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Residential Choice and Households Strategies in the Greater Paris Region

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Abstract

Households' strategies relative to residential choice in the Greater Paris Region are developed in this paper. The question of the presence or not of a trade-off between transport and housing expenditures is tackled. Evaluation method, discussed at length throughout the paper, is based on the combined use of a daily mobility survey, of transit and traffic assignment models, and of additional prices and household expenditures databases.

Results point out that average transportation budget share (as the ratio of transport expenditure on income) grows significantly with increasing distance to Paris, from 7% to 21% for the furthest zone. Housing budget shares remain fairly stable over location, with an average of 33%. Nevertheless, a slight decreasing trend of these latter shares leads to total transportation plus housing budget shares which seem relatively stable relatively to location, with a mean of 44%. While this seems to corroborate the existence of a trade-off between transport and housing expenditures, further analysis, taking incomes into account, unveils that this is in fact not the case. For instance, middle and high incomes groups allocate a constant share of their budget to housing, and therefore bear a total budget share highly dependent on transport share and thus on location. For low income households, the situation is worse: the transport share is also increasing with increasing distance to Paris, but the housing share is so significant that there no longer is a trade-off issue. Low-income households face such a strong housing constraint due to their needs (household size), their low resources and the housing supply (location, price and type of dwelling available) that the question of transportation costs is probably neglected.

1. Introduction

1.1 The housing and transport linkage with policy implications

With the increasing concerns about global warming and the rise of energy prices, the issue of land-use planning, and more precisely of the linkage between transportation and land use, has become a major topic of interest. Previous transport policies in many European cities, mainly in favour of car use, have led to urban sprawling, which is well known to come along with an increase in energy consumption.

The issue of the interactions between transportation and residential choices has been tackled by a number of research projects. Notably, the question of whether the distance to the Central Business District has an influence or not on the housing price, as suggests the urban economic theory, has largely been addressed. Nevertheless, most studies focused on the impact of transportation supply on housing prices, and did not consider the issue from the household point of view. However, households' location behaviour is a major motor of the urban dynamics.

Therefore, several projects such as Scatter in Brussels or Simaurif in Île-de-France have been undertaken to deepen the knowledge of the links between transportation supply and residential choices.

1.2 Microeconomic theory

In this paper, we adopt a broader approach by addressing the matter of household strategies in residential choices.

Numerous economic studies, theoretical as well as empirical one, tried to bring to light the main determinants of location choices. It results from all these studies that models can hardly account for the diversity of behaviours, which is the outcome of the heterogeneity of households' preferences for different urban services. Thus, works on the household behaviours are not articulated as clearly around stylized facts as those on the firms; moreover, empirical works seem to outnumber theoretical works.

This said, theoretical results can be schematically articulated around four axes:

- the housing-transportation trade-off : in standard urban economic theory, the model of the monocentric city, developed by Von Thünen and then improved by Alonso (1964), Mills (1967) and Muth (1969) addresses the issue of residential location choice within a simplified framework. The city is assumed to be a homogeneous plain, all employment being located at the center. To determine its residential location, which is simply characterized by the distance to the center, the household maximises its utility under a budget constraint, which leads to a trade-off between the costs of their daily commutes and their housing costs. The bid curve representing the maximum price for a unit of land that an individual is willing to pay in each place of the city is decreasing with the distance to the central business district (CBD). In each location, land use is allotted to the individual offering the highest bidding. This model leads to land rents which decrease according to the generalized cost of access to employment

- the "amenity-accessibility trade-off" improves the preceding model by considering amenities in the household utility function; it can lead to contrasted results in terms of household behaviors and resulting equilibria depending on the amenities gradient. It also raises the issue of assessing amenities. Depending on whether the amenities are regarded as more important in the center (cultural and social amenities) or in the periphery (space, landscape, reduction of the harmful effects of vicinity), the model predictions will vary accordingly.

- the relationship between income and location was studied in a variety of works, in particular to explain the differences between American and European cities; to summarize the theoretical results, if the elasticity of transportation costs is higher than the elasticity of housing demand, high income households will prefer the center and *vice versa*. However, some empirical studies showed that the two elasticities were very close, and others stressed the importance of the preferences for urban amenities which are strongly related to income and thus dominate the preceding effect.

- urban segregation spawned many theoretical and empirical works, e.g. the Schelling model (1969). To sum up the main results, the externalities of vicinity, the social and cultural attitudes build the urban environment and lead spontaneously to space concentration of homogeneous social groups. This phenomenon is reinforced by two mechanisms: the concentration of the social groups with low incomes in certain zones decreases the capacity of financing public services and thus the attractivity of these zones; the stigmatization of the workers living in these zones increases the rate

of unemployment there; in addition, residential mobility being weaker for low-income social groups, urban segregation is characterized by irreversibility or important hystereses.

Despite all these achievements, there exist still some shortcomings in the theory. For instance, the fallouts of the trade – off on the household expenditures remain unclear unless in few specific cases.

1.3 Empirical evidence in the Paris area

The issue of interactions between transportation and housing is becoming more compelling by the day in the Greater Paris Region, both politicians and public opinion becoming more sensitive to the particular issue of urban sprawl. Therefore, our work takes place in a series of studies tackling the issue of housing – transport interactions in the Paris area.

The IAURIF ("Institut d'Aménagement et d'Urbanisme de la Région Ile-de-France") and the THEMA, a laboratory of the Cergy-Pontoise University, engaged in June 2003 a research on the interaction between urbanization and transportation. This research aims at developing a dynamic and integrated model on the Ile-de-France area. This model, called SIMAURIF, uses three existing models:
- UrbanSim, a land-use model, developed by Washington University in Seattle,
- METROPOLIS, a dynamic road traffic model developed by the THEMA,
- the IAURIF model for the graphs networks, the origin-destination matrices of demand and the transit assignment model. Although great advances have been achieved in this project, few empirical results are currently available to our knowledge, since the calibration of all the models is so time consuming.

In another direction extremely similar to our approach, Polacchini and Orfeuil (1999) examined the interactions between transportation and residential choices in the Greater Paris Region (Ile-de-France region), by studying housing and transportation budget shares. Housing expenditures correspond either to a rent or to a repayment of housing loans. Transportation expenditures were estimated from a survey on households' daily mobility in the Greater Paris Region in 1991 (Enquête Globale Transport). The Greater Paris Region was furthermore divided into 9 zones reflecting decreasing prices. The authors found that the budget share of housing was roughly constant, irrespective of the zone of residence; it seemed that precautions taken by banks and lessors were effective in limiting households' housing expenditures and ensuring households' solvency. Travel time budgets were found to be constant from one zone to another. However, travelled distances grew steadily from the most expensive to the cheapest zones, that is to say the further from the center, thanks to an increasing use of the car, so that the share of the income assigned to transport was strongly increasing with the distance, and could reach the equivalent of the housing expenditure in the most distant zones. On the whole, if there is compensation between transport and housing expenditures in the central zones, the share of the total "housing and transportation" expenditure in the income is significantly increasing as one goes towards the cheapest prices zones. Polacchini and Orfeuil also showed that, from the most expensive towards the cheapest zones, the households' size increases and the average income decreases, so that the average income per consumption unit strongly decreases : on average, the "choice of the distance" and the weakest price's zones is the fact of the families with modest incomes. Thus, regulations limiting housing expenditures to a certain ratio of the income seize only one part of the phenomenon and may even have negative aftermaths as they can conduct modest households towards zones with lower housing prices, but with higher total "housing + transportation" costs, thus endangering their financial condition.

Berri (2007) confirmed this work using expense data from the Family Budget surveys (Enquêtes Budget des Familles) conducted by the National Institute of Statistics and Economic Studies (INSEE) in 1978-79, 1984-85, 1989 and 1994-95. The sequence of four surveys allows a setting in prospect on more than 15 years, during which the diffusion of the car intensified, the systems of price changed

and urban sprawl increased. Note that the space level of aggregation is coarser (Paris/Première Couronne/Grande Couronne) than Polacchini and Orfeuil's one. Conclusions are however very close.

Note that Cervero and al. (2006) were also interested in the trade-offs between costs of transport and costs of housing: the authors seek to understand in what way the trade-offs of "working families" of 7 American metropolitan areas (Atlanta, Chicago, Dallas, New York City, Los Angeles, the San Francisco Bay Area, Baltimore-Washington) differ from those of wealthier families ("upper income families").

Given this series of studies tackling the issue of housing – transport interactions in the Paris area, we will now expose the main objective of this present work.

1.4 Objective

The main purpose of this article is to study households' location strategies: in an update of Polacchini and Orfeuil's work (1998), we will seek to evaluate whether households proceed to a trade-off between transportation costs and housing costs.

To do so, we bring forth a geographical analysis focused on the households' transportation and housing budgets in the Greater Paris Region. The relative weight of each budget in the global budget of the households, and the presence or absence of a relationship between the two, will be highlighted.

In order to account for the great variability of households' strategies according to their characteristics, the income and the structure of the household will be used as control factors in the subsequent analysis.

1.5 Method

Housing and transport matters are still often a matter of different cultures, with no coordinated instruments of observation: Transportation surveys are often more oriented towards detailed practices of mobility and leave relatively little place for transportation costs and even less for housing characteristics and costs. Conversely and logically, housing surveys focus on the detailed characteristics of housing and include few questions on the associated transportation expenditure. Though surprising it might seem, this particular point reflects the diversity of local authorities holding stakes existing in the Greater Paris Region, may it be at the transportation or at the housing level, this diversity going against a concerted collection of data.

This study, its methodology and limits, are largely due to this sectorized way of functioning and to a somewhat limited access to comprehensive data. Mobility costs, that is to say, transportation expenditures as well as travel times and distances will be computed thanks to the Enquête Globale de Transport (EGT) of 2001, a regional household trip survey carried out in the Île-de-France and giving very detailed information about mobility practices on a daily basis. On the other hand, up to now, we did not have access to a specific housing data. However, Polacchini and Orfeuil's work has had as the useful outcome to enrich the EGT 2001, in particular concerning households housing characteristics and costs. Finally, the EGT 2001 gives us comprehensive information about the households, their location, their income, their mobility, their dwelling, and enables us to derive housing and transportation costs. Note that we focus on new house – buyers, private and public renters, since no housing costs could be computed for house owners. However, given the rates of non-responses and nonsensical answers, especially for the new housing characteristics, we have to remain careful: this work has to be considered as an exploratory study that needs more data and checking to produce final and robust answers.

1.6 Structure

The paper is divided into six sections, section 1 being the introduction. An overview of the different databases is developed in section 2. Sections 3 and 4 present our methodology to compute transport and housing budgets. The geographical analysis of households' strategies is undertaken in section 5. Section 6 offers some conclusions.

2. The database issue for the Paris Area

Before tackling the issue of available housing and transport data for our study, we will proceed to a short presentation of the Paris area, so as to point out some specific characteristics of this region. Then, the main types of databases used in this study will be described. ,

2.1 Presentation of the Greater Paris Region

The "Région Île – de – France" (IDF), or Greater Paris Region, is composed of Paris and its seven closest "départements" (administrative divisions within the Region), which form two rings around Paris. The inner ring, composed of the Seine St Denis, the Val de Marne and the Hauts de Seine, is called the "Petite Couronne", while the outer ring is called the "Grande Couronne".

Figure 1 : The Greater Paris Region

In 1999, according to Census, 4,5 million households inhabited the Paris area, summing up to 10,9 million people, with approximately 2 million people living in inner Paris.

The two following maps, both representing human activity density (which is defined as the ratio (population + employment)/built surface), highlight a significant concentration of activities in and close to Paris:

Figure 2 : Human Activity Density in the Greater Paris Region (Source : Census)

This tends to indicate that the Greater Paris Region could fit the monocentric assumption. Unfortunately, such is not the case, since further analysis points out several major spatial heterogeneities. E.g. high income households are concentrated in the western part of the Paris area, as shown in figure A (provided in annex).

Local housing price indexes also display strong non – isotropic features, as can be observed in the figure below:

Figure 3: 2005 local housing price indexes (Source : Hourdez (2005))

Local housing price indexes are here simply defined as average prices per square metre in the private rental sector, using data from Hourdez (2005). In 2003, prices in the private rental sector were typically around 10-12€ per square metre, except in inner Paris or in the cheapest zones within the region. While the map does exhibit a decrease of housing prices with increasing distance to Paris, it also points out major asymmetries, such as high housing prices in the Yvelines and the Hauts – de - Seine départements (both located in the west of Paris).

Conversely, the transport system does exhibit strong isotropic features. The road network is designed like a spider web centered on Paris, as can be noted in figure B provided in Annex. At first glance (see figure C), the public transit system falsely seems homogeneously developed throughout the region. Nevertheless, the study of the subway and regional railway network (the latter being the fastest public transit mode by far) unveils a blatant radial structure, as can be seen in figure D.

Considering the particularities of the Greater Paris Region, the IAURIF (“Institut d’Aménagement et d’Urbanisme de la Région Ile-de-France”) proposes a zoning sytem which is especially designed for transport issues. While this zoning system might not a priori be optimal for addressing both transport and housing issues, it possesses several desirable features, such as increasing distance to Paris with increasing zone number, and it a posteriori proved effective for our study.

Figure 4 : The IAURIF Zoning System

Moreover, the IAURIF 8 zones system takes account of peculiarity of the Greater Paris Region, the "Villes Nouvelles". "Villes Nouvelles" are a set of recently developed agglomerations that, while being located somewhat remote from Paris, have a very good access to the capital thanks to highways and heavy rail public transit services. Considering all these characteristics, we deliberately chose this zoning system for this study.

2.2 On transport-oriented databases

Three main types of transport databases are used in this study:

- A mobility database
- Transport supply and demand databases
- Price and household expenditure databases

In order to study daily mobility, the "Enquête Globale de Transport" (EGT, which literally translates as Global Transport Survey) is used in this work. This survey, carried out by the DREIF, is the major survey concerning daily mobility in the Greater Paris Region. The 2001 survey is the fifth EGT, thus the methodology is quite robust. The EGT provides comprehensive data regarding household and individual characteristics, daily trips, and the 2001 version even provides some data about housing characteristics and costs.

The EGT consists actually of two parts, a week day survey and a week – end survey. The first one addresses daily mobility for the week, and provides a one day observation for each household. 10 478 households answered the week day survey, adding up to a total of 23 656 individuals, which corresponds to a sampling fraction of 0.23% of the households. About one third of the surveyed households were asked to answer the week – end survey, and had to provide information about their trips for both Saturday and Sunday. The week – end survey thus differs from the week day survey, since it provides information for two days instead of one. It is also less detailed in its content.

Transport supply and demand databases constitute our second main set of databases, necessary for our transit assignment model and for our road model. All those databases were provided by the DREIF, and completed and revised by Thierno Aw (LVMT). More precisely, we use a public transit supply database, integrating the transit network, transit services with their main characteristics (such as vehicle headway by transit line for the peak period), and a simplified tariff system. For the traffic assignment model (the road model), classic supply and demand databases are used.

Lastly, transport price and expenditure databases were put to use in order to evaluate public transit and private vehicle expenditures. A detailed price database of the Greater Paris public transit system was provided by the RATP, while a combination of several databases was required to estimate private vehicle fixed and variable costs. This mainly includes a fuel consumption survey carried out by the Energy Observatory in 2003, which allowed us to monitor fuel consumption, and the 2001 Family Budget Survey ("Enquête Budget des Familles 2001"), which gives comprehensive data at the regional level for households' budget composition. The latter enabled us to estimate fixed costs and variable costs other than fuel expenditure, and to calibrate our two work hypotheses. Other costs databases were used to validate the estimation of fixed and variable costs.

2.3 On housing-oriented databases

Housing statistical sources are numerous, with approximately fifteen to twenty different surveys describing the housing (such as physical characteristics or prices, rents, residential mobilities or volumes) as well as its dwellers. However, a good half of these surveys are carried out from a national level sample. That means that these surveys provide some good framing data but can not be used for our study, which aims at looking further into local markets' mechanisms. Moreover, only a reduced number of statistical sources are exhaustive; most surveys are only available at the city level, which is too coarse a level when one treats local housing markets. Furthermore, among these surveys, only the ones relating to prices and rents of the IDF region allow us to estimate the housing expenditure for each household.

Eventually, it appears that only a few "exhaustive" sources are obviously able to produce a true base of knowledge on the housing local market of IDF. These are the FILOCOM (FIchier des LOgements par

COMmunes) file and some specific sources like the notarial data or the rents surveys. The FILOCOM file is a database built by the Direction Générale des Impôts which brings information at a very fine spatial level on housing characteristics (such as the price and rental values) and dwellers characteristics (such as their income). The notarial databases constitute one of the rare exhaustive sources as regards real estate transactions. More precisely, the base BIEN (Base of Notarial Economic Information) registers all IDF area real estate and land transactions, starting from the actually signed notarial acts. Concerning rents, the private rental sector suffers a serious lack of global data: only the financing of specific housing surveys, such as those carried out by the Office des Loyers de l'Agglomération de Paris (OLAP), enables data collection. By contrast, many surveys on the public rental sector are carried out (Enquête sur le Parc Locatif Social (EPLS), enquête sur l'Occupation du Parc Locatif Social (OPS)). All these data sources characterize at the same time the housing and its occupants, and provide information on households' income and the financial effort they are willing to make for their dwelling. However, this type of information, as those on the incomes, is, in France, difficult to obtain or unavailable. Thus, at this date, we do not have access to a specific housing database. The access to the FILOCOM file is restricted to few State services, and the base BIEN and rent surveys are difficult to acquire. Moreover, supposing we had access to these various bases, we would still have to relate them to the mobility database, which in itself constitutes a major hardship. Even linking one housing database to another proves harder than it seems: the difficulties hold either to the variables' definition, or to the observation scales, or to the perimeters covered by the surveys, which differ from one institution to another.

However, thanks to Polacchini and Orfeuil's work, the EGT 2001, which is in first place a regional household mobility survey, has been enriched with variables concerning households' housing characteristics and costs. Households' residential location is geocodified at a 300mx300m level; dwelling status (renters, owners, home-buyers…), type of housing (house, collective flat), housing superficies, amount of rent or amount of loan's refunding are filled in. Finally, the EGT 2001 gives us comprehensive information about the households, their location, their income, their mobility, their dwelling, and enables us to derive housing and transportation costs. Given the traditional sectorized way of functioning of France, the EGT 2001 is a first step toward an integrated approach of housing and transport matters, which is quite good news. However, since these improvements concerning the housing side are quite new, we could fear a lack of reliability (see 4.4). To control the quality of the housing EGT data, and especially the stated rents and refundings of loan, we used a database produced by Hourdez (2005), which gives for each city within the Greater Paris Region the theoretical prices per m² according to the dwelling status and the number of rooms: these theoretical prices were computed based on real estate agencies' data and aggregated at the city level. Hourdez' database is probably not panacea, but still remains a satisfactory tool to control and replace when necessary some incoherent stated prices in the EGT.

3. The evaluation of transport budgets

After this overview of the different databases used in this study, this next section describe the methodology used to compute transport expenditures. Some results and comments will then be presented.

3.1 Scope of transport budgets

The aim of this article is to study household strategies regarding residential choice, and notably to question the existence or not of a trade – off between housing costs and transport costs subsequent to the residential location choice. Therefore, only transport costs linked to daily mobility are considered, excluding costs related to holiday mobility, which are considered beyond scope.

Transportation costs do include monetary costs, which will be referred as transport expenditures, nevertheless the scope of the study is larger and also includes travel time and distance budgets as significant decision variables for households.

Transport expenditures borne by the household can be broken down into three categories of expenditures:

- Public transit budget : this includes the purchase of passes and tickets
- Private vehicle budget: private vehicle costs encompass fixed costs and variable costs, for cars, two – wheeled vehicles and commercial vehicles
- Parking budget: this includes expenditures linked to the rental or the purchase of a parking lot, and payment of parking tickets

Variable costs for private vehicles incorporate fuel expenditures, maintenance and purchase of accessories for the vehicle. Fixed costs include the purchase of the vehicle and insurance costs.

3.2 Evaluation method

Detailed evaluation method is provided in annex. This said, here are the main specificities of our evaluation method:

- Household monetary budgets are evaluated on a monthly basis
- Household non – monetary budgets are estimated on a daily basis
- Two work hypotheses were made concerning fixed costs. H1 hypothesis assumes that fixed costs are as actually variable costs, perfectly correlated to fuel expenditure. H2 hypothesis assumes on the other hand that fixed costs are indeed fixed, and that each household faces the same fixed cost per vehicle, whatever the age, brand or power of its vehicle may be. We do distinguish between cars and commercial vehicles, two – wheeled motorized vehicles and bikes though.

Regarding non – monetary budgets, one novelty of our approach lies in the fact that instead of using stated times and distances provided in the EGT, we estimate the two budgets using a transit assignment model and a traffic assignement model. Both of these models run with the TransCAD software. The advantage of this approach is twofold:

- As regards distance budgets, we can compute network distances instead of crowfly distances corrected by a curvature factor as commonly used in other studies.
- As regards time budgets, we have an alternate measure of the travel time, which is not sensitive to respondents'statement errors.

3.3 Results

Estimations of the different budgets are presented and discussed in this sub – section.

Distance budgets are presented at the household level, so that we can discuss the impact of motorization and location. Note that house owners are excluded from the dataset, so as for the coherence of results with the housing section (see section 4):

Chart 1: Distance Budgets relatively to the number of cars

IAURIF	Location	Number of Cars	All

	0	1	2 and +	
	Average Distance Budget (kilometres)			
Paris	19,8	31,1	49,1	25,5
Inner Suburbs	26,5	41,2	60,2	38,9
Outer Suburbs	27,8	48,6	73,3	50,4
Agglomeration fringes	28,8	56,1	87,6	67,7
« Villes Nouvelles »	35,7	65,7	97,2	70,6
Accessible cities	32,5	71,4	108,7	79,9
Isolated Cities	23,3* ()	79,5	123,8	88,7
Rural	34,8**	91,9	149,1	131,4
All	24,3	47,2	84,5	47,7

Source : Authors' calculations

Estimation of households' distance budgets unveils an increase of travelled distance with the variable "IAURIF location", from 25km a day for zone 1, to 131 km a day for zone 8. This result is not surprising since IAURIF location variable is correlated to the distance to the CBD as mentioned previously. Distance budgets also increase with motorization, which also makes sense since cars allow for greater speeds than public transit, and two cars in a household often being a signal of a two – earner household. When the household owns no car, the relative decrease in distance travelled for the last zones (except the rural zone) goes along with the lack of public transit services for these zones. Two explanations arise: the lack of public transit might lead to an endured decrease in mobility, but the decrease in mobility might also reflect a particular location strategy, e.g. a retired household getting away from the city and knowing that it has few needs for good public transit services. Moreover, it must be noted that the number of observations for these particular classes is quite small.

In comparison to distance budgets, individual travel time budgets are much more stable respectively to individual's location, with an average of 64 minutes spent in transport a day, as shown in the chart below:

Chart 2 Individual Travel Time Budgets

IAURIF Location	Travel Time Budget (Minutes)
Paris	65,0
Inner Suburbs	61,9
Outer Suburbs	61,2
Agglomeration fringes	63,0
« Villes Nouvelles »	65,7
Accessible cities	69,7
Isolated Cities	73,1
Rural	78,4
All	64,0

Source : Authors' calculations

This result does bode well, since Zahavi's law is known to be accurate for the Greater Paris Region. We can observe a slight increase of the travel time budgets for the last zones, but the relative increase remains small compared to the increase in travelled distances.

Lastly, the breaking down of transport expenditures in the main categories points out that private vehicle expenses account for the major part of the transport budget with each of the two work hypotheses:

Chart 3 : Household Monetary Transport Budgets in Euros (H1 Hypothesis)

IAURIF Location	Transit Budget	Private Vehicle Budget	Parking Budget	Total Transport Budget
Paris	31,7	71,1	29,4	132,2
Inner Suburbs	30,8	144,5	19,9	195,3
Outer Suburbs	30,0	208,1	18,5	256,6
Agglomeration fringes	26,6	293,0	22,1	341,7
« Villes Nouvelles »	36,8	264,3	17,2	318,3
Accessible cities	31,3	291,9	18,9	342,1
Isolated Cities	22,4	380,1	14,9	417,4
Rural	42,3	630,1	41,5	713,9
All	31,1	181,8	22,2	235,1

Source : Authors' calculations

Chart 4 : Household Monetary Transport Budgets in Euros (H2 Hypothesis)

IAURIF Location	Transit Budget	Variable Private Vehicle Budget	Fixed Private Vehicle Budget	Parking Budget	Total Transport Budget
Paris	31,7	26,4	46,3	29,4	133,8
Inner Suburbs	30,8	53,6	77,0	19,9	181,3
Outer Suburbs	30,0	77,2	102,5	18,5	228,1
Agglomeration fringes	26,6	108,7	135,1	22,1	292,5
« Villes Nouvelles »	36,8	98,0	114,0	17,2	266,0
Accessible cities	31,3	108,2	121,9	18,9	280,4
Isolated Cities	22,4	141,0	123,7	14,9	302,0
Rural	42,3	233,7	186,7	41,5	504,2
All	31,1	67,4	87,4	22,2	208,2

Source : Authors' calculations

The analysis of the two charts highlights very similar results for both hypotheses, the main difference lying in the estimation of private vehicle expenditures for the last two zones. For these zones, the increase of travelled distances outweighs the increase in mean number of cars, which leads to higher transport expenditures for the last two zones with the H1 assumption. This said, we choose to keep only the H2 hypothesis for the remainder of the study.

Working with H2, private vehicle expenses (adding up to 155€) account on average for 75% of the household transport budget, public transit expenditures only standing for 15% and parking for 10% of the transport budget. While the two former budgets are relatively stable over location, fixed and variable private vehicle costs are highly sensitive to the zone of location, reflecting both motorization choices and an increase in travelled distances when moving away from the CBD. For the last two zones, variable costs are even greater than fixed costs. This entails an increasing total transport budget with increasing zone number, from 134€ for inner Paris to 504€ for the rural area. The worse situations in terms of transport expenditures seem to be explained by the distance to Paris and somewhat by a lack of public transportation supply. We will not proceed any further in the analysis for the time being, section 5 providing a more thorough discussion about these results.

3.4 Comments

While annex provides a detailed discussion item by item of the main issues encountered while setting up our methodology, and the induced limitations of our results, we will discuss here few points relating to fixed and variable costs.

The first issue when assessing private vehicle budgets was dealing with variable and fixed costs. So called “fixed costs” are not entirely fixed. An individual travelling 40 000 km a year with his car will need to replace his car faster than one driving 5 000 km a year. Similarly, the former driver will be more likely to have accidents, all other things being equal, and therefore to have a larger insurance rate. This works the other way round, car replacement being not perfectly correlated to fuel expenditure (nor to mileage). That’s why H1 and H2 hypotheses were put to test. We chose these simplifying assumptions, so as for the clarity of the demonstration, but also because not enough information is available in the EGT to accurately allocate fixed and variable costs at the household level. While it is interesting to note that agregate results are not very sensitive to this hypothesis, further analysis should be led to validate H2.

Regarding fixed costs, another issue relates to holiday mobility. Private vehicles are also used for such a purpose, therefore fixed costs should be reduced accordingly. While this assumption is implicit in H1 because of the way fixed costs are computed, we discounted fixed costs in H2 by one third. The discount factor was estimated based on the estimation of yearly fuel expenditure linked to daily mobility, compared with data on total yearly fuel expenditure provided in the Family Budget Survey (which once more proved its usefulness).

Starting from section 5, we will work exclusively on monetary budgets, for the sake of clarity and simplicity. This said, we will keep in mind non – monetary costs (that is to say travel times and distances) and its implication for monetary costs as well as household strategies.

4. The evaluation of housing expenditures

The major issue of this article is to unveil the existence or not of a trade – off between housing costs and transport costs consequential to residential location choice. Previously, transportation costs, including, monetary costs, travel time budgets and distance budgets have been assessed. This next section will now focus on the housing side of the trade-off: we will first present the methodology used to compute housing expenditures, followed by results and comments.

4.1 Scope of housing expenditure

The housing budget is calculated at the household level, as the rent, in case of tenants of private or public sectors, or as the refunding of loan, in case of new home buyers, paid by the household. It is

indeed impossible with our data to establish a total expenditure (housing and transportation costs) for owners who don't pay anymore loans: thus they will be cast aside in this study.

4.2 Evaluation method

As mentioned previously, housing expenditure is estimated for private and social renters based on the rent and for new home buyers based on the refunding of the loan. To control the reliability of the data on rents and loans, we use a database produced by Hourdez (2005) which gives for each city of the Greater Paris Region the theoretical prices per m² according to the dwelling status and the number of rooms: These theoretical prices were used to control and replace when necessary the stated prices. The housing budget share of a household is obtained by the ratio of its housing expenditure on its income. It is calculated for households (owners excluded) whose income is indicated. In the EGT, the income is known by class. At the present time, the household income corresponds to the barycentre of the class of income to which it belongs. A study of the income distribution for the Paris area would allow an improvement of the income estimate, and consequently of the housing share estimate.

4.3 Results

Estimations of the housing budgets are presented and discussed in this sub – section.

Chart 5 : Household housing budgets relatively to dwelling status

Inner Suburbs
843
565
352
509
Outer Suburbs
821
532
351
538
Agglomeration fringes
810
539
388
616
« Villes Nouvelles »
768
511
423
566
Accessible cities
756
506
386
549
Isolated Cities
772
543
308
520
Rural
723
528*
434*
667
All
801
589
368
554

Source : Authors' calculations

Chart 6: Household housing budget shares relatively to dwelling status

IAURIF	**Dwelling Status**			
Location	**Home Buyers**	**Private Renters**	**Public Renters**	**All**
	Housing budget / income			

	Mean	Mean	Mean	Mean
Paris	0.32	0.45	0.30	0.40
Inner Suburbs	0.26	0.34	0.27	0.30
Outer Suburbs	0.30	0.34	0.33	0.33
Agglomeration fringes	0.24	0.32	0.26	0.27
« Villes Nouvelles »	0.30	0.43	0.27	0.31
Accessible cities	0.27	0.34	0.34	0.31
Isolated Cities	0.30*	0.31*	0.36	0.33
Rural	0.24	0.35*	0.33**	0.27
All	0.28	0.39	0.30	0.33

Source : Authors' calculations

Whatever the location, average home-buyers' expenditures are more important than tenants' expenditures. Rents in the private sector and refundings of loans slightly drop with increasing distance to Paris; a less clear tendency can be seen for the public rental sector. Conversely, the housing share in income is more important for private sector tenants than for home-buyers. The ratio is yet somewhat stable whatever the location, except for Paris, where the housing share is on average significantly higher than every where else.

Following charts points out that average housing expenditure is higher for houses than for flats, and is quite determined by the household type: family with children bear higher expenditures than couples with no kids or single persons or single parents. The housing budget also grows with the numbers of workers in the couple. Thus, it seems that housing budgets are coherent with households 'constraints, like their size or their resources.

Chart 7 : Housing budgets relatively to dwelling type and household type

	Dwelling type		
	Collective Flats	**Individual Houses**	**All**
	Housing Budget (euros)		
Household Type	**Mean**	**Mean**	**Mean**
single	430	409	428
couple <= 40y	561	766	583
couple > 40y	530	882	593
family kid<6y	594	884	679
family kid 6-12	608	805	680
family kid 12-18	559	805	662
family kid>18	600	818	667
single parent	446	693	475
All	504	781	554

Source : Authors' calculations

Chart 8 : Housing budgets relatively to number of workers

	Numbers of workers in the couple			All
	0	1	2	
	Housing Budget (euros)			
	Mean	Mean	Mean	Mean
All households	415	514	696	554

Source : Authors' calculations

Chart 9 : Housing budget shares relatively to dwelling type and household type

	Dwelling type			All
	Collective Flats	Individual Houses	Else	
	Housing Budget / Income			
Household Type	Mean	Mean	Mean	Mean
single	0,4	0,37	0,35	0,4
couple <= 40y	0,25	0,36	0,16**	0,26
couple > 40y	0,26	0,27	0,14**	0,26
family kid<6y	0,27	0,3	0,25**	0,28
family kid 6-12	0,31	0,29	/	0,3
family kid 12-18	0,34	0,3	/	0,32
family kid>18	0,26	0,27	0,14	0,26
single parent	0,38	0,41	0,29	0,39
All	0,33	0,31	0,29	0,33

Source : Authors' calculations

Conversely, single parents and single persons have the most important housing budget share. And the ratio is also lower for home dwellers than for flat dwellers. These tendencies are strongly linked to the average income of each household type: those who have the most expensive housing budget are not those who face the most important housing effort.

4.4 Comments

We will now discuss the main issues encountered while setting up our methodology, and the induced limitations of our results.

Settling the question of the reliability of housing costs is the main issue relating to housing expenditure. As a matter of fact, in addition to statements and information biases, our housing expenditure is affected by certain biases difficult to correct but that we have to keep in mind:

- The real housing expenditure can be less than the stated expenditure. This is due to the existence of public housing subsidy for low-income households (APL), which are not addressed by the survey. Thus, there is a potential over estimation of the housing expenditure. Moreover, another tricky point is that, though it is likely that most households declared the absolute amount paid, some might have

taken into account these benefits and deduced them from their total rent. However, in his work on Great Paris Region's households, Berri (2006) compared housing shares based on net housing expenditure, that is to say, absolute amounts paid net of housing subsidy, to housing shares based on absolute expenditure: the difference, if any, is only of some tenths of percentage point. Thus, it seems that these housing subsidies have few impacts on housing shares, which is quite reassuring.

- The initial contribution to buy a home is not known and thus not taken into account while it often stands for a significant share of the housing expenditure.

- Charges and taxes (such as the dwelling tax and the land tax) are also part of the housing expenditures; they are quite dependent on the type of housing and its location. Despite their sizeable amount in the housing expenditure, they are not addressed in the survey and consequently not taken into account in the housing expenditure.

While these biases are detrimental to our results, their outreach remains limited and should not overhaul 10 to 15% of the total housing expenditure. Furthermore, some costs such as taxes or initial contributions are omitted for all households, in such a way that it only removes some space variability (since taxes are space dependent) and should not create huge discrepancies between households expenditures.

Adding to these biases, the non-response rate for housing variables, and in particular for costs variables (rent or loan) amounts to 5,6%, while the amount of incoherent responses is estimated to be around 2%, which is not negligible. This is only little surprising since it was the first time these variables were introduced into the EGT; moreover, the survey took place at the time of the conversion of franc to euro, which can potentially explain some statement or input errors; finally, like income, this type of variables is particularly subject to refusal of answering. For now, in order to improve the reliability of the data on rent and loan, we used Hourdez' (2005) database. Moreover, while the non – response rate is non – negligible, it also stays within a reasonable range.

Considering all these difficulties, ideally a specific housing survey would be used in order to valid or not the EGT housing data. Yet, given the quality of the data from which the analyses are carried out, an average rate of 33% of income allocated to housing expenditure is quite satisfying since quite close to what is usually announced. Variations of housing budget shares per type of household, number of workers, or by location seem coherent with the ones observed by Polacchini and Orfeuil (1999) : the share falls with the number of workers within the households but remains relatively constant whatever the location zone.

5. Household budget shares

We will now proceed to the analysis of households' budget shares, by considering several possible factors relevant to households' strategies, and tackle the question of the transport – housing expenditure trade – off. To do so, total transportation plus housing budget shares (that is to say: Transport + Housing / Income, also named in this paper "T – H share") will be carefully scrutinized, as well as transportation or housing budget shares when relevant.

5.1 General results

A first overview of budget shares, regardless of dwelling status (Column All), highlights an irregular but somewhat stable T – H share, with an average of 44%.

Chart 10 : Budget shares with respect to dwelling status

IAURIF Location	Dwelling Status									All		
	Home Buyers			Private Renters			Public Renters					
	T / I (H2)	H / I	T + H / I	T / I (H2)	H / I	T + H / I	T / I (H2)	H / I	T + H / I	T / I (H2)	H / I	T + H / I
Paris	5%	32%	**37%**	7%	45%	**53%**	7%	30%	**37%**	7%	40%	**47%**
Inner Suburbs	9%	26%	**35%**	10%	34%	**45%**	10%	27%	**37%**	10%	30%	**40%**
Outer Suburbs	13%	30%	**44%**	12%	34%	**46%**	13%	33%	**46%**	13%	33%	**46%**
Agglomeration fringes	12%	24%	**36%**	13%	32%	**45%**	12%	26%	**38%**	12%	27%	**39%**
« Villes Nouvelles »	14%	30%	**44%**	14%	43%	**57%**	13%	27%	**41%**	14%	31%	**45%**
Accessible cities	14%	27%	**42%**	17%	34%	**51%**	18%	34%	**52%**	17%	31%	**48%**
Isolated Cities	19%*	30%*	**49%***	21%*	31%*	**52%***	19%	36%	**56%**	20%	33%	**53%**
Rural	20%	24%	**44%**	21%*	35%*	**56%***	21%**	33%**	**55%****	21%	27%	**47%**
All	12%	28%	**40%**	10%	39%	**49%**	11%	30%	**41%**	11%	33%	**44%**

Source : Authors' calculations

While average transportation budget share increases greatly with increasing distance to CBD, housing share slightly counterbalances this tendency. This is especially the case for three zones, inner Paris (where high housing prices couterbalance low transportation expenses), the agglomeration fringes and the rural area (with low housing shares for these two zones).

The relatively stable T – H share tends to corroborate a trade – off between transport and housing budget shares. The agglomeration fringes prove to be the "cheapest" zone as regards total expenditure, while isolated cities endure high total expenditures. Nevertheless, we have to bear in mind the possible influence of income composition within the zones, which will be studied in more detail below, and the "stability" remains of the T – H shares remains weak.

Analysis per dwelling status shows an increasing trend for T – H shares for public and private renters, with some singular points though. In the case of public renters, T – H shares go from 37% in Paris to 56% in the isolated cities. The rise of T – H share with increasing zone number is first the result of increasing transport budgets shares, then of both increasing transport and housing shares. Outer cities appear as a singular point, with a sudden increase of average housing share. As regards private renters, T – H shares increase from 45% for the suburbs to 56% for the rural area. The increasing trend is mainly the outcome of increasing transport shares. Paris and "Villes Nouvelles" appear as two singular zones, with significantly higher housing budget shares (45% and 43% respectively). On the other hand, home – buyers T – H share is very irregular, varying from 35% for inner suburbs to 49% for isolated cities (with few data for this zone though). This irregularity is linked to the great variability of the housing share of home-buyers over location.

Finally, we can note that while the transportation share and its evolution with location are quite similar whatever the dwelling status; the level of the housing share depends largely on the dwelling status: private renters face the most important housing share. Consequently, while home – buyers and public renters T – H shares are fairly close on average (with respectively 40% and 41%), T – H shares are significantly higher for private renters (49% on average).

Analysis per dwelling status therefore gives a different perspective, and does question the existence of a trade – off: if transport share is strongly correlated to distance, housing share is most dependent on dwelling status and given this framework, private renters seem to be the great losers. The presence of singular points and the case of home – buyers still prevent us from drawing any hasty conclusion. But in any case, it does reveal a need for further analysis, and looking into other factors.

5.2 Budget shares with respect to household structure

While spatial analysis proves extremely difficult, with very irregular T – H shares except in some specific cases, average results prove to be relatively intuitive:

Chart 11: Budget shares with respect to household structure

IAURIF Location	Household Structure							
	single	couple <= 40y	couple > 40y	family child<6y	family child 6-12	family child 12-18	family child>18	Single parent
	T + H / I							
Paris	52%	29%	36%	37%	58%	35%*	28%*	62%
Inner Suburbs	42%	35%	33%	38%	45%	38%	41%	43%
Outer Suburbs	47%	50%	35%	43%	38%	66%	44%	45%
Agglomeration fringes	45%	34%	31%	36%	39%	38%	39%	43%
« Villes Nouvelles »	49%	43%	36%	42%	44%	41%	56%*	50%
Accessible cities	47%	53%	37%*	45%	46%	61%	44%	54%
Isolated Cities	45%*	37%**	33%**	47%*	33%**	62%**	49%**	109%*
Rural	45%*	45%**	42%**	44%	49%*	40%*	42%**	87%**
All	48%	38%	35%	40%	44%	48%	42%	50%

Source : Authors' calculations

Single parents and single persons have the highest T – H shares, with respectively 50 and 48%, while couples have the lowest shares, with 35% on average for couples over 40 and 38 for couples below 40. Families are between those two former groups, with T – H shares ranging from 40% to 48%. The most plausible explanation for these results is that housing budget shares decrease with increasing number of workers, and increase with increasing household size.

5.3 Expenditure with respect to income group

Spatial analysis with respect to income group proves extremely useful, with robust results for middle and high income groups. For these groups, T – H shares are almost unambiguously increasing with increasing zone number:

Chart 12: Budget shares with respect to income group

IAURIF Location	Income											
	Low Income				Middle Income				High Income			
	T / I (H2)	H / I	T + H / I	N	T / I (H2)	H / I	T + H / I	N	T / I (H2)	H / I	T + H / I	N
Paris	10%	67%	**77%**	*364*	6%	25%	**31%**	*264*	5%	21%	**26%**	*332*
Inner Suburbs	12%	43%	**55%**	*604*	10%	23%	**33%**	*437*	7%	18%	**26%**	*470*
Outer Suburbs	18%	51%	**68%**	*480*	11%	23%	**34%**	*372*	9%	19%	**28%**	*406*
Agglomeration fringes	15%	38%	**54%**	*103*	13%	26%	**39%**	*119*	10%	20%	**30%**	*188*

« Villes Nouvelles »	18%	50%	**67%**	*125*	14%	26%	**40%**	*162*	10%	20%	**29%**	*146*
Accessible cities	22%	45%	**67%**	*161*	15%	25%	**40%**	*158*	11%	21%	**32%**	*142*
Isolated Cities	25%	49%	**75%**	*42*	18%	22%	**40%**	*34*	11%*	18%*	**30%***	*23*
Rural	34%*	44%*	**79%***	*28*	23%*	25%*	**48%***	*27*	15%	21%	**36%**	*77*
All	14%	51%	**66%**	*1907*	10%	24%	**35%**	*1573*	8%	20%	**28%**	*1784*

Source : Authors' calculations

As a matter of fact, these categories bear quite stable housing budget shares and increasing transport shares over location, which leads to the increasing trend. The significant rise in T – H shares levels for the rural area (13% above average for middle income group, 8% above average for high income group) stems mainly from an extremely high transport share.

Nevertheless, for the low income group, results are less clear. While an increasing trend appears for the last zones, such is not the case for the first zones. E.g, housing expenditure is so high in Paris that it leads to a T – H share of 77%. Finally, while whatever the income class, the transport shares increase with the distance, the housing shares are stable over location for middle and high income but not for low income: it seems that housing shares have a location dependency for this class, thus so do total T-H shares; the most advantageous situation for low income households is to live in agglomeration fringes. We have to note that in the case of low income groups, our estimation of income probably proves insufficient, which leads to weaker results.

This said, additional comments can be made. Transport budget shares strongly and unambiguously decrease with income, whatever location is considered. The same goes for housing shares, especially from low to middle income, with even greater relative decreases in respect to income class. Considering these two point, T – H shares trivially decrease greatly with income. The significance of the decreasing trend for both the transportation and the housing share can surprise because higher income comes intuitively with higher housing and transportation expenses. While this might be the case, these results show that the income effect is overwhelming : the gap between renting expenditures and refunding of loan are less significant than those between income classes. Therefore, even if with the rise of income the housing expenditure increases, the housing share tends to decrease. . This result needs to be explored and commented more precisely, which we will do in further work.

5.4 Discussion and validation of our results

This whole analysis leads us to draw some conclusions about households' strategies regarding residential location:

- · Transportation shares increase greatly with increasing zone number, which is a consequence of motorization choices probably subsequent to the residential choice. Transportation shares are first a question of location. As distance to CBD increases, households opt more frequently for car as the transport medium, allowing them to keep a constant time budget over location. Nevertheless, the higher the income, the lower the share becomes for a fixed location, in such a way that high income households are in relative terms less sensitive to this increase of transportation expenditures.
- · While middle and high income households seem to allocate a fixed ratio of their income to housing, low income households appear to be more sensitive to price variations and more constrained in their residential choice, leading to significantly higher housing shares. The disastrous side – effect is very high total T – H shares for the most remote zones (75% for zone 7 and 79% for zone 8), which endangers households solvency. The same goes for zone 1, that is to say inner Paris. High housing prices in this particular zone put a severe burden on low income households, with a

total T – H share of 77%. Finally, for the poorer, no trade-off is guiding the residential choice: low income household are trapped between their housing needs (linked to the household type and size), their low resources and the housing supply, that is to say the prices and the available dwelling location.

- · Dwelling status choice plays an outstanding role in determining housing budget share level, private renters being obviously put at a disadvantage. Housing is kind of an incompressible constraint because of the households' needs and the poorer have less possibilities of trade-off because of their resources: the housing prices push these households to rent. And, households unable to opt for public rentals are therefore worse off.
- · Finally, household structure also plays an important role in determining T – H share level, with intuitive results. Couples are better off than single households, family worse off than couples.

To conclude this section, we will proceed to a short comparison with previous results from Polacchini and Orfeuil (1999), by considering budget shares per dwelling status, while keeping in mind that zoning systems differ from one study to the other.

For home – buyers, Polacchini and Orfeuil find T – H shares ranging from 33% to 59%, against 35 to 49% for our study. While spatial variations are fairly close, lower T – H shares levels are mainly the consequence of significantly lower transport budgets shares in our case. While our estimations provide an average share of 12% regarding transportation expenditures, Polacchini and Orfeuil find an average share of 19%. They observed, just like us, an average housing share of 28%.

For private renters, the exact opposite happens. While we find T – H shares ranging from 45% to 57%, with an average of 49%, Polacchini and Orfeuil's estimate go from 33% to 52%, with a mean of 37%. In this case, transport budget shares are quite similar (11% on average for Polacchini and Orfeuil against 10% in our case), and the gap in the T – H average share level stems from significantly higher housing shares found in our study : Polacchini and Orfeuil observed an average share of 26% for private tenants, against 39% in our case. This increase can be explained by the raising of housing prices between 1994 and 2001; note that the year 1994 is usually associated to the end of the preceding housing market cycle and thus to low prices, whereas for the year 2001, the prices were high again with the resumption of a new housing market cycle after 1993-1994. The evolution of housing prices can account for such a difference, but further analysis needs to be carried out to validate this result.

To sum up, while we do find similar spatial variations according to dwelling status, T – H shares levels differ significantly for the two categories provided in Polacchini and Orfeuil's study, that is to say home – buyers and private tenants. While we can find a direct explanation for the latter case, the difference of transport budget shares found for home – buyers is still not accounted for. May it be the result of differing methodologies, or simply the consequence of the time difference between the two studies (Polacchini and Orfeuil's study being based on 1991 data as regards transport budgets), we are unsure of. Therefore, further analysis will be carried out in the near future regarding this point.

6. Conclusion

6.1 Summary

Evaluation of transport and housing expenditures at the household level, as well as non – monetary budgets, allowed us to seize several important features concerning households' residential strategies in the Greater Paris Region. First, transportation budget shares grow steadily with increasing zone number, from 7% to 21%, as a result of a significant increase of motorization and travelled distances, and of a lack of public transit services. Consequences of this particular aspect of households'

strategies are essentially monetary, since the outcome on travel time budgets is minimal, with only a slight increase for the last two zones. On the other hand, housing budgets shares are fairly stable over location, with an average share of 33%. They even exhibit a slight decreasing trand, with significantly higher shares in Paris and lower shares in the agglomeration fringes and the rural area.

The outcome is a somewhat stable total transport plus housing budget share (T – H share), with a mean of 44%. This said, we can note that agglomeration fringes provide the lowest T – H shares (39% on average) while isolated cities bear the highest shares (53%). While this seems to corroborate the existence of a trade – off between transport and housing expenditures, further analysis points out that such is not the case: middle and high income groups display increasing T – H shares with increasing zone number, consequential to the allocation of a fixed ratio of resources to housing, and increasing transport shares. Concerning low income households, transport shares evolution over location is quite similar but housing shares are more dependent on location though not in a way to decrease the total T-H share. Moreover, household structure and dwelling status play a significant role in determining average housing effort, with significantly higher shares for private renters and single households.

6.2 Assessment

This study allowed us to develop an innovative methodology for estimating transport and housing budgets (monetary as well as non – monetary ones), comprising:

- · An integrated approach of the data, thanks to the specificities of the new EGT (“Enquête Globale de Transport”). Having linked transport and housing data at such a precise spatial level is quite uncommon in French studies, and enables us to compute total housing plus transport expenditure at the household level.
- · The use of transit and traffic assignment models for estimating travel time and distance budgets. This feature enables us to compute network distances instead of crowfly distances. Regarding time budgets, the methodology seems promising, but further analysis and calibration must still be carried out.

Despite these two achievements, results must be taken cautiously since two validations could not be made:

- · Validation of housing data with an alternate data source
- · Validation of private vehicle fixed cost allocation with a more extensive household expenditures dataset

6.3 Areas of development

While this study enabled us to deepen our understanding of household strategies regarding residential choice, the next logical step would consist in developing a residential choice model at the Greater Paris Region level, thanks to acquired knowledge. Doing so would be beneficial in two ways:

- · Consolidating and validating our results
- · Having a better understanding of residential dynamics

Thus, research will be carried out in this direction. Nevertheless, despite the prolific literature on the topic, several hardships await us, especially concerning price modelling and development models.

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8. Annex

8.1 Annex A: Evaluation method of transport budgets and comments

Evaluation Method

All household monetary budgets are assessed on a monthly basis. Since the EGT offers a one day observation for the week, and a one week-end observation for each individual, variable daily costs need to be multiplied by 20,95 for a week day, and 9,49/2 for a week-end day. Household non – monetary budgets are on the other hand appraised on a daily basis, and will be provided for an “average day”.

We will now outline the evaluation method used for each item.

Assessment of the travel time budget and the distance budget

Travel time and distance budgets are evaluated for both a week day and a week – end day at the individual level, thereafter at the household level via agregation over the members of the household. Each of these budgets is computed as the sum of the travel times or the distances of the different trips made by an individual during the surveyed day.

One novelty of our approach lies in the method for estimating travel time and distance budgets. Instead of using stated times and distances provided in the EGT, we estimate the two budgets using a transit assignment model and a traffic assignement model. Both of these models run with the TransCAD software. The advantage of this approach is twofold:

- · As regards distance budgets, we can compute network distances instead of crowfly distances corrected by a curvature factor as commonly used in other studies.
- · As regards time budgets, we have an alternate measure of the travel time, which is not sensitive to respondents'statement errors.

Drawbacks of this approach are discussed in the comments sub – section.

To assess travel time and distance, our approach distinguishes three classes of trip:

- · Walk trips: for this class of trip only, computed distances are bird's eye distances corrected by a curve factor of 1,1. Travel times are estimated using several classes of speed according to the individual's age.
- · Public transit trips: trip distances and trip times are evaluated using the public transport model, based on the DREIF transit supply database. Frequency modulation is taken into account.
- · Road trips: trip times and distances are estimated using the road model, based on the DREIF supply and demand database, and considering two periods, peak hour and off – peak hours.

Furthermore, access times are added at the beginning and the end of the modeled trip, representing the time needed to exit the building starting point, to access the car or the transit station... Access times are typically fixed to one minute long, but may be longer depending on the circumstances of the trip.

<u>Assessment of public transit budget</u>

Public transit budget is also assessed first at the individual level, then at the household level, taking into account purchases of passes and tickets

Assessment of passes associated expenditures

The STIF offers a panel of passes, depending on the duration required by the user (which may be weekly, monthly or yearly) and the zones he wants to access. There also exist several "special" passes, such as a student yearly pass, or an elderly pass. All these passes give free access to the preselected zones, thus the user would only have to buy a ticket when travelling outside of these zones.

Detention of such passes is thoroughly detailed in the EGT, including the type of the pass and the preselected zones. Therefore computation of these costs is quite straightforward. Weekly passes are treated as monthly passes, since no information can be inferred from the EGT on the purchasing

behaviour of the individual for the unobserved weeks in the month of study. Furthermore, a transport indemnity, specific to Ile de France, is taken into account: any employee pays only half the price of the chosen pass, the employer paying the other half.

Assessment of tickets expenditures

In the EGT, every time an individual uses a public transit mean, the cost associated to the use of this mean is evaluated. If the individual uses a pass for his trip, the cost associated is null. Otherwise, the price of the ticket is evaluated thanks to ratemaking rules provided by the RATP, the main transport operator in the Paris area with the SNCF. Costs are then agregated over the day at the individual level to provide a daily cost, either for a week day, a week-end day, or an average day.

Ratemaking rules used in our program do not always provide the exact price of the trip, which would be too complicated to appraise in some cases. Nevertheless, in the main cases, they do produce a very accurate estimation. Furthermore, transfer rules are implemented, taking into account transfer possibilities offered by the Greater Paris Region transport system.

Assessment of the private vehicle budget

Once again, the private vehicle budget of the household is estimated for both a week day and a week – end day at the individual level, then at the household level (fixed costs constituting a slight exception since they are directly assessed at the household level in the H2 work hypothesis). It is eventually assessed on a monthly basis thanks to the multiplying rule indicated above.

Variable costs are evaluated from the fuel expenditure. Fuel consumption is first computed at the trip level thanks to the EGT, using the COPERT3 fuel consumption model and speeds and distances derived from the road model. Fuel expenditure follows considering the type of motorization, by multiplying fuel consumption by the adequate price. Other variable costs (maintenance and accessories) are based on fuel expenditure using a correlation factor. The 2001 Family Budget survey provides a correlation factor of 0,47, which entails a total variable cost of 1,47 times the fuel cost.

Fixed costs are assessed using once again the 2001 Family Budget survey. Two work hypotheses were tested. H1 work hypothesis assumes that fixed costs are as a matter of fact variable costs perfectly correlated to fuel expenditure. Considering H1, the Family Budget Survey provides us with a correlation factor of 2, implying that total private vehicle expenditure is approximately 3,5 times the fuel expenditure. H2 work hypothesis assumes “perfectly fixed” costs, meaning that everyhousehold bears the same fixed cost per vehicle. Working with H2, monthly fixed costs add up to 145€ for each car owned by the household (131€ for the purchase of a car and 14€ for insurance), 45€ by two – wheeled motorized vehicle and 2€ by bike.

Assessment of the parking budget

Parking budget is once more evaluated at the individual and then at the household level, thanks to the EGT which provides detailed information about parking. The survey allows us to know at every period of the day where a vehicle is parked, the type of parking space used, the duration of the parking, as well as the destination activity underlying the trip triggering the parking.

All of these informations are used to compute the parking cost, mainly using an hourly cost depending of the zone of parking and the type of parking. Parking cost is assumed to be borne by the driver, therefore neglecting the case of car – pooling where the parking cost could be split between the passengers. When the trip triggering the parking is work – based, a discount of 50% is applied to represent company coverage.

Comments

Concerning travel time and distance budgets

The main issue lies in the estimation of travel time budgets with models. The comparison of stated times with modeled times brings to light a significant gap (the individual travel time budget adds up to 63 minutes for our model, against 74 minutes with stated times), which leads us to make several comments. First of all, access times are not calibrated, since no data of our knowledge exist on this particular topic. Travel time budgets are quite sensitive to this variable though, since an individual makes on average approximately 3,5 trips a day. Secondly, modeled times are computed based on the assumption of an optimizing behaviour of the travellers. This assumption is quite strong, considering that it implies perfect information, which is not often the case for irregular trips. This comment is particularly true for road trips, since good public transit information is provided in the Greater Paris Region. Furthermore, our models do not include risk management behaviour by the travellers. Some travellers might want to make longer trips, in order to minimize the risk of congestion or incidents.

As regards road trips, the model used in this article is a static 4 – step model, including peak and off – peak periods. A dynamic model would have been more appropriate for a more robust estimation of the travel times throughout the day. Moreover, several time costs can't be taken into account, such as waiting for a person who needs to be picked up, looking for a parking slot...Finally, there is some evidence that congestion is underestimated, we will further discuss this point below.

As regards trips using the public transit system, delays are not taken into account in the model, which is a first shortcoming. Secondly, once again some time costs are necessarily omitted, such as time spent on purchasing a ticket, on looking for your itinerary... Last but not least, the supply database has some flaws, especially considering the description of the services in the "Grande Couronne". Therefore, trips originating or heading towards this area are more subject to estimation errors.

Estimation of distance budgets in comparison to travel time budgets is reliable and sturdy. Comparison with corrected bird's eye distances shows a small gap, which is normal considering that we do estimate actual distances. Nevertheless, the issue of the optimizing behavior of the traveller remains, which might lead to an inaccuracy in the estimation of distances.

Concerning public transit budgets

At this stage, no significant shortcoming has been pointed out for our methodology. Prices are well – known and available, and ticket and pass information is quite thorough in the EGT. Furthermore, the "Compte Transports 2003" (2003 Transportation Account), established by the STIF, provides yearly figures for household public transit expenditures matching our monthly estimates.

Concerning private vehicle budgets

Regarding variable costs, prior fuel consumption estimates did not match other regional estimates provided by a specific fuel consumption survey. Therefore, fuel consumption estimates have been corrected at this date by a factor of 4/3. Since the COPERT3 model is quite sensitive to speed, this underestimation tends to point out a slight underestimation of speeds, which might explain part of the gap between stated times and modeled times.

Lastly, fixed costs and variable costs have been assessed using the family budget survey, but other surveys provide different estimates for the same costs, providing ratios private vehicle comprehensive costs/fuel expenditure ranging from 3,5 (family budget survey) to 4,4 (ADEME data).

The family budget survey gives the smallest amounts, therefore leading to maybe an underestimation of costs (counterbalanced by other points mentioned above and in 4.4).

Concerning parking budgets

Estimation of parking budgets raises several significant issues, due to the multiplicity of parking possibilities and of the associated costs. Hourly prices/costs were computed using previous work of data collection by Gallez (2001) and updated using the inflation rate. Further and more up to date data collection should be done to provide more robust results. Nevertheless, parking expenditure does not prove to be the most significant and variable over space expenditure, therefore results should only be slightly affected by our assumptions.

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See e.g. the PLanning and Urban Mobily in Europe (PLUME) project (Clifford and alii (2005))

See Gayda and alii (2003)

See Brueckener, Thisse and Zenou (1999)

See Fujita (1989) or Huriot and Thisse (2000) for a good review of this topic and of all the extensions of monocentric model

E.g. when the size of the land slots is constant, the sum of transport and housing expenditures is constant.

At least for new buyers and tenants of the private sector, being the only categories for which data were available and reliable

Briefly, the authors found that, the more their income increases, the more American households allocate their money in transportation and the less in housing. Moreover, the more the income increases, the smaller the share of total expenditure (housing plus transportation expenditure) in the income is. However, the 2 groups use the car in the same proportions and have similar commuting times, although they occupy quite distinct types of work, in different locations. Finally, Cervero and al. conclude that the poorest have not as many choices as the wealthiest, especially concerning housing: Choice is always a matter of income, it enables the richest to make trade-offs much more advantageous in terms of quality and affordability.

See more below on this database and its drawbacks

Provided in Annex

See Annex

Note that some “Villes Nouvelles” exist in other regions.

When a specific class gathers less than 30 observations, an * is added. When it is less than 10, an ** is added.

Corresponding to the IAURIF zone number

This choice is made for the sake of the simplicity of the argument, and translates author's opinion on the matter.

The Public Transit Budget is stable over location, except for agglomeration fringes and isolated cities: for those two zones, the lack of public transport supply explains a lower public transport expenditure. Logically, these lower transit expenditures are linked to higher vehicle expenses.

Let's note that agglomeration fringes constitute a singular point, with a sharper increase of the transport budget. This is the outcome of a fall of transit supply for this area, and subsequent motorization choices.

Polacchini and Orfeuil faced the same difficulties concerning those biases

Single persons and couple over forty display relatively stable T – H shares. Family with youngest child ageing 6 to 12 and single parents seem to bear decreasing then increasing T – H shares.

First analyses led by the authors corroborate this point, but lack of time and of robustness of current results regarding this point prevented us from presenting them

Isolated cities in the case of high income groups constitute the only singular point, with a slight decrease (-2%) of the T – H share. Nevertheless, the decrease is small, and so are the number of people pertaining to this category.

This is mainly the case for the lowest income classes. For theses classes, the relative difference between upper bound and lower bound is significant. Therefore, budget shares are more sensitive to the way average income is estimated within such classes. Moreover, low income households are the main recipients of housing benefits : thus, their housing share could be less than it appears in our results

Since one would expect high income households to opt more frequently for ownership and for buildings of better quality and with more amenities, leading to a substantial increase in housing expenses. The same goes for the mobility and motorization choices, leading a priori to an increase in transportation expenses.

Which proves difficult considering that beyond the income condition required, demand is so great that waiting time is typically one or two years.

A month comprises on average 30,44 days, 9,49 of which being "week-end" days (including french public holidays), the remainder adding up to a total of 20,95 days. Since the week-end part of the EGT provides observations for Saturday and Sunday, the number of week-end days needs to be divided by 2.

By computing the weighted average between a week day and a week – end day

Note that there exist some differences in the methodologies used for the week survey and the week – end survey, considering that the week – end survey is less detailed. Nevertheless, the outline is basically the same for both methodologies, so we won't precise here the existing differences.

6 km/h for individuals from 15 to 34, 4,5 km/h from 6 to 14 and 35 to 64, 3 km/h for people over 65

DREIF : Direction Régionale de l'Equipement Ile de France

E.g. in the case of access to a subway station, which is time consuming, an additional time of 1 minute and a half is incorporated

STIF : Syndicat des Transports d'Ile de France

RATP: Régie Autonome des Transports Parisiens

SNCF : Société Nationale de Chemins de Fer

This is mainly the case for suburban trips using the railway system, for which the price system is especially complex. Nevertheless, a fairly accurate regression of the price over the distance of the trip exists. For the other trips, the exact price is available since the tariff system is simpler

"Fuel" may be gas, diesel, electricity or natural gas

In one case, when the car is parked on the public roads with a resident tariff, a daily cost is used in stead of an hourly cost, since the resident tariff is day based.

Several websites provide efficient itinerary planners, travellers have access to transit services maps *en route*,...