Accessibility and Environmental Quality: Inequality in the Paris Housing Market

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Abstract

In this paper we examine empirically the market for local amenities in the Paris metropolitan region. We find first that there is considerable inequity in the spatial distribution of these local amenities, including accessibility, environmental and social indicators. We use a spatial representation and Lorenz curves to examine the degree of inequity in these amenities, and this provides evidence that some amenities (or disamenities) are much more inequitably distributed than others. The most extremely unequally distributed amenities are noise (due to its concentration near airports), 'Significant Urban Zones" (areas with high concentrations of social and economic difficulties targeted for government assistance), presence of water (lakes and rivers) and forests, and presence of train and subway stations. Some indicators, such as the "Poulit accessibility" measure, were by contrast remarkably constant over the region. We recognize that local amenities should be capitalized into the housing market, and explore the willingness to pay of households for these amenities within the Paris region using alternative specifications of a location choice model. One of the core questions we examine is the spatial scale of the amenity effects and how this is captured in a location choice context. By estimating models at both a commune and at a grid cell level, we obtain new insights into how households in the Paris region trade off amenities against each other and against housing cost. We find that the residential location choice model fits the data moderately better at the smaller scale of the grid cell compared to the commune.

Keywords: Equity, efficiency, local public goods, integrated model, transportation modelling, Paris area.
JEL Classification: R23, R41

1 Introduction

Integrated land use and transportation models have received increased attention in research and practice over the past decade, principally based on their ability to examine the combined effects of land use and transportation policies on the endogenous system of urban development and patterns of travel, and their ability to represent the long-term induced travel effects of expansion in transportation capacity (Waddell, Ulfarsson, Franklin and Lobb, 2007). The utility of integrated models goes well beyond the examination of induced travel demand effects, however. There is considerable potential

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to use these tools to examine questions such as efficiency and equity in markets for local public goods (and local public bads). In addition, there has been growing interest in using integrated models to examine the spatial patterns and distributional effects of environmental externalities such as vehicle-related emissions (Wegener, 2004). In this paper, we undertake an analysis of *equity* in the spatial distribution of accessibility and environmental quality in the Paris metropolitan region, using an integrated land use and transport model system, and examine how these (dis)amenities are capitalized into the housing market.

Our approach integrates recent work in urban land use modelling (see, e.g. Waddell, Borning, Noth, Freier, Becke and Ulfarsson, 2003, Waddell, Ulfarsson, Franklin and Lobb, 2007) with recent advances in dynamic transportation modelling (see, e.g. de Palma, Lindsey and Kilani, 2005) to provide an integrated platform for land use and transportation policy analysis. UrbanSim is a land use model system that simulates the location choices of households and firms, the real estate development choices of developers and real estate prices resulting from the interactions of these agents in urban real estate markets (see Waddell, Ulfarsson, Franklin and Lobb, 2007 for details). A range of urban amenities and disamenities, including accessibility, land use, and social composition are incorporated in the model system through the utilities of location choice and as determinants of dwelling prices. UrbanSim is a microsimulation model system that simulates individual households and firms (or jobs), and models the changes in the composition of the population of households and firms, and their locations, on an annual basis. The aggregate targets for population and employment are defined for the region as a set of constraints, or control totals. Models representing relocation, location choice, real estate development and prices are connected via their operations on a shared database, which is updated from one simulation year to the next. Accessibilities are measured by interfacing UrbanSim with a travel model, and combining results of traffic assignment with the spatial patterns of activity location predicted by UrbanSim.

METROPOLIS simulates the dynamic traffic patterns over the course of a day, based on the spatial distribution of households and jobs and the configuration of the transportation network (see de Palma, Marchal and Nesterov, 1997 for details).Transportation demand is represented at the microscopic level allowing representation of population heterogeneity and providing detailed information about travellers' costs. Transportation supply is represented by a macroscopic model of road traffic that computes travel times on links based in this paper on a simple congestion function. The information transferred from METROPOLIS to UrbanSim is a matrix that gives the individual travellers' surplus in each Origin –Destination pair. In UrbanSim, the accessibility measures from METROPOLIS influence residential and business location choices, real estate development and real estate prices. UrbanSim then simulates these location choices, which are in turn used to update an O-D matrix that is then used in the next iteration of METROPOLIS. This cycle is repeated at time steps that could be as small as one year (the time step for UrbanSim), to reflect the joint evolution of the transportation system conditions and urban development patterns. More details are provided in de Palma, Motamedi, Picard and Waddell, 2005.

By linking these two model systems, it is possible to examine in a more comprehensive way than has been possible previously the implication of a range of urban externalities on travel, land use, and environmental outcomes. Our intent is to apply the integrated model system to an analysis that examines equity and efficiency in the markets for local public goods. We concentrate on two types of externalities: accessibility and environmental quality (or to be more precise, its degradation by pollution). Note that in order for a public good to have the potential to influence intra-metropolitan location choice, prices and urban development, it should meet two necessary conditions: (1) it is unevenly distributed over the region; (2) it is valued by households.

In the next section, we present a brief review of economics literature concerning urban externalities and inequality in urban zones. The third section describes the region under study and available data, and discusses spatial disparities and population inequalities in the region. We propose in this paper a simple measure of inequality based on Lorenz curves. This concept is related to equity. In the fourth section, we examine through a discrete choice model of residential location how households in the region trade-off these local public goods against housing cost. This provides direct evidence on their willingness to pay for these local public goods. Estimation results are reported and discussed in the fifth section. The sixth section concludes this paper.

2 Externalities and urban form

In many situations, the cost associated to the action of an agent is not equal to the cost born by the society (social cost). If the cost born by an individual is smaller than the social cost, externalities are negative (pollution, noise, accident provide the easiest examples). On the other hand, if the social cost is smaller than the individual cost (or if the social benefit is larger than the individual benefit), externalities are positive (green spaces provide by some individuals provide an example of such positive externalities). Externalities are endemic in urban life, and motivate much of urban public policy and sometimes, pricing or quantity regulations. Externalities represent a market failure, in the sense that the market does not produce an efficient outcome in the presence of externalities. They justify, according to Pigou (1920), government intervention. Pigouvian taxes or subsidies introduce prices that internalise the externalities (for example, road pricing can address congestion externalities)[1]. Such taxes can be positive (as in private transportation, to take into account congestion and pollution) or negative (in this case, it is a subsidy, as in the education sector).

Coase (1960) later argued that the market could internalize such externalities by means of private contracts between affected parties. Coase's Theorem can be summarized as follows: if transaction costs among private persons are nil and there are no income effects, the externalities may lead to a mutually beneficial agreement between the parties without any government intervention. However, as Coase knew, transaction costs are seldom zero, and other solutions are required. In particular, the assumption of zero transaction cost is not acceptable in the context of urban and regional development.

We are concerned in this paper with the examination of externalities in the urban context. Pollution caused by industrial plants in the early 20th century precipitated the development of zoning policy in the United States, and led to the widespread use of land use regulation to separate land uses that were considered incompatible. Traffic congestion and air pollution are notorious externalities arising from private travel choices. Massive public investments attempt to reduce congestion, generally with limited success due to the underlying incentives to over-consume transportation arising from its under-pricing (the exclusion of external costs from the calculations of the individual traveller). Of course, the situation in the US and in Europe is very different with respect to transportation costs: the price of gasoline is probably too low is the US and too high in Europe (see the details on the computation of the optimal price of gasoline in Small and Parry, 2005).

Although urban externalities can be positive, as in the case of knowledge spillovers and other interactions that lead to agglomeration economies and the rise of employment centers (see for example, Krugman, 1991), most literature addressing urban externalities focuses on the negative effects of specific land uses, of low-density urban form generally referred to as sprawl, and of travel patterns dominated by extensive use of single-occupancy vehicles. A variety of approaches to measuring the nature and magnitude of these externalities has been developed, but the most common approach is the use of hedonic regression to estimate the effect of the externalities on housing prices. Since locational amenities and disamenities are likely to be capitalized into the price of housing due to the locational fixity of the housing stock and its durability, house prices provide a convenient measure of the degree to which housing consumers value the presence of a particular externality. Many studies, numbering at least in hundreds, have attempted to measure in different localities the housing price impacts of urban externalities, especially with respect to environmental degradation. Note that this approach is represented as capturing both point-source and broader non point source effects from water, air and noise pollution. Early research along this line was reviewed by Brown and Li, 1980. For a recent review of studies of the housing price effects of air quality, water quality, undesirable land uses, neighborhood effects, and multiple environmental effects, see Boyle and Kiel, 2001. To our knowledge, the housing price effects of traffic congestion have not yet been systematically explored.

Much has also been written about the externalities associated with urban sprawl (see, for example, Verhoef and Nijkamp, 2003, Koland, 2006, and Chan, 2004), a term used to describe low-density, auto-oriented development. A systematic attempt to estimate the costs of sprawl was undertaken by Burchell, 1998, though the problems associated with measuring sprawl have not been easy to overcome. Brueckner (2000) argued that urban sprawl represents three related forms of market failure: "These are the failure to account for the benefits of open space, excessive commuting because of a failure to account for the social costs of congestion, and failure to make new development pay for the infrastructure costs it generates." This assessment led Brueckner to advocate for development impact fees and for congestion pricing as means to internalise the externalities related to urban sprawl.

Aside from the efforts to measure the effects of externalities on housing prices noted above, there appears to be a dearth of research examining broader influences of externalities in urban areas on outcomes such as residential location or business location or on real estate development. Nor is there any significant body of literature that provides an analytic framework for addressing transportation and land use interdependencies among the causes and effects of urban externalities. We suggest that this is an important gap in the literature, and that an integrated land use and transportation analytic framework is useful to better inform public policies intended to address these urban externalities.

We also study equity of population access to urban amenities. Equity corresponds to moral judgements on the distribution of welfare. It is an important concept since it allows assessment of the degree on inequality of a policy. It is also related to the concept of acceptability, since it is most likely that a fair policy (with reduces inequalities) will have higher acceptability, or expected approval by voters or potential voters. It therefore provides an important barometer to decision makers[2]. Beyond the political implications of inequality, we anticipate that inequality in the spatial distribution of amenities or disamenities produced by local externalities impact households differentially, and influence their location preferences. Social externalities such as those produced by the social composition of neighbourhoods interact with the social preferences of households making location choices to influence patterns of social clustering and segregation. We explore these and other interactions between household preferences and local externalities in Section 5.

3 Descriptive Analysis of the Study Area

The Ile de France is the capital region of France. It is a large metropolitan region of over 11 million inhabitants, with the city of Paris at its core (See Appendix Fig. 8). There are two levels of administrative units we will refer to in this paper: (1) 1300 "*Communes*" corresponding to municipalities outside Paris, and to "Arrondissements" or large administrative neighbourhoods with local governance within Paris; and (2) 8 *districts* that are administrative units larger than communes and directly managed by central government. In order to provide a context for our analysis of the equity of externalities in this region, we present below indicators of accessibility and environmental quality for the communes. An additional unit of analysis we use in this paper is a grid of 500 meter resolution, resulting in approximately 50,000 cells in the region (see appendix figure 8 where dots represent cells[3]). We compare below the variability of the different local attributes at the three geographical levels, and comment on the consequences of these inequalities.

Table 1 shows the variance decomposition at the three relevant geographical levels: district, commune and grid cell. For each variable X, the model is:

$$X_{dcg} = \mu + \eta_d + \xi_c + \varepsilon_g, \tag{1}$$

where, according to the analysis of variance model, X_{dcg} denotes the value of X in grid cell *g* located in commune *c* and in district *d*, μ is the average level of X in Ile-de-France, η_d, ξ_c and ε_g are independent random Gaussian variables with zero mean and variances $\sigma_d{}^2, \sigma_c{}^2$ and $\sigma_g{}^2$, respectively. The total variance of X is denoted by $\sigma^2 \equiv \sigma_d{}^2 + \sigma_c{}^2 + \sigma_g{}^2$, and the fraction of variance (reported in Table 1) at level *i, i=d, c, g*, is: $\alpha_i = 100 \bullet \sigma_i{}^2 / \sigma^2$, with $\alpha_d + \alpha_c + \alpha_g = 100$.

Table (1): Variance decomposition of accessibility and environmental variables over different scales

Variable	District (σ_d)	Commune (σ_c)	Cell (σ_g)
Distance and accessibility			
Number of subway and tramway stations	60.5%	22.1%	17.4%
Number of subway and tramway stations around	65.2%	22.3%	12.4%
Number of train stations	10.0%	23.1%	66.9%
Number of train stations around	17.0%	33.4%	49.6%
Accessibility to employment (Public Transit)	35.1%	64.9%	0.0%
Accessibility to employment (Private Car)	39.1%	60.9%	0.0%
Accessibility to shops (Public Transit)	34.9%	65.1%	0.0%
Accessibility to shops (Private Car)	35.8%	64.2%	0.0%
Distance to nearest arterial	7.8%	84.1%	8.1%
Distance to nearest highway	7.8%	83.0%	9.2%
Distance to Chatelet (Paris center)	42.7%	56.9%	0.4%
Environment			
% surface in noisy zone (severe noise: >96dB)	1.8%	62.4%	35.9%
% surface of parks and gardens	5.2%	17.2%	77.6%
% surface of Water	7.4%	19.3%	73.4%
% surface of forests	2.5%	36.2%	61.3%
% surface in 'Zones Urbaines Sensibles'*	3.9%	17.3%	78.8%
% surface of Public spaces	0.5%	19.3%	80.3%
% surface of Open Space	1.9%	37.6%	60.5%
% surface of Sport Spaces	2.0%	11.3%	86.7%

* Urban sensitive zones that receive special social care, in French 'Zone Urbaine Sensible'
Source: Author's computations from IAURIF GIS database.

Table 2 gives complementary information, indicating the average values of the same variables in each district. The cells' attributes are weighted by the number of households in the cell in order to compute these averages. Table 2 also indicates average values of other variables, which are defined only at the commune level (and therefore not presented in Table 1). These averages are also weighted by the number of households in the commune. We comment here on Tables 1 and 2 together. Note that the variance decomposition and district average values give only limited information concerning the inequalities in distance, accessibility and environmental variables. A more complete overview is given by Lorenz curves, which are used to represent the distribution of a characteristic Y among a population[4]. We now consider specific amenities reported in Tables 1 and 2.

Metro, subway and train stations

The number of (subway, tramway and train) stations around a cell corresponds to the number of stations in a cell and its 8 neighbouring cells. As a consequence, the average number of stations around a cell is approximately 9 times the average number of stations in the cell. The small differences are explained by the fact that some adjacent cells are located in a district different from the one of the cell considered. The fraction of the variance at the grid cell level is significantly lower for the stations around the cell compared to the stations in the cell, which goes along intuition. Train stations are distributed rather equally between the 8 districts (see Table 2), and between the communes (most of the variance is at the cell level), although they are less concentrated in the outer ring, especially in the East.

The inequalities are more prominent in the distribution of subway or tramway stations: *more than 60% (resp. 70%) of households live in cells with no train (resp. subway) stations either in the cell or in the 8 surrounding cells (Appendix Fig. 1)*. These percentages are even larger when restricting to the number of stations in a single cell. The large inequalities in the presence of subway stations are consistent with the fact that they are concentrated in Paris and in the inner ring surrounding Paris. Consequently, the largest fraction of the variance for the numbers of subway and tramway stations (both in the cell and around it) is at the district (α_d) level (see Appendix Fig. 10 and 11).

Distance to main roads or center of region

As seen in Table 1, most of the variability for the distance to arterial or to highway is at the commune level, which suggests that arterials and highways are rather equally distributed between districts, but not between communes. Table 2, on the other hand, suggests a different interpretation, since it shows important differences between district averages. However, the apparently large differences between district averages in Table 2 hides even larger differences between communes in the same district. This apparent inconsistency is partly due to the fact that District 77 is very large (nearly half the total number of cells in Ile-de-France, corresponding to the entire East part of the outer ring) and the distance to arterial or to highway is particularly unevenly distributed in this large district (see Appendix Fig. 12 and 13). Tables 1 and 2 (and intuition) agree that a large fraction (43%) of the variability in (Euclidian) distance to Chatelet is at the district level (Chatelet is the main regional trains station located in the centre of Paris, see Appendix Fig. 9), and an even larger fraction (57%) of the variance is at the commune level.

The distances to Chatelet, highway or arterial are more unequally distributed than travel times (see Appendix Fig. 2 and 3), with the 20% of the population farthest from Chatelet (resp. from the closest arterial or highway) sharing 45% (resp. 50% and 55%) of the distance to Chatelet (resp. to closest arterial or highway).

Travel times

The average travel time by Private Car is slightly more unequally distributed than the average travel time by Public Transit (see Appendix Fig. 3, 14 and 15). Note that the average travel time by Private Car roughly increases with the distance to Paris centre, whereas the average travel time by Public Transit is low in some regions of the outer ring. This is probably because the averages are computed using O - D matrix and people living in the outer ring tend to travel by car for longer trips and by Public Transit for shorter trips[5]. *The accessibility to employment by Private Car consistently increases with the distance to the Paris Centre, whereas the accessibility to employment by Public Transit varies less regularly with the distance to Paris Centre, depending on the geographical distribution of train stations.*

Table (2): Average accessibility and environmental variables, by District (population-weighted)

Variable \ District	75	92	94	93	78	91	95	77
Number of Grid Cells	420	704	980	952	9400	7399	5187	24194
Number of communes	20	36	47	40	262	196	185	514
Distance and accessibility								
Subway and tramway stations	8.17	0.80	0.65	0.72	0.00	0.00	0.00	0.00
Subway and tramway stations around	71.93	7.14	5.77	6.49	0.00	0.00	0.00	0.00
Train stations	0.98	0.75	0.44	0.53	0.53	0.47	0.68	0.30
Train stations around	9.35	6.89	3.94	4.76	4.29	4.07	5.60	2.35
Accessibility to employment (Public Transit)	50.93	49.29	48.02	48.25	45.20	44.30	45.97	41.86
Accessibility to employment (Private Car)	54.45	53.88	53.42	53.48	51.18	51.15	51.82	48.60
Accessibility to employment (M)*	-72.9	-72.3	-73.9	-74.0	-73.8	-93.3	-68.8	-89.9
Average travel time (PT)	28.08	31.54	38.45	38.54	47.84	52.04	46.24	48.86
Average travel time (PC)	16.19	16.08	16.31	16.90	24.13	36.58	20.31	35.59
Accessibility to shops (Public Transit)	33.24	32.25	31.98	32.06	30.28	30.25	30.94	28.66
Accessibility to shops (Private Car)	35.58	35.30	35.30	35.31	34.06	34.27	34.48	32.96
Private car travel time variability	2.72	4.11	3.07	3.46	3.55	6.65	3.71	3.56
Distance to arterial	2.03	1.28	0.74	0.67	3.27	1.62	2.71	2.15
Distance to highway	1.48	1.19	1.27	1.28	2.78	3.12	2.34	4.68
Distance to Chatelet	3.57	8.95	11.42	10.88	27.64	26.36	20.27	41.50
Environment								
% surface in noisy zone (severe noise: >96dB)	0.00	0.00	4.44	0.03	0.00	2.32	1.36	0.76
% surface of parks and gardens	7.59	9.13	9.54	8.65	13.09	12.66	10.60	12.74
% surface of Water	0.90	1.37	1.80	0.65	1.42	0.98	0.71	1.43
% surface of forests	0.27	1.54	1.20	1.01	7.15	7.28	3.97	8.02
% surface of Sport Spaces	1.43	3.05	2.48	3.03	2.42	2.36	2.89	1.77
% surface of Public spaces	9.32	13.72	13.20	12.69	22.67	22.31	17.46	22.52
% surface of Open Space	8.95	12.13	12.60	12.54	16.18	15.65	14.31	14.99
% surface in snsible zone	5.01	8.32	5.23	8.14	2.18	6.67	6.57	1.63

Source: Author's computations from IAURIF GIS database and Metropolis computations.
The variables in italics are computed at the commune level and not represented in Table 1.

Accessibility measures

We now consider a set of accessibility variables, computed using the method proposed by Jean Poulit in 1974, based on the logarithm of product supply at each destination. The variable Q_j represents the opportunity at destination *j* (number of employments or shops) and $\log(Q_j)$ is considered as the benefit of travelling to destination *j*. The utility S_{ij} of travelling from origin *i* to destination *j*, subtracting travel cost (C_{ij}), is:

$$S_{ij} = \lambda \log(Q_j) - C_{ij}, \tag{2}$$

where λ is a weighting factor which is computed as $\lambda = \frac{\alpha}{a}$, where α is the value of time (VOT), and *a* is an empirical coefficient used in the gravity trip distribution model.

In the gravity model, the volume of travel between origin *i* and destination *j*, denoted by (V_{ij}) is given by $V_{ij}=E_i*A_j*f(C_{ij})$, where $f(C_{ij}) = \frac{1}{C_{ij}^{a}}$, where E_i is the production of trips from *i* and where A_j is the attraction of trips to *j*. These parameters have been estimated using travel survey data (see IAURIF/THEMA, 2005). In those estimates, the travel cost parameter, C_{ij} depends linearly only on travel time tt_{ij}: $C_{ij} = \alpha * tt_{ij}$.

Accessibility from origin *i* is the log-sum of the accessibilities over all the destinations, j, given by:

$$S_i = \lambda \log\left(\sum_j Q_j \exp\left[-\frac{C_{ij}}{\lambda} \right] \right). \tag{3}$$

The variability of Poulit accessibility (to employment or to shops) at the grid cell level is clearly null. Cells have the same access attributes within the same travel model zone (which are nearly synonymous with communes). The between-districts differences represent more than 1/3 of the variance and mainly reflect differences between the city of Paris, inner ring and outer ring. Note that the coefficient of variation of the accessibility variable is very low, so one point difference represents a large fraction of the variance. Indeed, Lorenz curves (see Appendix Fig. 4 and 16 to 19) show that the four Poulit accessibility measures are very equally distributed among the population , suggesting that these accessibility measures do not really vary within the region. Therefore, it seems that the Poulit accessibility measures may significantly underestimate inequalities compared to other approaches to measuring accessibility, such as travel time.

We therefore also consider another accessibility measure, unfortunately restricted to access to employment using private car. The "*accessibility to employment (M)*" variable corresponds to the average travellers' surplus (integrated over the morning peak) for home to work travels computed by METROPOLIS (see de Palma, Motamedi, Picard and Waddell, 2005 for more details). In addition to the travel time cost, this measure takes into account schedule delay cost omitted in the Poulit accessibility measure (but does not consider the quality of the opportunities offered at the final destination). This measure is more unequally distributed than Poulit accessibility but much less than travel times (see Fig. 3 in the Appendix which illustrates this with a Lorenz curve).

Environment

The variability of the environment variables is mostly at the grid cell level, which means that, if households are sensitive to environmental variables, the relevant location choice model should be estimated at the grid cell level rather than at the commune level. The between-district differences in environmental variables are very limited, which suggests that the average quality of environment is highly localized, and averages out across cells within districts. However, Table 2 reveals important differences in forests between Paris, inner ring and outer ring districts, as well as important differences in noise exposure. Note that the severe noise limit (96 dB), as Appendix Fig. 20 shows, corresponds to the zones located around Roissy airport in the North and Orly airport in the south, with East-West bands corresponding to the landing and taking-off corridors. The apparent paradox between Table 1 and 2 concerning forests and noise is similar to the one discussed above for the distance to arterial or to highway. Note also that the noise measured this way in District 94 is very large because a large airport is located in this small district, close to very dense cells (recall that Table 2 presents population-weighted average values). Commune differences are important concerning the surface of forests, and even more concerning the exposure to severe noise. The official reference in this matter (CGP, 2001) reports a decrease of 0.4 to 1.1 percent of dwelling prices for each decibel after 55. It gives about 40% depreciation for dwellings in a cell completely located in noisy zone.

Recreational areas are distributed relatively unequally over the region. The blue curve in Appendix Fig. 5 shows the fraction of the cumulated parks and gardens surface as a function of the fraction of the cumulated population (ordered by increasing parks and gardens surface in the cell). It is similar to Lorenz curves found for income distributions in developed countries. *It shows that the 20% of households who benefit the least from parks and gardens surfaces live in cells which together contain only 5% of parks and gardens surfaces, whereas the 20% of households who benefit the most from parks and gardens surfaces live in cells which together contain 50% of parks and gardens surfaces. The distribution of sports spaces is far more unequal,* since more than 40% of the population lives in cells with no sports spaces, whereas the 20% of households who benefit the most from sports spaces live in cells which together contain 80% of sports spaces, as shown in Appendix Fig. 5 and 25. The distribution of forests and water surfaces are even more unequal, since nearly 80% and nearly 90%, of the population live in cells with no forests or no water, respectively. We notice that here, Water concerns land covered permanently by water as lakes and rivers and is considered as an amenity. The rather equal distribution of parks and gardens is confirmed by Appendix Fig. 5, 22 and 23, which show that both population and parks and gardens are approximately concentrated in the same areas, mainly in Paris and inner ring. On the other hand, Appendix Fig. 22 shows that forests are unequally distributed among the population because forests are concentrated in the least dense regions. The reason for the large degree of inequality in water distribution is totally different: water is concentrated in a very small number of grid cells, mainly along the rivers, as shown in Appendix Fig. 24.

The negative local amenities are more unequally distributed. Indeed, less than 15% of the population lives in cells classified as "Zones Urbaines Sensibles", which translate approximately to "Significant Urban Zones" (which suggests they are neighbourhoods with high concentration of social problems, and may be unsafe). Appendix Fig. 21 shows that these zones are mainly located in the inner ring. The inequalities are even more striking concerning severe noise, which affects only 1.6% of the population, in the sense that 1.6% of the households live in a grid cell with a positive fraction of the surface affected by severe noise.

4 Model Specification

To the extent that households have preferences for the positive and negative local amenities described in the preceding section, spatial variations in these amenities should be capitalized into housing prices, which are higher in Paris and the Western part of the inner ring, and lower in outer ring, especially in the Eastern part. We turn now to the specification of a discrete choice model of residential location to examine willingness-to-pay for local amenities, and the trade-offs households make among them.

We wish so to investigate what is the most appropriate spatial scale for studying preferences for locational amenities. This raises the question of the most relevant level for estimating a household location choice model. We are asking whether people have preferences for communes or for smaller more homogeneous geographical units. In order to answer this question, we estimate two location choice models: one at the commune level, and the other one at the grid cell level. This is somewhat different from some prior work that has estimated the effects of right hand side variables at different levels of aggregation (see, for example, Guo and Bhat, 2005), since here we also vary the level of the unit of location choice.

Assuming that all the dwellings *i* located in the grid cell k, k=1,…,K, which is located in commune *j, j=1,…,J*, have the same observable attributes (since we do not have information on structural attributes of the housing units), household *h, h=1,…,N*, have the same expected utility $V_i^h = V_k^h$ for them. We assume that expected utility is a linear combination of grid cell attributes X_k and commune attributes Z_j, in which the marginal utilities of grid cell and commune attributes can be household-specific. Expected utility is therefore of the form:

$$V_i^h = X_k \beta_h + Z_j \gamma_h, \tag{4}$$

where β_h and γ_h denote the household-specific marginal utilities of grid cell and commune attributes, respectively.

If households choose among communes rather than grid cells, then expected utility of a dwelling located in commune *j* only depends on Z_j and is of the form:

$$V_j^h = Z_j \delta_h = Z_j \gamma_h + E\left(X_k \beta_h \mid Z_j \right), \tag{5}$$

where δ_h mixes the marginal utilities of commune attributes and the marginal utilities of grid cells attributes, weighted by their distribution in the commune. The exact formula for $E\left(X_k \beta_h \mid Z_j \right)$ corresponds to the log-sum in a nested logit model (see Anderson, de Palma and Thisse, 1992 for details).

The total number of dwellings in Ile-de-France is denoted by *I;* the number of dwellings in commune *j* and in grid cell *k* are denoted by C_j and G_k, respectively. The probability for household *h* to choose a dwelling *i* is given by the Multinomial Logit formula:

$$P_i^{\,h} = \frac{\exp\left(V_i^h \right)}{\sum_{i'=1}^{I} V_{i'}^h}, \tag{6}$$

Since all the dwellings located in k have the same expected utility, and the same probability of being selected, Equation (4) implies that the probability that household h selects grid cell k is:

$$P_k^h = G_k P_i^h = \frac{G_k \exp\left(V_k^h\right)}{\sum_{k'=1}^{K} \sum_{i' \text{ in } k'} V_{i'}^h} = \frac{\exp\left(V_k^h + \log\left(G_k\right)\right)}{\sum_{k'=1}^{K} \exp\left(V_{k'}^h + \log\left(G_{k'}\right)\right)}, \tag{7}$$

Similarly, the probability that household h selects commune j is:

$$P_j^h = C_j P_i^h = \frac{C_j \exp\left(V_j^h\right)}{\sum_{j'=1}^{J} \sum_{i' \text{ in j'}} V_{i'}^h} = \frac{\exp\left(V_j^h + \log\left(C_j\right)\right)}{\sum_{k'=1}^{K} \exp\left(V_{j'}^h + \log\left(C_{j'}\right)\right)}, \tag{8}$$

We report below the estimation results for the household location choice models at the level of 500 x 500 meter cells within the study area, and at the level of communes. These analyses extend the previous results reported in de Palma, Motamedi, Picard and Waddell, 2005, which were based strictly on a model specified at the level of communes.

5 Empirical Results

We now turn to the results from model estimation. We begin with a comparison of two models, one estimated at the grid cell level and the second at the commune level. We then proceed to a grid cell level model that combines grid cell and commune variables. Table 3 reports the estimation results for the household location choice model at the grid cell level, using only grid cell variables and at the commune level, using only commune variables. The overall explanatory power at the grid cell level is slightly larger than the explanatory power at the commune level (McFadden's LRI=.2414 and 0.2272, respectively). Table 4 provides results from a grid cell level specification that used both grid cell and commune level variables (LRI=0.2440). These new results are largely consistent with those presented in Table 3, which we focus on in the following discussion of these results.

We note that the different results obtained for location choice at two different levels of geography reflect several influences. One is a measurement effect related to aggregation bias. The larger the geographic scope, the more a measure reflects an averaging of variation that occurs within it, producing some level of aggregation bias due to loss of information in the aggregation process. See, for example, Zellner, 1962, for an early test for aggregation bias, and an assessment of aggregation bias in the context of choice models by Allenby and Rossi, 1991. The second influence is behavioural and perceptual. Households and individuals perceive neighbourhoods and the effects of various kinds of amenities differently at different spatial scales. A third influence is a reflection of what geographers have referred to as the Modifiable Aerial Unit Problem (MAUP), which reflects the general finding that models estimated on different levels of geography tend to produce different coefficients, indicating that a model is not independent of the scale at which it is applied (Openshaw, 1984). Note that it is easy to confound these effects. Guo and Bhat, 2004, have explored the question of separating behavioural from MAUP effects in the context of residential location choice in the San Francisco Bay area, and proposed a multi-scale logit model (MSL). They used parcels represented by household travel survey respondents as the universal choice set, and sampled alternatives from within this sample. It is not clear how such a small sample of the housing inventory (the survey respondents' parcels represent a very small fraction of the housing stock) would be able to adequately address problems of MAUP since the sample of housing alternatives would be very sparsely distributed. Our approach differs in that we use exhaustive data of all movers within the region from 1998 to 1999 as the sample of agents, and represent the full available housing stock in the universal choice set, representing these by grid cells in one model, and communes in the second. Parcel-level data for the Paris region was unfortunately not available, and we recognize that the results will depend in part on the aggregate units of geography we were able to use.

An unusual aspect of our study is that we were able to obtain information on the prior residential location, which we find to be extremely important in influencing residential location choice. The most significant variable in our results is (by far) the dummy variable indicating that the cell or commune is located in the same district as the one in which the household lived before it moved. This indicates that households have a strong preference for relocating not too far from their previous residence, which can be partly explained by the proximity to their current employment (indeed, 53% of active persons work and live in the same district) or to other attachment to their neighbourhood and the limit of their search extent. Unfortunately, the previous commune of residence was not indicated in our data, so we could not measure the preference to stay in the same commune.

We found that price effects significantly varied as a function of household head age, and household income and size. The insignificant coefficient of Log(Price of Flat) in Table 3 means that a reference individual, aged 40, living alone and with a yearly income equal to exp(9.97)=21,400 €[6] is not sensitive to the prices of *flats*. The positive coefficient of the income/price interaction variable Log(Price of Flat)* (Log(Income)- $\overline{\text{Log(Income)}}$) means that poorer people are attracted by lower prices, whereas richer people are attracted by higher prices (or more likely, by amenities we are not directly measuring that command higher prices). According to commune level estimates, older and larger families are slightly more sensitive to the prices of flats[7]. Results not reported here show that the coefficient of flats price is not sensitive to household head age or family size at the grid cell level. Our reference individual seems to prefer communes with higher *house* prices. One can suspect that omitted variable bias (prices are higher in places with better unobserved amenities, and their positive effect is not modelled explicitly in the location regression) dominates the true negative price effect. However, with the same income and family size, houses price effect becomes negative when household head is aged over 49 (commune level estimates) or 62 (grid cell level estimates)[8]. Similarly, at the reference income and age, the house price coefficient is negative for families with more than 2 members.

Table 3: Estimation results at commune and grid cell level

Variable	Estim. at commune level		Estim. at cell level	
	Coefficient	t-statistic	Coefficient	t-statistic
Same district as before move	2.53879	275.91	2.53494	272.47
Paris	-0.25412	-10.10	-0.16871	-10.29
Log(Price of Flat)	0.00644	0.20	0.02178	0.94
Log(Price of Flat)* (Age-40)/10	-0.02976	-1.74		
Log(Price of Flat)* (Log(Income)- $\overline{\text{Log(Income)}}$)	0.40919	8.20	0.24849	5.84
Log(Price of Flat)* (Number of hh members – 1)	-0.04236	-2.40		
Log(Price of House)	0.08735	3.70	0.13934	7.41
Log(Price of House)* (Age-40)/10	-0.10359	-8.78	-0.11371	-20.90
Log(Price of House)* (Log(Income)- $\overline{\text{Log(Income)}}$)	0.18693	5.78	0.14874	5.17
Log(Price of House)* (Number of hh members – 1)	-0.10932	-8.38	-0.13038	-20.43
Number Subway stations around			-0.00412	-2.37
Number Subway stations in the commune / cell	0.00518	4.59	0.00146	0.21
Number Railway stations around			0.01326	3.85
Number Railway stations in the commune / cell	-0.00940	-4.86	0.00616	0.60
Average travel time from j, commuting (TC) [hr]	0.02483	0.80	0.04007	1.45
TC*(Dummy female) [hr]	-0.37377	-8.28	-0.29400	-6.56
Distance to highway [km]	-0.00594	-3.10	-0.00146	-0.74
Distance to arterial [km]	-0.00798	-2.98	-0.01500	-5.87
Distance to Chatelet (Paris centre) [km]	0.00167	2.94	-0.00054	-1.06
% households with 1 member * 1 member in h	1.87670	20.62	2.27023	30.73
% households with 2 members* 2 members in h	1.33649	4.20	1.77322	10.03
% households with 3+ members* 3+ member in h	2.22967	22.16	2.07516	27.98
% hh with no working member * no working member in h	7.79690	33.91	5.38190	33.49
% hh with 1 working member * 1 working member in h	-0.93134	-5.84	0.50248	4.58
% hh with 2+ working member * 2+ working member in h	1.66425	14.83	0.40430	5.01
% hh with a young head	0.45006	3.01	1.02140	10.86
% hh with a young head * young head in h	4.77740	28.34	3.24295	29.59
% hh with a middle age head * middle aged head in h	-0.69337	-4.16	-0.16208	-1.51
% Rich hh * Rich h	3.28038	28.36	2.87636	36.58
% Medium Income hh * medium income h	1.62120	10.11	1.92296	17.00
% Poor hh * poor h	0.45889	3.53	1.06997	12.11
% households with a foreign head * foreign head in h	5.04570	26.74	4.57810	37.26
% households with a foreign head * French head in h	-1.99493	-17.44	-1.30553	-16.71
% of surface in Sensible Zone * Rich h	0.67811	4.97	-0.22815	-4.28
% of surface in Sensible Zone * Med. Inc. h	-0.08340	-0.78	-0.19330	-5.16
% of surface in Sensible Zone * Poor h	0.43164	4.45	0.16457	4.99
Log of the number of residential units	0.06682	9.26	0.02295	3.27
% of Flats in total dwellings * Foreign head in h	1.36775	15.42	0.67595	11.37
% of Flats in total dwellings * French head in h	0.48469	7.28	0.16077	3.76
% of Flats in total dwellings * (N. of members - 1)	-0.08459	-4.29	-0.05561	-4.29
% of Flats in total dwellings * young head in h	-0.13120	-2.43	-0.03680	-1.01
% of Flats in total dwellings * old head in h	-0.76601	-8.40	-0.18806	-2.82
% of surface in Noisy Zone	-0.08929	-1.56	-0.07667	-1.52
% of surface covered by Forest	-0.11708	-3.09	-0.29739	-5.05
% of surf. covered by Forest * N. of Children	0.42292	6.87	0.46115	4.99
% of surface covered by Water	0.20360	1.62	0.33284	4.24
% of surface covered by Parks and Gardens	-0.42727	-4.22	-0.15159	-2.93
% of surf. covered by Parks * N. of children	-0.12942	-0.71	0.61447	6.67
% of surface covered by Sport spaces	0.44171	2.50	-0.37138	-4.06
% of surf. covered by Sport spaces * N of children	0.26755	0.83	0.78619	4.93

Notes: “%” sign represents the proportion. “N. of children” counts family members aged 11 or less.
Source: Authors’ estimations

Table 4: Estimation results at grid cell level with grid cell and commune variables

Variable	Communes' variables		Cells' variables	
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**
Same district as before move	2.53671	271.53		
Paris	-0.22675	-8.43		
Log(Price of Flat)	-0.01300	-0.51		
Log(Price of Flat)* (Age-40)/10	0.28139	6.29		
Log(Price of Flat)* (Log(Income)- $\overline{\text{Log(Income)}}$)	0.14508	7.11		
Log(Price of Flat)* (Number of hh members – 1)	-0.13010	-22.93		
Log(Price of House)	0.25108	8.44		
Log(Price of House)* (Age-40)/10	-0.13981	-19.70		
Log(Price of House)* (Log(Income)- $\overline{\text{Log(Income)}}$)			-0.00322	-1.71
Log(Price of House)* (Number of hh members – 1)	0.00605	5.16	0.00097	0.14
Number Subway stations around			-0.00322	-1.71
Number Subway stations in the commune / cell	0.00605	5.16	0.00097	0.14
Number Railway stations around			0.02115	5.77
Number Railway stations in the commune / cell	-0.01494	-7.10	0.00677	0.66
Average travel time from j, commuting (TC) [hr]	0.01065	0.33		
TC*(Dummy female) [hr]	-0.35600	-7.73		
Distance to highway [km]			-0.00067	-0.33
Distance to arterial [km]			-0.01314	-4.96
Distance to Chatelet (Paris centre) [km]			-0.00028	-0.47
% households with 1 member * 1 member in h	-0.16085	-1.15	2.30278	20.02
% households with 2 members* 2 members in h	-0.28286	-0.75	2.04371	9.65
% households with 3+ members* 3+ member in h	-0.08790	-0.59	2.11213	19.15
% hh with no working member * no working member in h	5.09950	16.50	3.30625	15.56
% hh with 1 working member * 1 working member in h	-2.63547	-12.42	1.65813	11.18
% hh with 2+ working member * 2+ working member in h	1.53570	9.18	-0.04502	-0.36
% hh with a young head	-0.40537	-2.16	1.11631	9.36
% hh with a young head * young head in h	1.93974	9.14	2.64059	19.00
% hh with a middle age head * middle aged head in h	-0.86585	-4.05	0.00740	0.05
% Rich hh * Rich h	0.60752	3.91	2.56647	23.79
% Medium Income hh * medium income h	-0.37902	-1.73	1.97329	12.54
% Poor hh * poor h	-0.80207	-4.71	1.35812	11.62
% households with a foreign head * foreign head in h	1.21668	4.63	3.99283	23.27
% households with a foreign head * French head in h	-0.10054	-0.67	-1.30069	-12.58
% of surface in Sensible Zone * Rich h	0.85358	5.58	-0.35104	-6.05
% of surface in Sensible Zone * Med. Inc. h	0.21783	1.82	-0.22336	-5.43
% of surface in Sensible Zone * Poor h	0.24909	2.28	0.12894	3.56
Log of the number of residential units	0.01889	2.46	0.00828	1.11
% of Flats in total dwellings * Foreign head in h	1.31465	10.50	0.06254	0.73
% of Flats in total dwellings * French head in h	0.33011	3.75	0.07201	1.23
% of Flats in total dwellings * (N. of members - 1)	-0.08926	-3.23	0.00257	0.14
% of Flats in total dwellings * young head in h	0.01850	0.23	-0.08934	-1.59
% of Flats in total dwellings * old head in h	-1.30230	-8.72	0.45902	4.19
% of surface in Noisy Zone	-0.14111	-1.94	0.01074	0.17
% of surface covered by Forest	-0.05748	-1.46	-0.25683	-4.21
% of surf. covered by Forest * N. of Children	0.33436	5.07	0.30723	3.15
% of surface covered by Water	0.35641	2.70	0.24600	2.99
% of surface covered by Parks and Gardens	-0.52131	-4.90	-0.05872	-1.08
% of surf. covered by Parks * N. of children	-0.26030	-1.36	0.56111	5.73
% of surface covered by Sport spaces	0.25816	1.41	-0.36015	-3.89
% of surf. covered by Sport spaces * N of children	0.48338	1.46	0.75183	4.63

Notes: "%" sign represents the proportion. "N. of children" counts family members aged 11 or less.
Source: Authors' estimations

Interestingly, larger or older families are more sensitive to the price of houses than flats,[9] which is consistent with the fact that, when they become older and/or have children, families have a stronger tendency to live in a house rather than in a flat. On the other hand, the price coefficient is more sensitive to income for flats than for houses. For the richest households, the net price effect is positive even in very large households with an old head. This reflects the fact that richer families are more sensitive to unobserved amenities and less sensitive to prices (for example they may be willing to pay a premium to live in neighbourhoods with exclusively wealthy neighbours).

Households prefer living in communes with many subway or tramway stations, but dislike the close proximity of such stations. Note that a station located in the commune but not in the cell or surrounding cells is clearly beneficial since it improves accessibility. On the other hand, a very close station may be detrimental because of the noise and crowding, and the clustering of business activity around stations, so the sign of the overall effect is not clear a priori.

Table 4 shows that households are mainly sensitive to stations in the commune or in the surrounding cells rather than in the cell they live, with positive and significant effects for the commune and negative for nearby stations. Railway stations around a cell were positive and significant in their influence on location choices, while it was negative in commune and not significant at the 5 percent level for cell-level concentration. This suggests that individuals value proximity to railway stations, and are willing to walk or drive (or take the bus) relatively long distances (more than 500 meters, to go to adjacent cells.

All the distance variables have a negative sign meaning that, ceteris paribus, households prefer to locate close to arterials or highways, or close to the centre of Paris (Chatelet). The negative coefficient for Paris dummy reflects the fact that, ceteris paribus, individuals prefer the suburbs to Paris. However, it seems more plausible that this negative coefficient rather reflects the non-linear effect of other variables, which are particularly high in Paris, and interactions with the distance variables. For example, the coefficient of the number of subway stations is particularly high in some cells within Paris. If the marginal utility of a subway station is decreasing with the number of subway stations, then imposing a linear specification for the effect of the number of subway stations leads to overestimate this effect in the cells or communes with a very large number of stations, which happen to be all located inside Paris. The (negative) Paris coefficients then corrects for this overestimation. This interpretation is consistent with the fact that Paris coefficient is significantly larger (in absolute terms) in the commune estimates than at the grid cell level (very large numbers of stations are more common in communes than in grid cells).

We tested (results not reported here) a non-monotonous specification for the distance to arterial or to highway. The idea was that the close proximity to a highway is a nuisance because of pollution and noise, whereas individuals also dislike a too large distance to highway, for accessibility considerations. However, we failed to estimate the intuitive inverse U-shaped effect for those distance variables, with a large number of specifications for the covariates. This suggests that accessibility and travel time considerations dominate pollution and noise nuisance considerations with respect to location choice, at least at the scale we are measuring these effects.

Female-headed households dislike communes with larger average commuting times by transit. This is consistent with the tendency towards shorter commutes by women reported elsewhere. We failed to estimate significant effects for average travel time using Private car or accessibility variables, probably because of the large correlation between the variables measuring distances, average travel times and accessibility.

Households tend to prefer locating close to households with a rather young head. The places with a high concentration of young people are indeed usually particularly dynamic and attract new people of all age classes. As far as age, household size or income is concerned, households tend to locate close to similar households. According to Table 4, these segregation effects seem to operate more at a very small neighbourhood level, since the coefficients of percentages defined at the grid cell level are usually more significant than the coefficients of percentages computed at the commune level. Note that the counter-intuitive negative coefficients of some commune level variables in Table 4 might, similarly to Paris dummy, reflect some non-linearities of the effect of the corresponding composition variables.

Foreign households tend to locate in grid cells and, to a lesser extent, communes with more foreign households, whereas French households prefer to locate in places with less foreign households. Poor households tend to locate close to other poor households, and the same is true for rich households. According to grid cell estimates, rich or medium income households tend to locate far away from ‘Significant Urban Zones’, whereas poor people have a stronger tendency to locate in such neighbourhoods, because they can not afford better locations. The positive effect of for rich or medium income households is harder to explain.

As expected,, households dislike noise. According to Table 4, this effect is more important at the commune level than at the grid cell level, suggesting that the negative effect of airports are not limited to the grid cells suffering from severe noise. Households with children like living close to forests, whereas households without children seem to avoid forests. However, this probably reflects a displacement effect (more forests means less room for dwellings) rather than a preference effect. This hypothesis is supported by the more negative or less positive signs at the grid cell level (where the displacement effect is a priori more important) than at the commune level. Households seem to appreciate the proximity of water, but this is not very significant, and there seems to be some displacement effect at the grid cell level.

Households tend to locate very close to parks and gardens, especially when they have children. This effect is important at the grid cell level, but negative and hardly significant at the commune level. The difference between commune and grid cell estimates might result from the fact that parents are only interested in parks and gardens available within walking distance. In addition, parks and gardens are rather uniformly distributed over communes. Households seem to appreciate the availability of sports spaces, even quite far away (i.e. at the commune level), even when they do not have children. The negative coefficient at the grid cell level may result from the displacement effect, since sports spaces are often large and occupy a significant fraction of a grid cell.

We have studied the effect of density, which is positive and larger at the commune level than at the grid cell level (results not reported here). The positive coefficient for the logarithm of the number of households in the cell reflects the fact that new households tend to locate in more populated areas. The positive signs reflect the fact that dense areas are more dynamic, attract more people and rotation is more important (more households move in and out). The difference in the coefficients for cell and commune density results from a displacement effect (denser parts have less room for new households to come in). This displacement is likely to be more important at a small geographical level, since a large density in a cell probably means a large density everywhere in the cell, whereas a large density is a commune may corresponds to a very large density in some parts and more room for new households in other parts of the commune. These results on interactions of household characteristics with social characteristics of neighbourhoods are consistent with a substantial body of literature on residential segregation tendencies. Note that, with importance sampling, the alternative cells were included in the choice set with a probability proportional to the number of dwellings, so the variable “Number households” was never zero. The coefficients of the number of collective dwellings (by itself and crossed with household size) means that only singles are attracted by collective dwellings, whereas 2-member households are not sensitive to the number of collective dwellings and larger families prefer locations with less collective dwellings. The opposite effects prevail for the number of individual dwellings, except that only families with more than 6 members are attracted by places with more individual dwellings. These two coefficients reflect both a displacement effect (more individual dwellings imply less room for new inhabitants) and a preference effect (larger families prefer a neighbourhood of individual dwellings). The displacement effect dominates for most families (6 members or less).

Compared to the results reported in Table 3, the main difference in Table 4, from the grid cell estimation using grid cell and commune variables is that we can see more complex interactions among the scales at which different kinds of amenities are more significant. No clear dominance of one scale appears to emerge from these results for different types of effects. In some cases, the commune and grid cell effects are both significant and in agreement, while in others they have opposite signs, and in others only one or the other is significant. We do not attempt to generalize from this any clear lessons about the most natural scales for measuring differing locational amenity effects.

6 Conclusions

In this paper we have examined empirically local amenities in the Paris metropolitan region. We find first that there is considerable inequity in the spatial distribution of these local amenities, including accessibility, environmental and socio-economic indicators such as the distribution of households’ income, the fraction of minorities or the foreign-born population. We use spatial representation and Lorenz curves to examine the degree of inequity in these amenities, and this provides evidence that some amenities (or disamenities) are much more inequitably distributed than others. The most extremely unequally distributed amenities are noise (due to its concentration near airports), ‘Zones Urbaines Sensibles’ (areas with high concentrations of social problems), presence of water and forests, and presence of train and subway stations. Some measures, such as the Poulit accessibility measure, were remarkably insensitive, by contrast, appearing to be more ubiquitous.

We have recognized that local amenities are generally capitalized into the housing market, and explored the willingness to pay of households for these amenities within the Paris region using alternative specifications of a location choice model. One of the core questions we examined was the spatial scale of the amenity effects and how this is captured in a location choice context. By estimating models at both a commune and at a grid cell level, we have generated new insights into how households in the Paris region trade off amenities against each other and against housing cost.

We find that the residential location choice model fits the data moderately better at the smaller scale of the grid cell level compared to the commune level. Some have previously argued that models are likely to fit better at more aggregate levels, but this is not what we find. This could be due to some combination of better measurement (less aggregation error), and a more accurate representation of households preferences of households. We have not completely avoided the MAUP problem, however, since both units of analysis we have examined are aggregate in nature. Nevertheless, our results are largely consistent at the two levels of geography, with some notable exceptions. Some amenities appear to be more localized in their effect while others are broader in their effect.

This study has provided considerable insight into the way local amenities are distributed in the Paris region, and how these influence household location choices. Further elaboration of this research may explore ways of generating simulation-based sensitivity analysis to explore the trade-offs among amenities and cost for different classes of households. We also wish to further examine the potential endogeneity of prices, since amenities should be capitalized into housing prices.

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Appendix

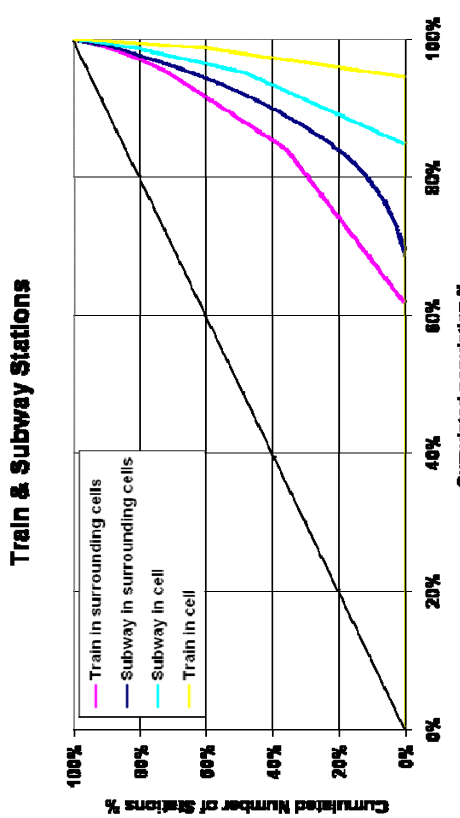


Fig. (1): Lorenz curve for Train and Subway stations in the cell or surrounding

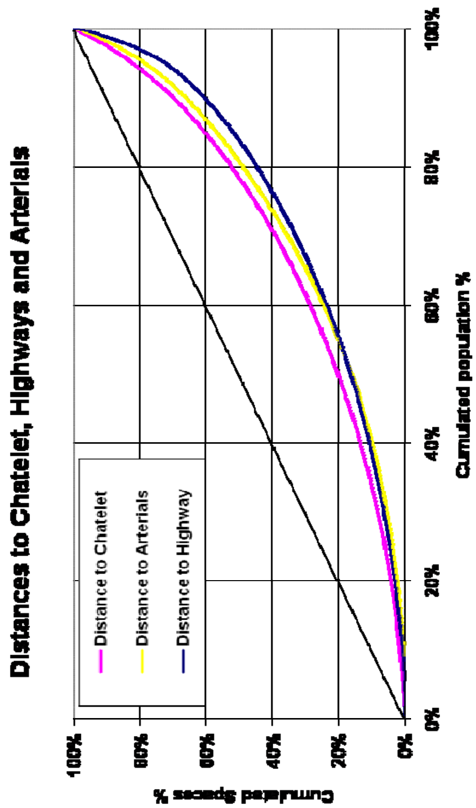


Fig. (2): Lorenz curve for Distances to Paris Centre, highway and arterial

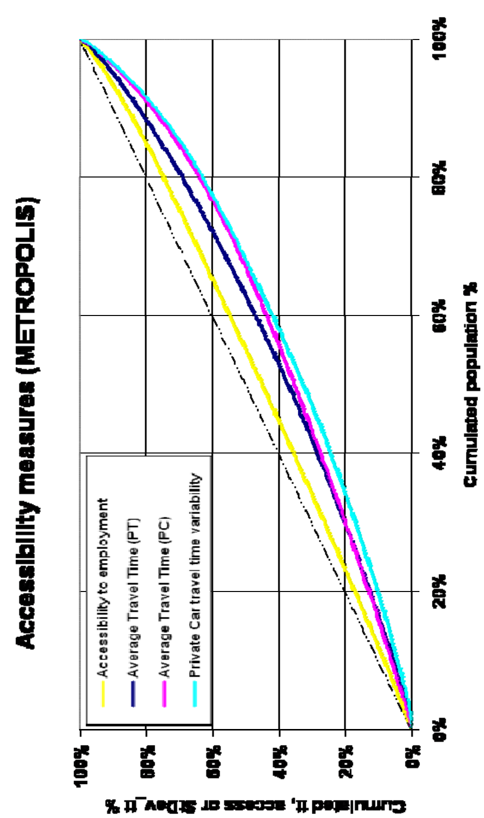


Fig. (3): Lorenz curve for different measures of Accessibility (by METROPOLIS)

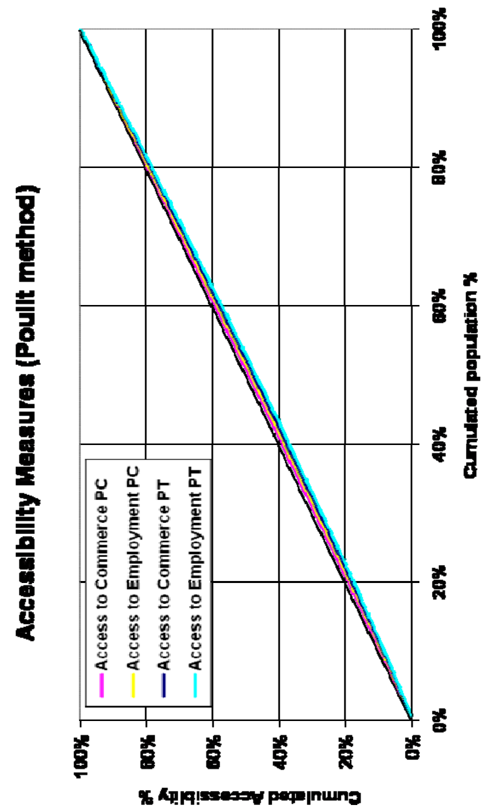


Fig. (4): Lorenz curve for different accessibility measures (by Poulit method)

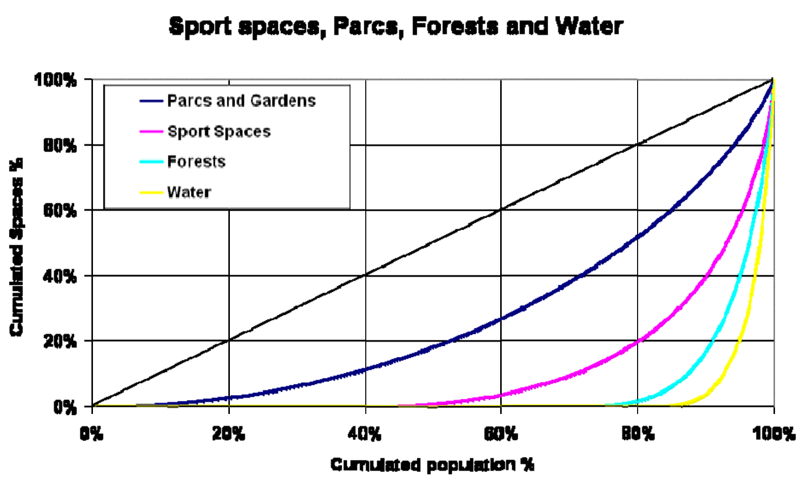


Fig. (5): Lorenz curve for Sport spaces, Parcs, Forests and Water

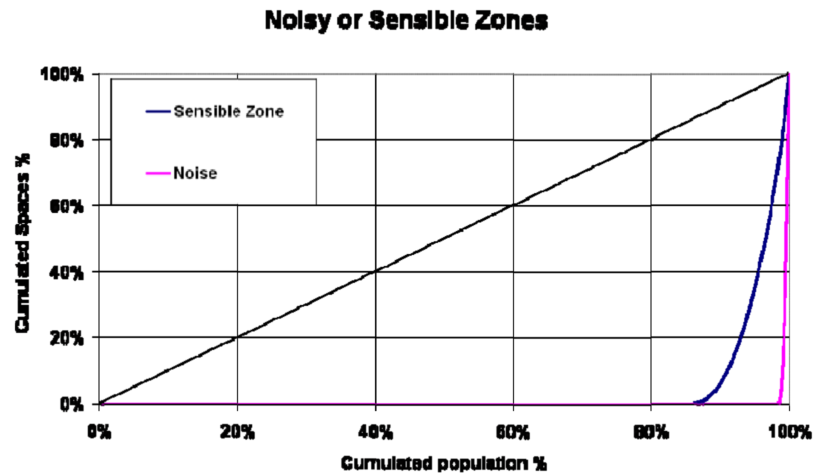


Fig. (6): Lorenz curve for Noisy and Sensible Zones

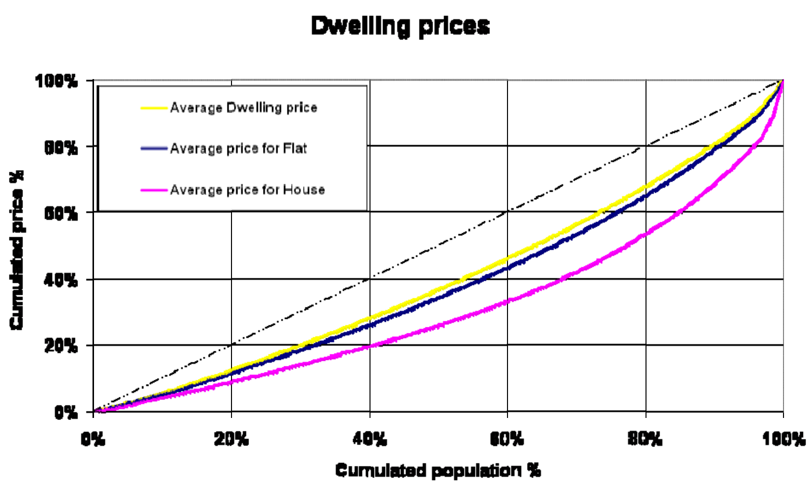


Fig. (7): Lorenz curve for Dwelling Prices

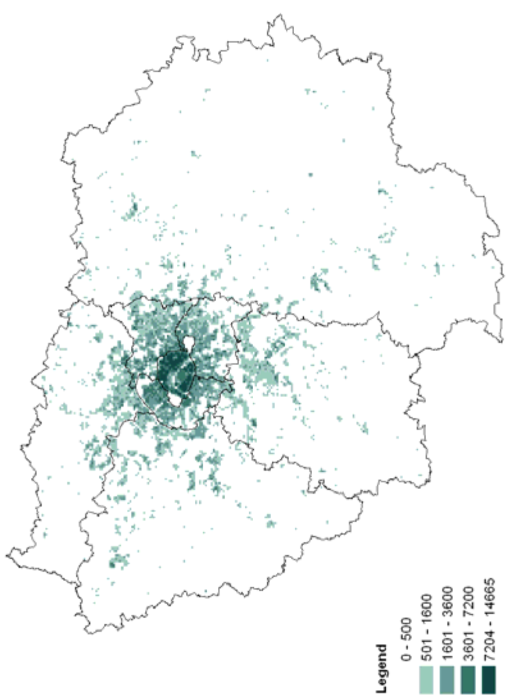


Fig. (8): Distribution of population over the region

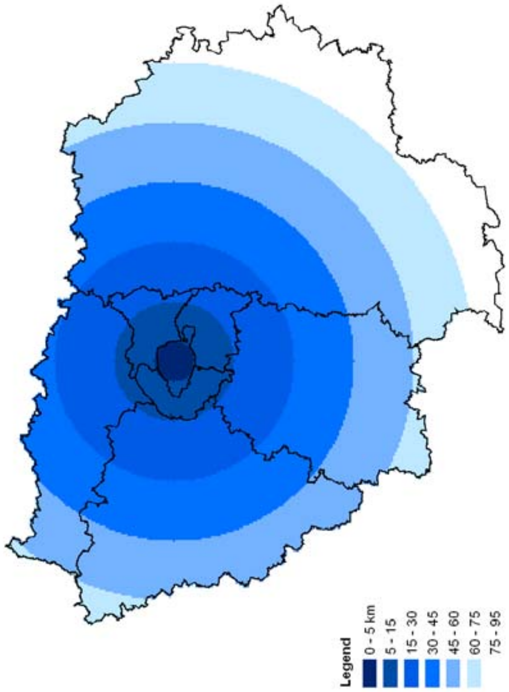


Fig. (9): Distance to Paris Centre

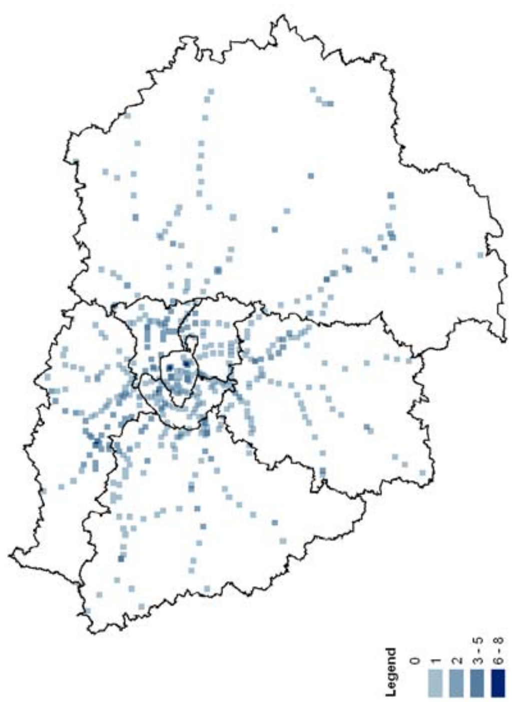


Fig. (10): Number of train stations in surrounding cells

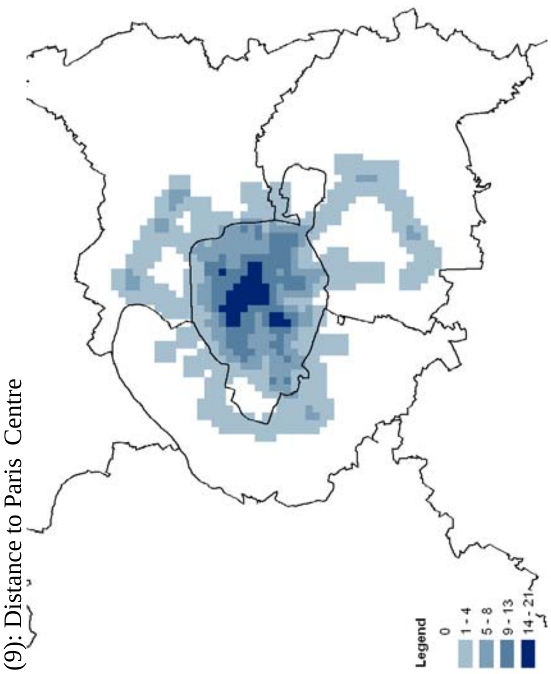


Fig. (11): Number of Subway stations in surrounding cells

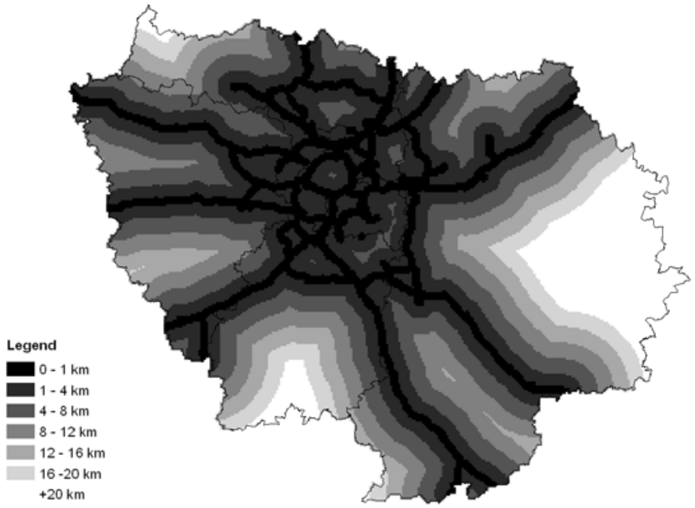


Fig. (12): Distance to the nearest highway

Fig. (13): Distance to the nearest arterial

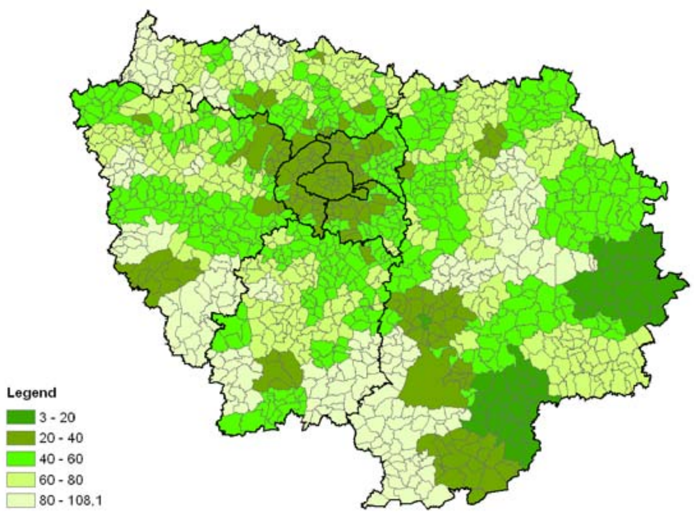
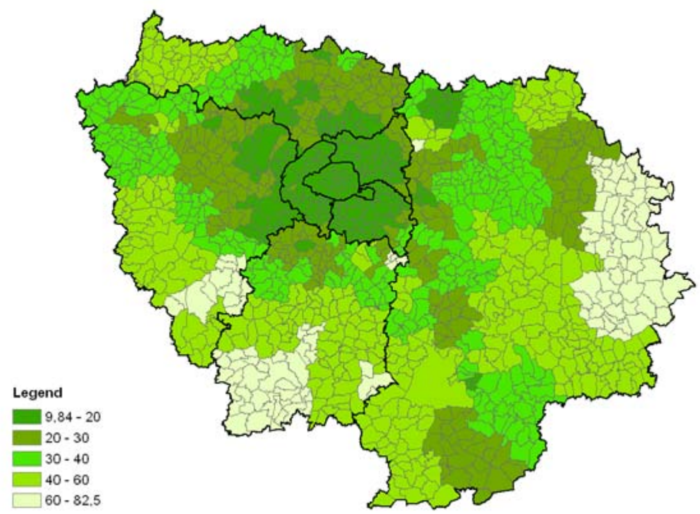


Fig. (14): Average travel time by Public Transit in minutes



Fig(15) Average travel time by Private Car in minutes

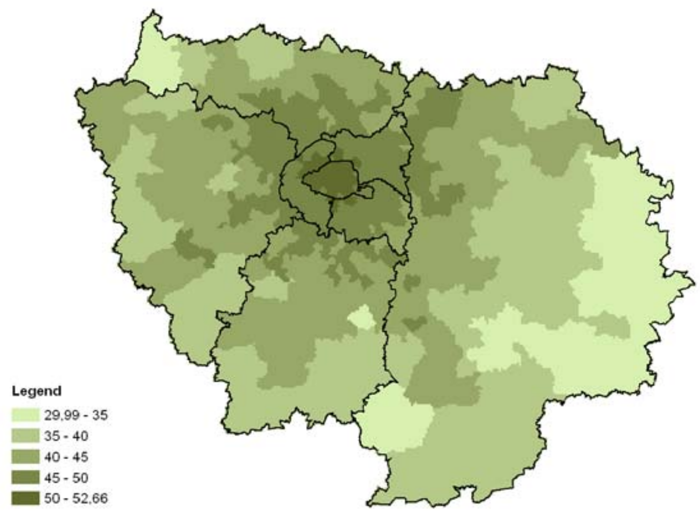


Fig. (16): Accessibility to Employment by Public Transit (Poulit method)

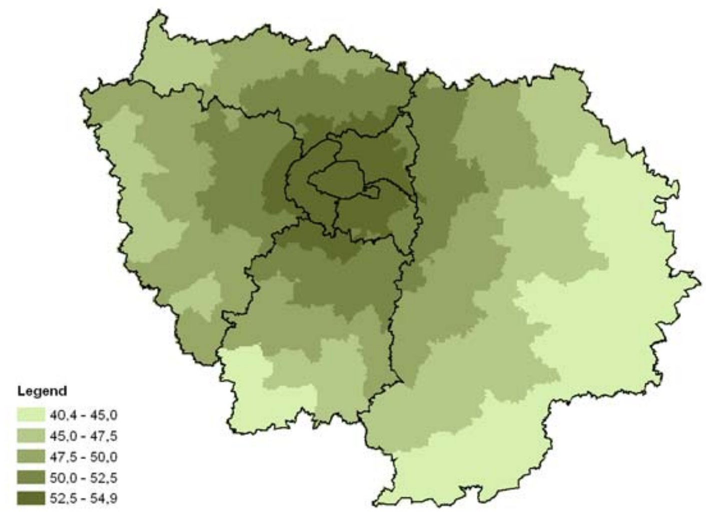


Fig. (17): Accessibility to Employment by Private Car (Poulit method)

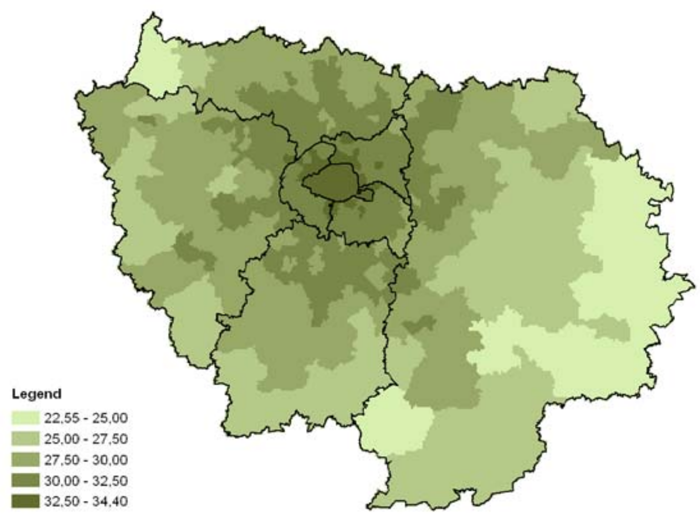


Fig. (18): Accessibility to Commerce by Public Transit (Poulit method)

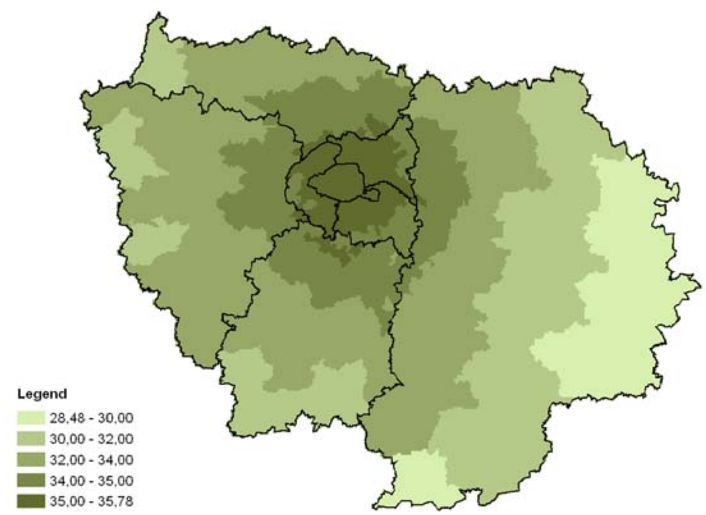


Fig. (19): Accessibility to Commerce by Private Car (Poulit method)

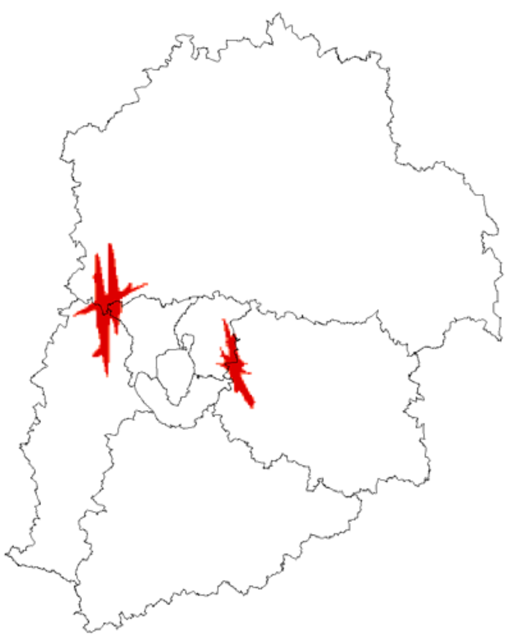


Fig. (20): Noisy zones near airports

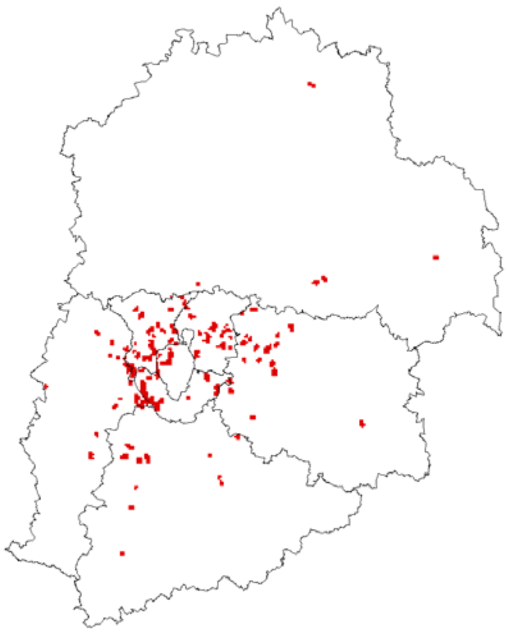


Fig. (21): Socially sensible zones

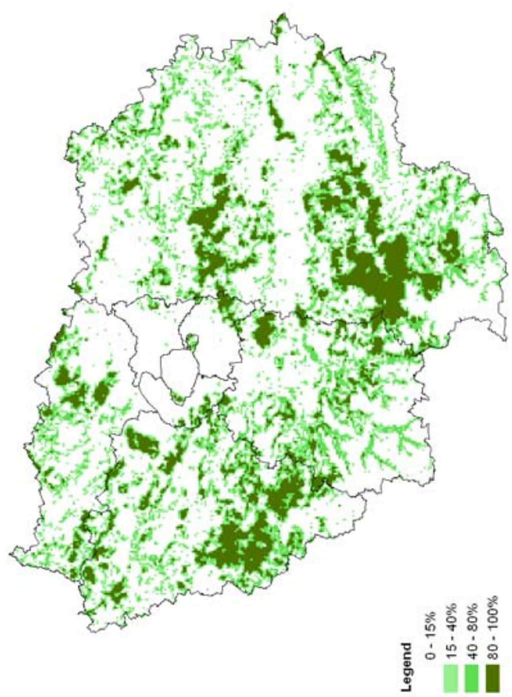


Fig. (22): Proportion of cells' surface covered by Forest

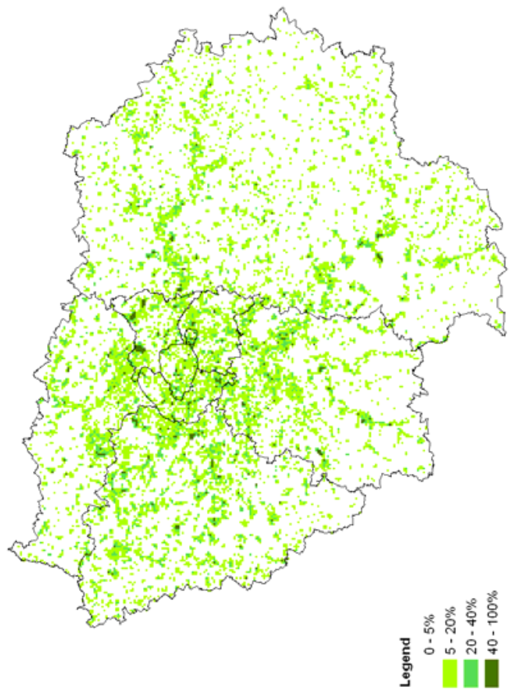
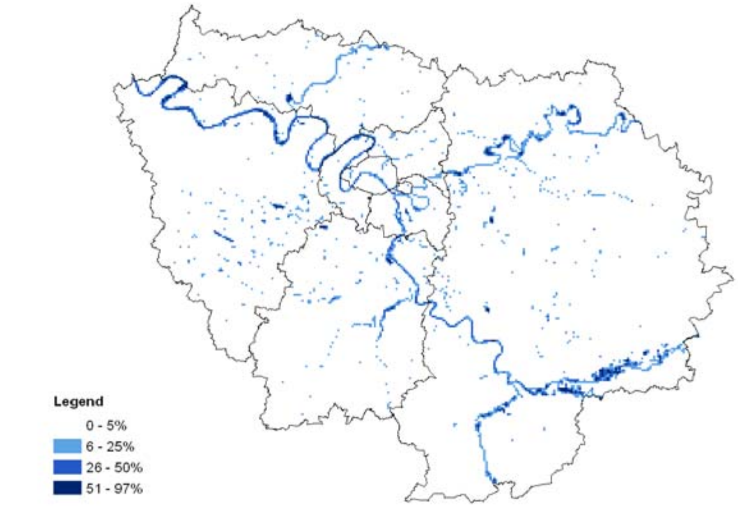


Fig. (23): Proportion of cells' surface in Parks and Gardens



Fig(24) Fraction of cells' surface covered by Water

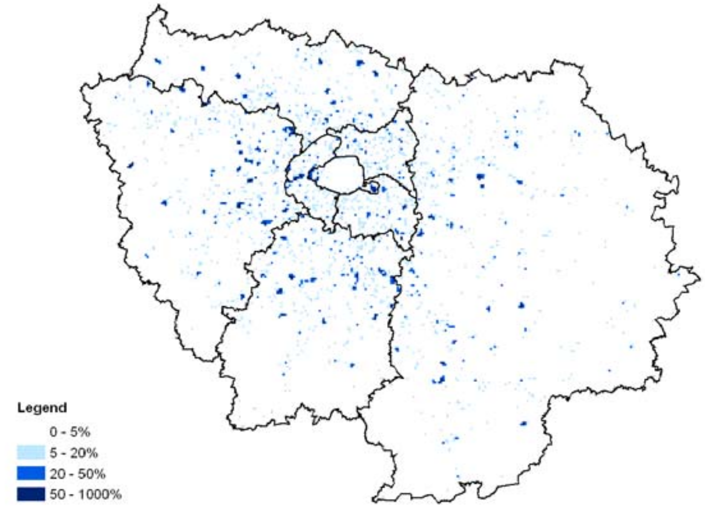


Fig. (25): Sport spaces in cells

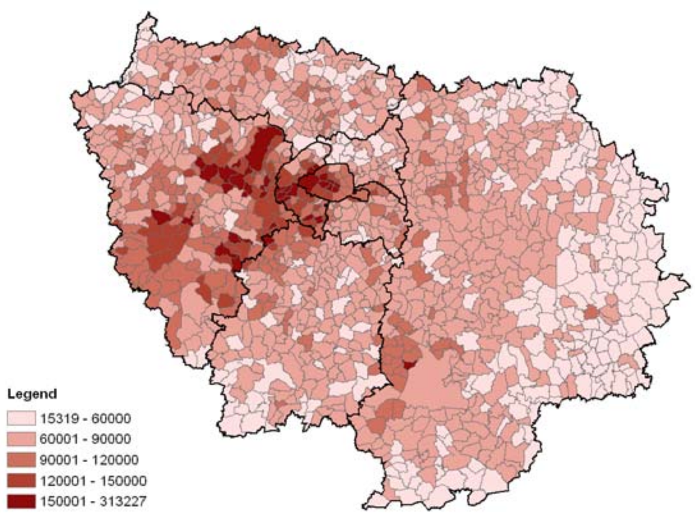


Fig. (26): Average price for Flats

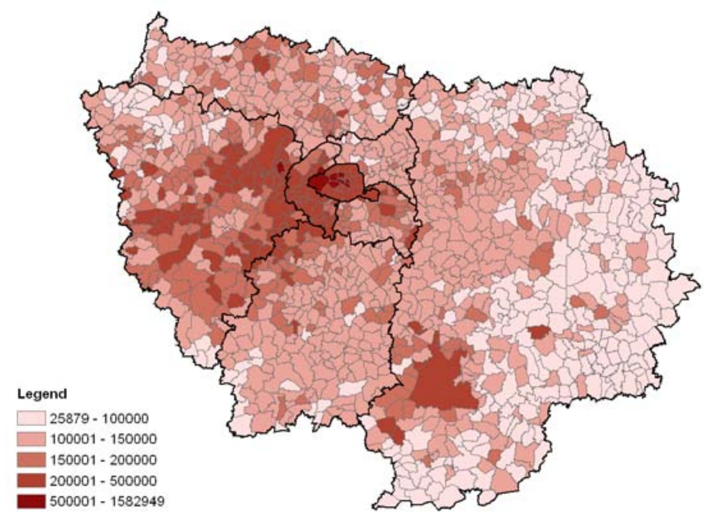


Fig. (27): Average price for Houses

[1] See also the early contribution of Knight, 1924. The Pigou-Knight controversy is described in detail in Pahaut and Sikow, 2006 .

[2] Mayeres and Proost, 2003, have argued that acceptability of a given policy by citizens can be simply measured by the utility change after the implementation of a policy. However, complications arise (see, e.g. Jones, 2003). For example, incorrect perceptions and envy can distort this simple measure based on utility changes. To further argue about the difference between equity and acceptability we can take a simple example from de Palma, Lindsey and Proost, 2007: "*A head tax on identical households may be considered inequitable but acceptable by politicians; conversely, a policy that confers small benefits on poor people while concentrating the costs on a richer majority may well be considered unacceptable by the majority, but would clearly be judged equitable*."

[3] See also appendix figures 10 and 11 where square represents a cell with its 8 neighbouring cells.

[4] The Lorenz curve was developed by Max O. Lorenz in 1905 for representing income distribution. It shows for the bottom x% of households (plotted on the x-axis), what percentage y% of the total Y corresponds to them (plotted on the y-axis). Perfect Equality (each household has the same quantity of Y) corresponds to the diagonal, while Perfect Inequality (a single household has all Y) corresponds to the x-axis together with a vertical line at x=100%. A Lorenz curve is always increasing and convex, and located between the lines of Perfect Equality and of Perfect Inequality. When the Lorenz curve is farther from the Perfect Equality line, this reflects more inequality. In this paper we apply this idea to measure spatial inequalities in an urban area.

[5] See Wenglenski (2002) for the distribution of travelled distance for home-to-work trips for different socio-professional categories of workers over the region.

[6] This corresponds to the average (in log terms) per capita household income in Ile-de-France. Household per capita income corresponds to household income divided by the square root of the number of household members, which is an equivalence scale commonly used.

[7] This is implied by the negative signs of the coefficients of Log(Price of Flat)* (Age-40)/10 and of Log(Price of Flat)* (Number of hh members – 1).

[8] This figure corresponds to age at which the marginal price effect is zero fro the reference income and family size, namely 0.08735*Log(Price of House)-0.10359*Log(Price of House)* (Age-40)/10=0 at the commune level.

[9] The coefficient of Log(Price of House)* (Number of hh members – 1) is larger than the coefficient of Log(Price of flat)* (Number of hh members – 1) in absolute terms.