Couple Residential Location and Spouses Workplaces

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Abstract

The main purpose of this paper is to study the bargaining power of the household members in the context of location decisions. One important side product of our analysis is the computation of the values of time of the man and the woman. The transport literature neglects the bargaining power, wich leads to biased measures of the values of time. We elaborate a new method to provide an unbiased measure of the value of time. More specifically, using census data on the Paris Region, we are able to disentangle bargaining power from the values of time of spouses. We show that the age of the women as well as the nationality of the men, play a crucial role in determining bargaining power.

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1 Introduction

Urbanization all over the world represents one of the most important phenomenons in our society. In many developped countries, more than 50 percent of households live in urban areas. In developping countries, urbanization is extremely fast. Not surprisingly, there is growing interest in the understanding of how large urban areas function and how they can be better managed. The residential location choice, the concern of this paper, plays a key role in the understanding of urban dynamics.
Strangely enough, all models we are aware of describe residential location as if the decisions were made by a single individual, the household head. Indeed, the situation is far more complex. Residential location depends on the local characteristics of the housing unit, as well as on local amenities. See dePalma et Al. [7], [8] for applications in Paris region. Crucial factors are the workplace's location of the husband and of the wife. Often there is more than one active individual in the household. In this case, the work location of each active member is important. The weight of each member in the bargaining process, related to the residential location choice model, depends on the characteristics of each household member. We consider household location to be predetermined by the workplace location of both spouses. This is relevant if the labor market is more rigid than the dwelling market in relation to life cycle and job stability.
From an economic point of view, one wish first to study if the residential locations are Pareto optimal. See Chiappori [2] [3] for a general setting when analyzing Pareto optimality of couples' choices. In other words, one wish to check if there exists residential locations, other than the one already chosen by the household, such as each active member can be better of. We will show empirically that this is not the case. The second question we wish to adress is to determine what are the explanatory power of several variables concerned with the bargaining power of the men and of the women. We will identify the factors in absoluted or relative terms, which explain the bargaining power of the man and of the woman.

2 Household Location Model

2.1 Notations

The husband is denoted by the superscript m, while the wife is denoted by the superscript f, and generically we use the superscript $g = m, f$ for the gender.
Spouses enjoy the consumption of dwelling characteristics and local amenities Z. Dwelling price P depends on dwelling location, which also affects commuting times t^g and the corresponding commuting costs $c^g\left(t^g\right),\ g = m, f$. Spouses also enjoy the daily consumption of private goods which is here considered in reduced form. Individual utilities are assumed to be additively separable in the public good part $V^s\left(P, Z\right), s = m, f$ and the private good part:

$$U^g = V^g\left(P, Z\right) - c^g\left(t^g\right) + \phi(d^g, d^c),\ g = m, f,$$

where P denotes the dwelling price per m^2, and Z denotes dwelling characteristics and local amenities.

2.2 Mixed Time Horizons

We question Pareto optimality when three time horizons are at stake. These time horizons are:

- the long run (household location pattern over the life cycle in relation to the work history)

- the medium run (household location conditional on spouse workplaces)
- the short run (daily consumption decisions of public and private good).

We are studying here the medium run bargaining power. We argue below that we can consider long run bargaining power, and short run decisions in the reduced form.

2.2.1 Long-term optimality of household location

In the long term, a full path of household locations responding to any shock on the husband or wife workplace. In this case, the household decides from the beginning how it will relocate after any change in either spouse workplace, and both spouses commit to this path all along their life cycle. If the household were fully optimal in the long run, it should anticipate any future shock on either spouse's workplace (and their impact on commuting cost), and choose location so as to maximize an expected utility, taking into account the probability of any future workplace, and the resulting commuting costs. Under standard assumptions, these anticipated variables would result in a log-sum variable measuring the (individual) accessibility to jobs from the household location. This accessibility measure, specific to household location, is implicitly included in the list of local amenities Z. Such dynamic approach along the life cycle of couples is developed by de Lapparent, de Palma and Picard [4].

2.2.2 Medium-term optimality of household location

Note that, in case the husband's workplace is modified and the couple does not move, the husband cummuting cost is affected, while the wife's commuting cost and the $V^g(.)$ utilities are not.

In the medium term, household location is conditional on both spouses' workplaces, and is renegotiated after any change in any spouse's workplace. This medium-term decision is relevant in case spouses cannot commit to long run decision paths as described above. If the medium-term decision process were *fully Pareto-optimal*, then household location should minimize the total (unweighted) commuting costs of the spouses (local amenities are neglected for the moment). In this case, the potential lack of balance in respective commuting costs could be compensated in the sharing rule for daily consumption. However, this implies that each spouse should be able to commit to respect this daily sharing rule in the future, which does not seem very realistic. We therefore consider a less restrictive case in which spouses take medium-run decisions without committing to compensations between medium-run and short-run decisions. The absence of commitment for long run decisions implies that the total travel cost $c^m(t^m) + c^f(t^f)$ is not necessarily minimized.

2.2.3 Short-term decisions

In the short term, spouses make daily decisions on their consumption. No commitment is needed for (unobserved) daily consumption of private goods, since the decisions concerning such consumption have no long-or medium-term impact (no retroaction). They can therefore be assumed Pareto-optimal and considered in a reduced form, so that the attention can be restricted to long term decisions.

2.3 Individual Utilities and Household Welfare

2.3.1 Building the welfare function

We consider a partially optimal program in which negotiation takes place at various time horizons without possible commitment allowing to compensate between long-term, medium-term and short-term shares, but is Pareto-efficient within each term. This is the case, for example, if spouses cannot commit on moving in case of any shock on either spouse's workplace. In this case, it is possible to define a Pareto weight for each term: μ_1 for long-term decisions reflected in $V^g(.)$, μ_2 for medium-term decisions reflected in $c^g(t^g)$ and μ_3 for short-term decisions, which are not modeled explicitly here. A partially optimal household location would then maximize:

$$(1-\mu_1)V^m(P,Z)+\mu_1 V^f(P,Z)-(1-\mu_2)c^m(t^m)-\mu_2 c^f\left(t^f\right)$$
$$+(1-\mu_3)\phi^m(d^m,d^c)+\mu_3\phi^f(d^f,d^c)$$

In this formulation, it is rather obvious that μ_1 cannot be disentangled from individual preferences for public goods. We therefore consider a household utility function for public goods

$$V^c(P,Z)=(1-\mu_1)V^m(P,Z)+\mu_1 V^f(P,Z)$$

without attempting to recover individual preferences for public goods and bargaining powers, and the index can be omitted in the medium-term bargaining power (μ_2 becomes μ). The welfare of the couple is then of the form:

$$W\left(P,Z,t^m,t^f,\mu\right)=V^c(P,Z)-(1-\mu)c^m(t^m)-\mu c^f\left(t^f\right). \tag{1}$$

2.3.2 Specification of the welfare function

The endogenous parameter μ, referred to as the Pareto weight, measures the woman bargaining power. In the parametric specification, we assume the following linear formulation for the couple's utility of public goods:

$$V^c(P,Z)=\sum_k v_k\left(y^c,X^c,X^m,X^f\right)Z_k-v_P(y^c)\ln P,$$

where y^c denotes household income and X^c denotes the household characteristics (not specific to any spouse) such as the marital status or the number of children. It is here assumed that the price elasticity depends on household income, through the ν_P parameter. The ν_k parameter denotes the couple's marginal utility for dwelling (or location) characteristic Z_k. It depends on the husband's and the wife's characteristics (X^m,X^f) and household characteristics, y^c,X^c, in order to reflect the heterogeneity in preferences and/or in long-run bargaining powers.
The individual commuting costs are assumed quadratic functions of commuting times:

$$c^g(t^g)=a^g(X^c,X^g)t^g+b^g(X^c,X^g)(t^g)^2,\ g=m,f$$

with $a^g(X^c,X^g)$.and $b^g(X^c,X^g)$ measuring individual-specific value of time. Note that the marginal value of time is either increasing or decreasing (i.e. the commuting cost function is either convex or concave), depending on the sign of $b^g(X^c,X^g)$. A linear formulation is assumed for $a^g(X^c,X^g)$.and $b^g(X^c,X^g)$:

$$a^g(X^g)=a_0^g+\sum_k a_k^g X_k^g+\sum_l a_l^g X_l^c,\quad g=m,f$$
$$b^g(X^g)=b_0^g+\sum_k b_k^g X_k^g+\sum_l a_l^g X_l^c,\quad g=m,f \tag{2}$$

In Equation (1), a linear formulation is assumed for the Pareto weight:

$$\mu=\mu_0+\sum_k\left(\mu_k^f X_k^f-\mu_k^m X_k^m\right)+\sum_l \mu_l^c X_l^c \tag{3}$$

It can be shown that μ_0 is not identified and can be normalized to 1/2.

Note that variables (if any) from the vector X_k^m,X_k^f,X_k^c entering Equation (3) but not Equation (2) can be considered as a medium-run distribution factor.

2.3.3 The couple location choice problem

We assume that spouses workplaces are predetermined, and that the negotiation for household location conditional on workplaces solves the following program:

$$\max_{(P,Z,t^m,t^f)\in\mathcal{A}} \left\{V^c(P,Z) - (1-\mu)\, c^m(t^m) - \mu c^f\left(t^f\right)\right\}, \tag{4}$$

where $\mathcal{A}$ denotes the set of feasible allocations $\left(P, Z, t^m, t^f\right)$, corresponding to available locations. Or, using parametric specifications:

$$\max_{(P,Z,t^m,t^f)\in\mathcal{A}} \left\{ \begin{array}{l} \sum_k v_k\left(y^c, X^c, X^m, X^f\right) Z_k - v_P(y)\ln P \\ -\left[1/2 - \sum_k \left(\mu_k^f X_k^f - \mu_k^m X_k^m\right) - \sum_l \mu_l^c X_l^c\right] \cdot \\ \left[\begin{array}{c} \{a_0^m + \sum_k a_k^m X_k^m + \sum_l a_l^m X_l^c\}\, t^m \\ + \{b_0^m + \sum_k b_k^m X_k^m + \sum_l b_l^m X_l^c\}\,(t^m)^2 \end{array}\right] \\ -\left[1/2 + \sum_k \left(\mu_k^f X_k^f - \mu_k^m X_k^m\right) + \sum_l \mu_l^c X_l^c\right] \cdot \\ \left[\begin{array}{c} \left\{a_0^f + \sum_k a_k^f X_k^f + \sum_l a_l^f X_l^c\right\} t^f \\ + \left\{b_0^f + \sum_k b_k^f X_k^f + \sum_l b_l^f X_l^c\right\} (t^f)^2 \end{array}\right] \end{array} \right\}.$$

2.3.4 The stochastic setting

Turning to the stochastic specification, we denote by γ the vector of parameters $\mu_l^c, \mu_k^g, a_k^g, b_k^g, a_l^g, b_l^g,\ g = m, f$, and we consider a finite number of alternatives j (communes). The stochastic utility of alternative j for household with characteristics y^c and $X = \left(X^c, X^m, X^f\right)$ is:

$$\begin{array}{l} W_j^c = W\left(P_j, Z_j, t_j^m, t_j^f; \gamma, y^c, X\right) + \varepsilon_j = \\ \sum_k v_k\left(y^c, X^c, X^m, X^f\right) Z_{k,j} - v_P(y^c)\ln P_j \\ -\left[1/2 - \sum_k\left(\mu_k^f X_k^f - \mu_k^m X_k^m\right) - \sum_l \mu_l^c X_l^c\right] \cdot \\ \left[\{a_0^m + \sum_k a_k^m X_k^m + \sum_l a_l^m X_l^c\}\, t^m + \{b_0^m + \sum_k b_k^m X_k^m + \sum_l b_l^m X_l^c\}\,(t^m)^2\right] \\ -\left[1/2 + \sum_k\left(-\mu_k^m X_k^m + \mu_k^f X_k^f\right) + \sum_l \mu_l^c X_l^c\right] \cdot \\ \left[\left\{a_0^f + \sum_k a_k^f X_k^f + \sum_l a_l^f X_l^c\right\} t^f + \left\{b_0^f + \sum_k b_k^f X_k^f + \sum_l b_l^f X_l^c\right\}(t^f)^2\right] + \varepsilon_j. \end{array} \tag{5}$$

The residual terms ε_j correspond to omitted variables, specification errors (from the econometrician) and optimization errors (from the household). They are assumed to be i.i.d. and distributed according to Gumbel's distribution, which leads to a multinomial logit formulation. If J denotes the total number of alternatives j (communes), then the probability for the couple c to choose the commune j is given by the Multinomial Logit formula[1]:

$$P_j^c = \left(\frac{\exp\left(W_j^c\right)}{\Sigma_{j'=1}^J \exp\left(W_{j'}^c\right)}\right) \tag{6}$$

3 Parametric Identification: Minimum Distance Approach

It is well known that, in the multinomial logit model with additive random utility, the likelihood function is quasi concave, so the maximization of the likelihood is straightforward. However, Equation (5) is not linear in the components of the γ

[1] See [1] or [9] for details.

vector, and the likelihood function proves to be very difficult to maximize directly. We therefore propose a two-step procedure based on a minimum distance estimator. In the first step, we estimate the unconstrained parameters, while in the second step, we take account of the constraints using the minimum estimator method summarized in Section 3.2.

3.1 Reduced-Form and Structural Parameters

The first step consists in developing Equation (5) in order to get an expression linear in the new parameters, β, to be estimated. Developing Equation (5) leads to terms quadratic in γ, multiplied by terms quadratic in X, denoted by XX, multiplied by $t^m, t^f, (t^m)^2$ and $\left(t^f\right)^2$, respectively:

$$\begin{aligned} W\left(P_j, Z_j, t_j^m, t_j^f; \gamma, y^c, X\right) + \varepsilon_j = & \sum_k v_k\left(y^c, X^c, X^m, X^f\right) Z_{k,j} - v_P\left(y^c\right) \ln P_j \\ & + \beta_1(\gamma) XX \cdot t^m + \beta_2(\gamma) XX \cdot (t^m)^2 \\ & + \beta_3(\gamma) XX \cdot t^f + \beta_4(\gamma) XX \cdot \left(t^f\right)^2 + \varepsilon_j, \end{aligned} \tag{7}$$

These quadratic functions are detailed in Section 4.3 for two examples. The right-hand side of Equation (7) is of the form

$$\begin{aligned} \tilde{W}\left(P_j, Z_j, t_j^m, t_j^f; \beta, y^c, X\right) + \varepsilon_j = & \sum_k v_k\left(y^c, X^c, X^m, X^f\right) Z_{k,j} - v_P\left(y^c\right) \ln P_j \\ & + \tilde{\beta}_1 XX \cdot t^m + \tilde{\beta}_2 XX \cdot (t^m)^2 \\ & + \tilde{\beta}_3 XX \cdot t^f + \tilde{\beta}_4 XX \cdot \left(t^f\right)^2 + \varepsilon_j. \end{aligned}$$

Let D_C denote the number of structural parameters (dimension of the γ vector) and D_U denote the number of lines in the $\beta = (\beta_1, \beta_2, \beta_3, \beta_4)$ vector. Note that the function $\tilde{W}\left(P_j, Z_j, t_j^m, t_j^f; \beta, y^c, X\right)$ is defined for $\beta \in \mathbb{R}^{D_U}$. Therefore, the likelihood function is defined over the unrestricted set $\mathcal{S}_U = \mathbb{R}^{D_U}$. There exists a bijection between the set $\mathbb{R}^{D_C}$ of structural parameters γ and the set $\mathcal{S}_C$ of constrained parameters $\beta = \left(\tilde{\beta}_1, \tilde{\beta}_2, \tilde{\beta}_3, \tilde{\beta}_4\right)$. The unconstrained vector $\beta \in \mathbb{R}^{D_U}$ is estimated using a standard maximum likelihood technique.

3.2 Minimum Distance Estimator

The second step, the minimum distance estimator, consists in minimizing the distance between the estimated unconstrained vectors of parameters $\hat{\beta} \in \mathcal{S}_U$, and their constrained counterparts $\beta(\gamma) \in \mathcal{S}_C$. This distance is weighted by the inverse of the variance-covariance matrix V estimated for $\hat{\beta}$. We therefore wish to solve the following problem:

$$\begin{aligned} & \underset{\beta \in \mathcal{S}_C}{Min} \left[\left(\hat{\beta} - \beta\right)^t V^{-1} \left(\hat{\beta} - \beta\right)\right] \\ & \text{or, equivalently, } \underset{\gamma}{Min} \left[\left(\hat{\beta} - \beta(\gamma)\right)^t V^{-1} \left(\hat{\beta} - \beta(\gamma)\right)\right]. \end{aligned}$$

The solution of this problem is denoted by γ^*, and the optimized objective function is denoted by

$$\chi = \left(\hat{\beta} - \beta(\gamma^*)\right)^t V^{-1} \left(\hat{\beta} - \beta(\gamma^*)\right).$$

Under the null hypothesis of partial medium-term Pareto-optimality, $\beta \in \mathcal{S}_C$, and the χ statistic has a chi-squared distribution with $D_U - D_C$ degrees of freedom. Under the alternative assumption, household location is not optimized in the medium run. Household location then depends on the same variables XX, but $\beta \notin \mathcal{S}_C$ is not Pareto-Optimal, the value of χ is statistically larger. The χ statistic can therefore be used to test partial medium-term Pareto-Optimality of household location.

3.3 Convergence Properties for Reduced Form and Structural Parameters

Likelihood is quasi-concave in $\tilde{\beta}$, so the estimation of the unrestricted $\tilde{\beta}$ parameters is straightforward. On the opposite, the minimization of the distance between the unconstrained $\hat{\beta}$ parameters and the constrained parameters $\beta(\gamma)$ is less well behaved, and exhibits several local minima. We therefore used a genetic algorithm in order to find the global minimum of the distance function.

It is possible to compute an asymptotic variance for γ, based on the delta method, but the size proved to be too small to rely on an asymptotic estimator. Therefore, we choose to use a bootstrap technique. We carried out 200 boostratp replications and computed the mean, the variance and the confidence interval of the estimated structural parameters.

4 Data and Empirical Application

4.1 Data

We use the 1999 General Population Census survey conducted in the Paris Region. The Paris Region is formed by 1300 communes. Inside Paris, a commune corresponds to an arrondissement (there are 20 arrondissemets in Paris).

In the census data, both household location and workplace are observed at the commune level in a 5% sample. We further restrict the sample to couples in which both spouses work, ending up with a sample of 60,798 households containing bi-active couples. For each household, 9 unchosen alternatives are randomly generated, using importance sampling. The weights are proportional to the number of dwellings in the commune. Finally, travel times are computed using the dynamic transport network model METROPOLIS (see [6] or [5]).

4.2 Determinants of bargaining power and values of time

Different variables can be supposed to influence either the bargaining powers μ, or the values of time $a^g(.)$ and $b^g(.)$, $g = m, f$. They are listed in the following table (Table 1)

Category	Variable	$\boldsymbol{\mu}$	$\mathbf{a}^m, \mathbf{b}^m$	$\mathbf{a}^f, \mathbf{b}^f$
Household level	Number of children, by age (3/6/10/18)		X	X
	Number of adults, by activity status		X	X
	Marital status	X		
	Tenure status	X		
Individual level	Husband's education and/or diploma	X	X	
	Wife's education and/or diploma	X		X
	Husband's age	X	X	
	Wife's age	X		X
	Husband's wage	X	X	
	Wife's wage	X		X
	Husband working part time (dummy)		X	
	Wife working part time (dummy)			X
	Husband's nationality	X	X	
	Wife's nationality	X		X
	Husband's Profession	X	X	
	Wife's profession	X		X
	Spouses' birth locations	X		
	Spouses' previous residence	X		

Table 1: Potential determinants of bargaining power and values of time

4.3 Specification Depending on the Nature of the Explanatory Variables

4.3.1 One continuous variable for each spouse: Age

We illustrate the case of one continuous variable by the age of each spouse, A^m for the husband's age and A^f for the wife's age[2]:

$$\begin{aligned} U^c = V^c(P,Z) &- [\frac{1}{2} + \mu_1 A^m - \mu_2 A^f] \cdot [\{a_0^m + a_1^m A^m\}t^m + \{b_0^m + b_1^m A^m\}(t^m)^2] \\ &- [\frac{1}{2} - \mu_1 A^m + \mu_2 A^f] \cdot [\{a_0^f + a_1^f A^f\}t^f + \{b_0^f + b_1^f A^f\}(t^f)^2] \end{aligned} \tag{8}$$

There are therefore 10 structural parameters, whereas the estimated model comprises 20 parameters:

$$\begin{aligned} U^c = {} & V(P,Z) + \beta_{10}t^m + \beta_{11}A^f t^m + \beta_{12}A^m A^f t^m + \beta_{13}A^m t^m + \beta_{14}(A^m)^2 t^m \\ & + \beta_{20}t^f + \beta_{21}A^m t^f + \beta_{22}A^m A^f t^f + \beta_{23}A^f t^f + \beta_{24}(A^f)^2 t^f \\ & + \beta_{30}(t^m)^2 + \beta_{31}A^f(t^m)^2 + \beta_{32}A^m A^f(t^m)^2 + \beta_{33}A^m(t^m)^2 + \beta_{34}(A^m)^2(t^m)^2 \\ & + \beta_{40}(t^f)^2 + \beta_{41}A^m(t^f)^2 + \beta_{42}A^m A^f(t^f)^2 + \beta_{43}A^f(t^f)^2 + \beta_{44}(A^f)^2(t^f)^2 \end{aligned} \tag{9}$$

[2] More precisely, $A^s = (Age^s - 20)/10$, $s = m, f$. With this specification, $\mu = \mu_0 = 1/2$ when both spouses are 20 years old, which is more relevant than normalizing to $\mu = 1/2$ when both spouses are just born (0 years old). The division by 10 is just to multiply associated parameters by 10 (and multiply by 100 paramaters associated with age squared), in order to get parameters not too close to 0, which can be interpreted in terms of marginal changes when one spouse is 10 years older.

In this case, the unconstrained parameters belong to the unconstrained space $\mathcal{S}_{UC} = \mathbb{R}^{20}$, whereas the constrained parameters $\beta(\gamma)$ belong to a constrained space $\mathcal{S}_C$ which is isomorphic to the structural parameters space, here $\mathbb{R}^{10}$. Equating the terms of the two polynomials leads to a system (S) of 20 equations (See Appendix 6.1.1 for the identification rule). This system leads to 10 independent constraints and 10 equations allowing to express the structural parameters as functions of the estimated parameters.

Estimation results The results of MNL estimations of β parameters is given in the following tables (Tables 2 & 3).

Variable	Coefficient	t-Stat
log(Number of Households) in the commune	-0.115	-10.10‡
Same Department as before move	2.689	154.320‡
Paris	-1.129	-22.560‡
Number of Subway Stations	$5.223E-4$	0.210
Number of Rail Stations	-0.013	-3.010‡
Distance to Highway	$1.25E-5$	3.510‡
Distance to Art	$1.52E-5$	3.310‡
Distance to Chatelet	0.059	47.480‡
% Flats	-0.900	-19.660‡
% of Noisy Area	-0.098	-1.140
% of Forests	0.357	4.260‡
% of Forest * Number of Children	0.239	5.240‡
% of Water	-0.990	-4.240‡
% of Gardens	0.255	1.160
% of Gardens * Number of Children	0.239	1.780
log(Average Price of Flats)	0.276	6.610‡
log(Average Price of Flats)* Income per Capita	0.093	1.530
log(Average Price of Houses)	-0.328	-9.520‡
log(Average Price of Houses) * Income per Capita	0.639	14.340‡

Table 2: Determinants of household location: local amenities (Age)

Two thigs are worth considering. First, it is important to point out that we have no information regarding the dwellings' (intrinsic) characteristics. This implies that all housing units located in a particular commune are considered to be statistically identical; and therefore providing the same expected utility and the same odds of being selected by a specific couple. That is, if the commune j, $j = 1, \ldots, 1300$ contains Dj dwellings (number of households), all dwellings i in commune j give the same expected utility $W_i^c = W_j^c$ for the couple c, $c = 1, \ldots, N$. The total number of dwellings in Ile-de-France is denoted by I.
Since all the dwellings i located in j have the same expected utility, Equation (6) can be rewritten as:

$$P_j^c = D_j P_i^c = \frac{D_j \exp\left(W_j^c\right)}{\left(\Sigma_{j'=1}^{J}\left(\Sigma_{i' in j'}^{I} \exp\left(W_{i'}^c\right)\right)\right)} = \left(\frac{\exp\left(W_j^c + \log\left(D_j\right)\right)}{\Sigma_{j'=1}^{J} \exp\left(W_{j'}^c + \log\left(D_{j'}\right)\right)}\right) \quad (10)$$

The variable ln(Number of Households) in the commune, measures the size of the commune (Dj). Observe that the coefficient of ln(Number of Households) should be equal to one but this would go against the $var\left(\varepsilon_j\right) = \frac{\pi^2}{6}$ standardization. By adding this (correcting) term into the expected utility, we can obtain consistent estimates of the local ammenities coefficients. Besides, alternatives for each household were generated using importance sampling, which allows us to obtain even more efficient estimates. Note that, when importance sampling is used, no correcting factor is necessary to obtain consistent estimates of the preference parameters of the household utility (See de Palma et Al [7]). Finally, households may have preferences for the size of the commune, which represents an additional reason for introducing ln(Number of Households) in the expected utility formulation, with no a priori on the value of the associated coefficient.

Second, when couples move, they tend to stay within the same county (French *Département*), which explains the highly significant positive coefficient for the dummy variable indicating that the alternative contemplated is located in the same county as the commune in which the couple lived in 1990, i.e. at the previous census. In addition, Ceteris Paribus, households are not attracted by Paris. This negative coefficient may reflec the fact that most of the characteristics of Paris, that one could normally think that attract people, are already taken into account by the local amenity variables (e.g., Number of Rail Station, Distance to Arterial, Distance to Chatelet).

Variable	**Coeff.**	**t-Stat**	**Variable**	**Coeff.**	**t-Stat**
t^m	-6.521	-31.760‡	$(t^m)^2$	0.726	10.010‡
$A^f t^m$	0.836	3.50‡	$A^f (t^m)^2$	-0.246	-1.910
$A^m A^f t^m$	-0.092	-0.980	$A^m A^f (t^m)^2$	0.050	0.990
$A^m t^m$	1.163	4.580‡	$A^m (t^m)^2$	0.104	0.900
$(A^m)^2 t^m$	-0.211	-2.590‡	$(A^m)^2 (t^m)^2$	-0.035	-0.840
t^f	-4.544	-31.320‡	$(t^f)^2$	0.507	13.540‡
$A^m t^f$	0.211	1.610	$A^m (t^f)^2$	-0.009	-0.270
$A^m A^f t^f$	-0.078	-1.400	$A^m A^f (t^f)^2$	0.011	0.720
$A^f t^f$	0.181	1.180	$A^f (t^f)^2$	-0.011	-0.260
$(A^f)^2 t^f$	0.002	0.040	$(A^f)^2 (t^f)^2$	-0.003	-0.270

Table 3: Determinants of household location: commuting costs (Age)

If we were to take the results of the MNL estimations of β parameters as definitives, that is, the ones that fail to take the bargaining power within the couple into account, then we would obtained baised estimates of the values of time of the man and the woman. The estimated coefficients depicted in Table 3 confirm this. The value of time for a 20 years-old man (resp. woman) is estimated about 6.52€ (resp. 4.54€) per hour at the origin, wich seem to be low values. When comparing with the structural parameters (see coefficients a_0^m and a_0^f of Table 4) we are able to say that these values of time are underestimated and that neglecting the bargaining power may lead to innaccurate results
Furthermore, other results in Table 3 would lead you into some misleading conclusions. For instance, that the value of time of the men significantly depends on the age of his spouse ($A^f t^m$is statistically significant), wich it is not particularly reasonable.

Estimation of structural parameters

Structural P.	Coeff.	Avg (BS)	SD (BS)	t stat	inf	sup
$\mu_1(\%)$	0.78	0.91	0.08	9.56‡	0.54	2.56
$\mu_2(\%)$	4.28	4.27	0.08	53.27‡	2.85	5.98
a_0^m	11.00	11.10	3.44	3.20‡	10.44	11.75
a_1^m	−0.82	−0.89	1.69	−0.49	−1.22	−0.59
b_0^m	−1.30	−1.39	2.05	−0.64	−1.75	−0.97
b_1^m	0.02	0.07	0.96	0.03	−0.12	0.24
a_0^f	8.42	8.44	1.87	4.51‡	8.06	8.80
a_1^f	−0.59	−0.58	0.65	−0.90	−0.69	−0.46
b_0^f	−1.01	−1.02	0.40	−2.53‡	−1.10	−0.95
b_1^f	−0.08	−0.08	0.27	−0.30	−0.14	−0.04

Table 4: Structural Parameters (Age)

Most of the structural parameters are significant (Table 4). Consider two women whose husbands have the same age; the first woman is 10 years older than the second woman. Then the bargaining power of the first woman is 4.28% larger than the bargaining power of the second one. Symmetrically, consider two men whose wives have the same age; the first man is 10 years older than the second man. Then the bargaining power of the first man is 0.78% larger than the bargaining power of the second one. Note that $\mu_2 \gg \mu_1$, which means that, when a given couple is getting older, the woman gains more and more bargaining power.
Commuting cost is a concave function of commuting time for both spouses. The value of time for a 20 years-old man (resp. woman) is about 11€ (resp. 8.42€) per hour at the origin (i.e. when commuting time tends to 0). The value of time is a decreasing function of age.

Testing Pareto-Optimality The value of the test statistic is 97.4, which is very large for a χ^2 distribution with 10 degrees of freedom, so the null hypothesis is clearly rejected. However, this result holds for a given set of explanatory variables, and Pareto-optimality is less clearly rejected when introducing other explanatory variables.

4.3.2 One Dummy Variable for Each Spouse: Nationality

The main difference with the previous case is that, for dummy variables N^g, $g = m, f$, we have: $(N^g)^2 = N^g$. We still have 10 structural parameters, but we now have 16 estimated parameters (See Appendix for the identification rule):

$$\begin{aligned} U^c = {} & V(P,Z) + \beta_{10}t^m + \beta_{11}N^f t^m + \beta_{12}N^m N^f t^m + \beta_{13}N^m t^m \\ & + \beta_{20}t^f + \beta_{21}N^m t^f + \beta_{22}N^m N^f t^f + \beta_{23}N^f t^f \\ & + \beta_{30}(t^m)^2 + \beta_{31}N^f (t^m)^2 + \beta_{32}N^m N^f (t^m)^2 + \beta_{33}N^m (t^m)^2 \\ & + \beta_{40}(t^f)^2 + \beta_{41}N^m (t^f)^2 + \beta_{42}N^m N^f (t^f)^2 + \beta_{43}N^f (t^f)^2 \end{aligned} \tag{11}$$

Estimation results[3]

[3]Refer to the Appendix (6.2.1) for the estimation results of local amenity variables for the Nationality specification.

Variable	Coeff.	t-Stat	Variable	Coeff.	t-Stat
t^m	−4.160	−23.950‡	$(t^m)^2$	0.472	7.760‡
$N^f t^m$	−0.289	−1.110	$N^f (t^m)^2$	−0.056	−0.680
$N^m N^f t^m$	0.748	2.050†	$N^m N^f (t^m)^2$	−0.085	−0.740
$N^m t^m$	−0.377	−1.240	$N^m (t^m)^2$	0.229	2.320†
t^f	−5.158	−41.270‡	$(t^f)^2$	0.627	20.270‡
$N^m t^f$	1.035	4.840‡	$N^m (t^f)^2$	−0.176	−3.280‡
$N^m N^f t^f$	−0.908	−3.440‡	$N^m N^f (t^f)^2$	0.172	2.500†
$N^f t^f$	1.013	5.190‡	$N^f (t^f)^2$	−0.141	−2.70‡

Table 5: Determinants of household location: commuting costs (Nationality)

As in the Age case, here neglecting the bargaining power would lead to innacurate values of time of the man and the woman. When comparing with the results of the structural parameters for the Nationality case, values of time would be underestimated by around 50%

Estimation of structural parameters

Structural P.	Coeff.	Avg (BS)	SD (BS)	t stat	inf	sup
$\mu_1(\%)$	−4.567	−4.695	0.139	−32.927‡	−7.482	−2.161
$\mu_2(\%)$	−0.096	0.032	0.269	−0.357	−5.893	4.412
a_0^m	8.468	8.652	0.409	20.698‡	7.851	9.385
a_1^m	−0.976	−1.146	0.395	−2.471†	−2.012	−0.420
b_0^m	−0.840	−0.992	0.205	−4.105‡	−1.435	−0.736
b_1^m	−0.197	−0.052	0.211	−0.932	−0.345	0.402
a_0^f	10.012	10.011	0.273	36.705‡	9.426	10.553
a_1^f	−1.190	−1.154	0.500	−2.378†	−2.015	−0.197
b_0^f	−1.220	−1.212	0.099	−12.319‡	−1.383	−0.986
b_1^f	0.171	0.157	0.141	1.211	−0.116	0.428

Table 6: Structural Parameters (Nationality)

Our results show that the bargaining power of a man is significantly reduced when he is a foreigner, whereas the nationality of the woman has no significant effect on bargaining powers (Table 6). Recall that the bargaining power is normalized to 1/2 when both spouses are French. Therefore, the above results show that being foreigner for a man induces a relative loss of bargaining power of nearly 10%. This implies that the woman who is married to a foreigner will travel less than she would if she were married with a French man. This also implies that ignoring bargaining powers would significantly underestimate the value of time of foreign men.

Testing Pareto-optimality The value of the test statistic is 16.87, which is not so large compared to a χ^2 distribution with 6 degrees of freedom. The p-value of this test is 1%. For the 200 boostrapped samples, the test statistic goes from a minimum value of 9.02 to a maximum one of 107.88, with an average value of 32.82.

5 Concluding Remarks

The main purpose of this paper was to study the bargaining power of the household members in the context of location decisions. One important side product of our analysis is the computation of the values of time of the man and of the woman. The transport literature neglects the bargaining power, which leads to biased measures of values of time. These biases have important consequences (in particular for Cost-Benefit Analysis) which remain to be quantified. We have developed a method to provide an unbiased measure of the values of time. More specifically, using census data on the Paris Region, we were able to disentangle bargaining power from the values of time of spouses. We have shown that the age of the women as well as the nationality of the men, play a crucial role in determining bargaining power.

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6 Appendix

6.1 Identification Rules

6.1.1 One continuous variable for each spouse : Age

The system to be solved is:

$$(S): \begin{cases} \beta_{10} = -\frac{1}{2}a_0^m \\ \beta_{11} = \mu_2 a_0^m \\ \beta_{12} = \mu_2 a_1^m \\ \beta_{13} = \frac{1}{2}a_1^m + \mu_1 a_0^m \\ \beta_{14} = \mu_1 a_1^m \\ \beta_{20} = -\frac{1}{2}a_0^f \\ \beta_{21} = \mu_1 a_0^f \\ \beta_{22} = \mu_1 a_1^f \\ \beta_{23} = \frac{1}{2}a_1^f + \mu_2 a_0^f \\ \beta_{24} = \mu_2 a_1^f \\ \beta_{30} = -\frac{1}{2}b_0^m \\ \beta_{31} = \mu_2 b_0^m \\ \beta_{32} = \mu_2 b_1^m \\ \beta_{33} = \frac{1}{2}b_1^m + \mu_1 b_0^m \\ \beta_{34} = \mu_1 b_1^m \\ \beta_{40} = -\frac{1}{2}b_0^f \\ \beta_{41} = \mu_1 b_0^f \\ \beta_{42} = \mu_1 b_1^f \\ \beta_{43} = \frac{1}{2}b_1^f + \mu_2 b_0^f \\ \beta_{44} = \mu_2 b_1^f \end{cases}$$

and the solution is:

$$\begin{cases} \mu_1 & = -\frac{\beta_{21}}{2\beta_{20}} = -\frac{\beta_{41}}{2\beta_{40}} \\ \mu_2 & = -\frac{\beta_{11}}{2\beta_{10}} = -\frac{\beta_{31}}{2\beta_{30}} \\ a_0^m & = -2\beta_{10} \\ a_0^f & = -2\beta_{20} \\ b_0^m & = -2\beta_{30} \\ b_0^f & = -2\beta_{40} \\ a_1^m & = -2\frac{\beta_{12}\beta_{10}}{\beta_{11}} = -2\frac{\beta_{14}\beta_{20}}{\beta_{21}} \\ a_1^f & = -2\frac{\beta_{22}\beta_{20}}{\beta_{21}} = -2\frac{\beta_{24}\beta_{10}}{\beta_{11}} \\ b_1^m & = -2\frac{\beta_{32}\beta_{30}}{\beta_{31}} = -2\frac{\beta_{34}\beta_{40}}{\beta_{41}} \\ b_1^f & = -2\frac{\beta_{42}\beta_{40}}{\beta_{41}} = -2\frac{\beta_{44}\beta_{30}}{\beta_{31}} \\ \beta_{13} = \beta_{10} \cdot \left(\frac{\beta_{21}}{\beta_{20}} - \frac{\beta_{12}}{\beta_{11}}\right) \\ \beta_{23} = \beta_{20} \cdot \left(\frac{\beta_{11}}{\beta_{10}} - \frac{\beta_{22}}{\beta_{21}}\right) \\ \beta_{33} = \beta_{30} \cdot \left(\frac{\beta_{41}}{\beta_{40}} - \frac{\beta_{32}}{\beta_{31}}\right) \\ \beta_{43} = \beta_{40} \cdot \left(\frac{\beta_{31}}{\beta_{30}} - \frac{\beta_{42}}{\beta_{41}}\right) \end{cases}$$

6.1.2 One dummy variable for each spouse : Nationality

The system to be solved is:

$$(S):\begin{cases}\beta_{10}=-\frac{1}{2}a_0^m\\ \beta_{11}=\mu_2 a_0^m\\ \beta_{12}=\mu_2 a_1^m\\ \beta_{13}=\frac{1}{2}a_1^m+\mu_1 a_0^m+\mu_1 a_1^m\\ \beta_{20}=-\frac{1}{2}a_0^f\\ \beta_{21}=\mu_1 a_0^f\\ \beta_{22}=\mu_1 a_1^f\\ \beta_{23}=\frac{1}{2}a_1^f+\mu_2 a_0^f+\mu_2 a_1^f\\ \beta_{30}=-\frac{1}{2}b_0^m\\ \beta_{31}=\mu_2 b_0^m\\ \beta_{32}=\mu_2 b_1^m\\ \beta_{33}=\frac{1}{2}b_1^m+\mu_1 b_0^m+\mu_1 b_1^m\\ \beta_{40}=-\frac{1}{2}b_0^f\\ \beta_{41}=\mu_1 b_0^f\\ \beta_{42}=\mu_1 b_1^f\\ \beta_{43}=\frac{1}{2}b_1^f+\mu_2 b_0^f+\mu_2 b_1^f\end{cases}$$

and the solution is:

$$\begin{cases}\mu_1 &=-\frac{\beta_{21}}{2\beta_{20}}=-\frac{\beta_{41}}{2\beta_{40}}\\ \mu_2 &=-\frac{\beta_{11}}{2\beta_{10}}=-\frac{\beta_{31}}{2\beta_{30}}\\ a_0^m &=-2\beta_{10}\\ a_0^f &=-2\beta_{20}\\ b_0^m &=-2\beta_{30}\\ b_0^f &=-2\beta_{40}\\ a_1^m &=-2\frac{\beta_{12}\beta_{10}}{\beta_{11}}\\ a_1^f &=-2\frac{\beta_{22}\beta_{20}}{\beta_{21}}\\ b_1^m &=-2\frac{\beta_{32}\beta_{30}}{\beta_{31}}\\ b_1^f &=-2\frac{\beta_{42}\beta_{40}}{\beta_{41}}\\ \beta_{13}=\beta_{10}\cdot\left(\frac{\beta_{21}}{\beta_{20}}-\frac{\beta_{12}}{\beta_{11}}+\frac{\beta_{21}}{\beta_{20}}\frac{\beta_{12}}{\beta_{11}}\right)\\ \beta_{23}=\beta_{20}\cdot\left(\frac{\beta_{11}}{\beta_{10}}-\frac{\beta_{22}}{\beta_{21}}+\frac{\beta_{11}}{\beta_{10}}\frac{\beta_{22}}{\beta_{21}}\right)\\ \beta_{33}=\beta_{30}\cdot\left(\frac{\beta_{41}}{\beta_{40}}-\frac{\beta_{32}}{\beta_{31}}+\frac{\beta_{41}}{\beta_{40}}\frac{\beta_{32}}{\beta_{31}}\right)\\ \beta_{43}=\beta_{40}\cdot\left(\frac{\beta_{31}}{\beta_{30}}-\frac{\beta_{42}}{\beta_{41}}+\frac{\beta_{31}}{\beta_{30}}\frac{\beta_{42}}{\beta_{41}}\right)\end{cases}$$

6.2 Local Amenities' Estimation Results

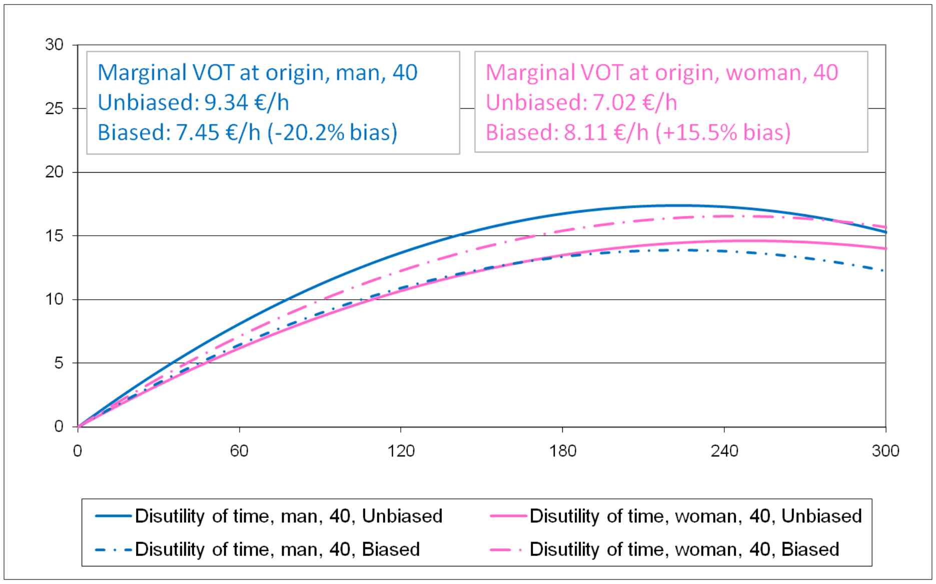
6.2.1 Nationality specification

Variable	Coefficient	t-Stat
log(Number of Households) in the commune	-0.115	-10.100
Same Department	2.676	153.710
Paris	-1.144	-22.820
Number of Subway Stations	0.001	0.350
Number of Rail Stations	-0.013	-2.990
Distance to Highway	$1.37E-05$	3.840
Distance to Art	$1.49E-05$	3.270
Distance to Chatelet	0.059	47.450
% Flats	-0.893	-19.510
% of Noisy Area	-0.114	-1.320
% of Forest	0.222	2.670
% of Forests * Number of Children	0.346	7.660
% of Water	-0.981	-4.210
% of Gardens	0.321	1.460
% of Gardens * Number of Children	0.173	1.340
log(Average Price of Flats)	0.270	6.480
log(Average Price of Flats)* Income per Capita	0.125	2.060
log(Average Price of Houses)	-0.308	-8.980
log(Average Price of Houses) * Income per Capita	0.542	12.360

Table 7: Determinants of household location: local amenities (Nationality)

6.3 Magnitude of bias in VOT

6.3.1 Magnitude of bias in VOT (40 years old)



6.3.2 Magnitude of bias in VOT (20 years old)