of the spouses	-1.12***	0.20
One of the spouses	-0.50***	0.09
Both spouses	Ref	
Vehicles available		
2 or more	0.16	0.12
1	-0.24***	0.22
0	Ref	
Log residence accessibility	-47.34***	2.57
Log workplace accessibility	13.39***	2.14
Age	25.42***	2.32
Age squared	-0.002	0.01
Age average	-0.00007	0
Ln of shortest -longest distance	0.33***	0.01
Logit W1-H-W2 angle	-0.07	0.06

Table 5: Total commute distance using IV

6 Conclusion

The empirical literature on home-workplace trips of two-earner households work-ers is full of conflicting results. This can be explained by the fact that the studied areas differ in terms of amenities, places of interest and historical heritage, but that is not all. The usage of simple econometric estimation techniques that don't address endogeneity problems is also an important element.

In this paper, the case of Paris region two-earner households trips is ex-plored. The various endogeneity tests reveal its existence. It is dealt with using instrumental variable and 3SLS techniques.

The obtained results show that two-earner households trips are shorter than those of single-earner ones, that women are on the one hand affected by the presence of children in the household and on the other hand adapt their trips to those of their spouses and not men.

Moreover, the non-significance of W1-H-W2 angle related coefficient proves

that Paris region two-earner households don't use localization strategies to reduce their total commute distance.

To conclude, some limits to this work must be noted. Firstly, the databases don't give information about the means of transport usually used for home-workplace trips. The only information available refers to the means used the day before the survey. Secondly, the home-workplace distances given are actually Euclidean distances. Real traveling distances are not available. Concerning housing characteristics, the information available is not detailed enough to properly understand the trade-off between traveling distance and housing quality. Finally, in terms of income, the information available relates only on the category of income to which the household belongs without specifying its sources. This is problematic particularly to control for the relationship between traveling distances and wage.

However, the results presented here remain robust and stable enough to draw relevant lessons that must be taken into consideration by Paris region planning policy makers.

Appendix

Endogeneity tests and efficiency of the instruments

Workers commute distance

H0 : Absence of endogeneity			
Variable	Type of test	Test statistic value	P-value
Number of vehicle	Wald	0.00	1
Public transport subscription	Wald	0.00	1

Table 6: Endogeneity tests

H0 :orthogonality		
Instrument	Test statistic	P-value
Log surface	1.82	0.17
Diploma	0.05	0.89
Paying parking fees	1.68	0.19
Employment contract of the spouse	2.14	0.14
Housing type	2.02	0.13
Log rent	4.02	0.05
Public bike subscription	9.49	0.002

Table 7: Orthogonality of the instruments

	Coefficient	STD
Constant	0.19***	0.02
Housing type		
Collective dwelling	-0.11***	0.02
Individual dwelling	Ref	
Paying parking lot fee at home		
Yes - The exact amount is not known	-0.61***	0.23
No - Included in the co-property/rental charges	-0.35***	
No	Ref	

Table 8: Efficiency of the number of vehicles instrumentation

	Coefficient	STD
Constant	1.18***	0.11
Log of house surface	-0.50***	0.02
Educational level		
Without baccalaureate	-0.10**	0.04
Bac + 2 years	0.06	0.04
Bac + 3 years or more	0.18***	0.04
Baccalaureate	Ref	

Table 9: Efficiency of public transport subscription instrumentation

Two-earner households total commute distance

H0:Exogeneity of logit W1-H-W2 angle		
Type of test	Statistic of the test	P-value
Wald	87469	<.0001

Table 10: Endogeneity test of logit W1-H-W2 angle

	Coefficient	STD
Constant	0.15***	0.03
Man has a higher education diploma		
No	-0.24***	0.05
Yes	Ref	
Woman has a higher education diploma		
No	0.07	0.05
Yes	Ref	

Table 11: Efficiency of the instrumentation of having a public transport subscription

	Coefficient	STD
Constant	0.15***	0.03
Man having a higher education diploma		
No	-0.24***	0.05
Yes	Ref	
Woman having a higher education diploma		
No	0.07	0.05
Yes	Ref	

Table 12: Efficiency of instrumenting the number of vehicles

	Coefficient	STD
Constant	1.28**	0.52
Log house surface	-0.55***	0.11

Table 13: Efficiency of W1-H-W2 angle instrumentation
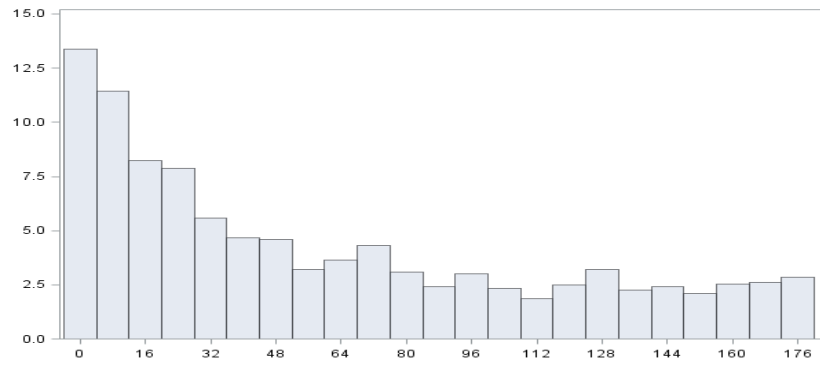
W1-H-W2 angle distribution

Figure 2: W1-H-W2 angle distribution

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