Routledge
Taylor & Francis Group
Edinburgh Napier UNIVERSITY

INTERNATIONAL JOURNAL OF STRATEGIC PROPERTY MANAGEMENT
ISSN 1648-715X print / ISSN 1648-9179 online

2014 Volume 18(2): 101–115
doi:10.3846/1648715X.2013.864342

WILLINGNESS TO PAY FOR ACCESSIBILITY UNDER THE CONDITIONS OF RESIDENTIAL SEGREGATION

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Received 29 September 2012; accepted 16 January 2013

ABSTRACT. The hypothesis that different income groups have different willingness to pay for accessibility to the city centre is based on the standard monocentric model. This hypothesis is empirically tested with accessibility attributes in a hedonic model of apartment prices in the suburbs of the city of Lyon, France. The conditions of residential segregation are described, and apartment prices in the poor and the rich suburbs are analysed with regression techniques. Travel times to two urban centres are accounted for, as well as centrality and accessibility integral indexes. We found that in the selected areas the hypothesis is true. Spatial differences between the estimates for accessibility measures are significant. In more socially problematic areas, the willingness to pay for better accessibility is higher.

KEYWORDS: Accessibility; Bid-rent function; Hedonic regression; Apartment price; Residential segregation

REFERENCE to this paper should be made as follows: Kryvobokov, M.; Bouzouina, L. 2014. Willingness to pay for accessibility under the conditions of residential segregation, *International Journal of Strategic Property Management* 18(2): 101–115.

1. INTRODUCTION

Economic literature about urban segregation experienced rapid development since the first work of Kain (1968) on the difficulties of employment access for the inhabitants of American ghettos. Numerous case studies dealing with the question of neighbourhood effect test the impact of social polarisation or accessibility on unemployment, isolation, crime or school results in problematic districts of different cities and countries (Case, Katz 1991; Hoxby 2000; Bayer *et al.* 2008; Galster *et al.* 2008).

In France, the economic studies of segregation are more recent and mainly dated by the years 2000s (Fitoussi, Savidan 2003; Maurin 2004; Buisson, Mignot 2005). With several exceptions analysing geographic and ethnic origins (Pan Ké Shon 2010), this literature focuses on the socio-economic dimensions to demonstrate the increasing inequalities between rich and poor neighbourhoods and to measure their negative consequences on the economic, human and social capital of poor inhabitants, whose significant share is suffered from high unemployment (Bouabdallah *et al.* 2002; Choffel, Delattre 2003; Gaschet, Gaussier 2005; Gobillon, Selod 2004; Korsu, Wenglenski 2010). Most of these studies confirm the hypothesis that the unemployment of poor residents is partially caused by poor accessibility to jobs (especially to low-skilled jobs) and high poverty rates. The two main reasons of poor employment accessibility in the Paris region are location in remote neighbourhoods with few jobs and low car-ownership rate (Korsu, Wenglenski 2010). In their analysis of the Lyon, Marseille, and Lille urban agglomerations, Mignot *et al.* (2009) highlight the point that though some recent studies report little inequality in daily mobility since households have access to cars, at the same time inequality increases for those without car.

The growing interest of academic research to residential segregation in France can be explained by a complicated reality including violence and

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urban riots, which needs to be adequately understood before elaboration of a competent policy by decision-makers. The first urban riots in France took place in the eastern suburbs (*banlieues*) of Lyon: Vénissieux in 1981 and Vaulx-en-Velin in 1990, while the last one happened in 2005 and called "the suburb crisis" touched many French cities. This situation has often been interpreted as a fiasco of the integration policy in neighbourhoods mainly populated by immigrants and their descendants. While French law prohibits collecting statistical data on racial and religious principles, some studies based on nationality of origin demonstrate that ethnic segregation is often superimposed with socio-economic segregation (Fitoussi, Savidan 2003). Focusing on life conditions in the disadvantaged suburbs, Pan Ké Shon (2010) highlights the rise in ethnic segregation and simultaneous reduction in income segregation between two most recent censuses. While the socially best-equipped residents, mainly French nationals, leave problematic neighbourhoods, most of the younger arrivals, who are North Africans and Black Africans, have "poor social characteristics" (Pan Ké Shon 2010). However, he rejects the idea that the high concentration of immigrants is the result of self-segregation, because what is observed is not a "White flight", but rather "all run" (Pan Ké Shon 2009). Not taking into account discrimination, which is difficult to quantify, the problems of the *banlieue* population are mainly socio-economic, such as the access to housing market and employment market under the constraints of income, housing prices and job accessibility.

The theory of spatial mismatch (Kain 1968; Cutler, Glaeser 1997) first and foremost describes the problems connected with the social polarisation of disadvantaged population in the central parts of American cities and their poor accessibility to jobs in outlying subcentres. In French cities, most of jobs remain concentrated in the centre, while the most segregated neighbourhoods are situated in periphery (Bouzouina 2008). In such neighbourhoods, public investments are often taking place aiming at improving accessibility as well as economic and residential attractiveness in order to reach social and functional diversity. Transport projects are based on two leverages: land use development and transport cost reduction by speed increase. These gentrification projects can however have the opposite consequences penalizing population in problematic neighbourhoods if the positive economic effect of diminishing transport cost is weaker then an increase in housing prices. This can lead to eviction of the poorest population henceforward incapable to pay more for improved accessibility.

In this paper we deal with residential segregation, accessibility and housing price. We test the hypothesis that accessibility is evaluated differently by different income groups. This hypothesis is based on the standard monocentric model of residential bid rent. We study empirically how accessibility is evaluated at housing market in areas with different social status. The goal of the paper is to contribute to the empirical understanding of accessibility measures as housing price determinants. The spatial trend in their evaluation is analysed in the Lyon suburbs populated by households mainly belonging to different income groups.

In order to find differences in the impacts of accessibility on housing prices among income groups of population, the following sampling strategy is applied. With the intention to study the phenomenon in extremely poor and extremely rich areas, two extremums are selected geographically. The first one includes two of the poorest municipalities, while the second one – two rather prosperous areas. We are limited by the objective data constraints. In French urban areas, the poorest households live in apartment blocks and thus the apartment segment of housing market should be analysed for the richest households as well despite the fact that a big share of the rich lives in detached houses. Therefore, instead of looking for the areas with the highest overall average income, we choose the richest municipalities among those with representative samples of apartment sales.

The remainder of the paper is organised as follows. The next Section is a short literature review. Section 3 describes the standard bid-rent functions in a monocentric city for two income groups of population: the rich and the poor. The hypothesis that accessibility is evaluated differently is empirically tested in Section 4, which includes data description and hedonic regression models applying the methodologies of geographically weighted and spatial error regressions. The final Section concludes.

2. LITERATURE REVIEW

One part of the literature analysing the links between accessibility and housing price in disadvantaged neighbourhoods deals with gentrification issues focusing on the renovation urban policy. In the economic literature, the determinants of renovation and land use development can be grouped into the three following factors: first, those connected with the economic laws of location resulting from the monocentric model, they deal mainly with income, transport cost and housing demand; second, housing age and quality; and third, neighbourhood characteristics and population behaviour (Helms 2003). The third group confirms the impact of accessibility to the centre, especially by public transport: "Accessibility to the CBD matters: improvement is more likely in areas that are close to downtown and well-served by mass transit" (Helms 2003: 496).

In real estate valuation, accessibility issues are under close attention at least since the von Thünen theory has been elaborated in the first half of the 19th century. Accessibility to the city centre is in the core of the Alonso (1964) bid-rent model. In their residential location choice, households make a trade-off between housing price and transport cost in the bid-rent function representing maximal land price per unit, which an individual is ready to pay in each part of a city. This is the principal issue of the standard model of urban economics (Alonso 1964; Mills 1967; Muth 1969). Thus, households can either reside in the centre close to employment opportunities or prefer peripheral location with more spacious accommodation and pay higher transport cost. The model does not propose an analytical solution concerning the spatial distribution of population consisting of different income groups, but implicitly considers that rich population is more sensible to consume accommodation that leads to concentration of the poor in the centre.

However, the centre cannot concentrate all jobs. Polycentric patterns of modern cities have been recognised (McDonald 1987; McMillen, Lester 2003) and incorporated into hedonic analyses of real estate prices and rents (McDonald, McMillen 1990; McMillen 1996; Sivitanidou 1996). Urban form depends on the scale of the analysis; this point can be illustrated in the analyzed geographical context. According to Bouzouina (2008), the Lyon urban area is monocentric, with one centre *in* Lyon and Villeurbanne. Kryvobokov (2010) found fifteen candidates for service employment subcentres *within* Lyon and Villeurbanne.

Wheaton (1977) with the San Francisco data demonstrated that there exist substantial differences among income groups in the value of travel time and the demand for land, but these compliment one another to yield bid-price gradients that appear quite similar. Also, he found that although the value of travel time increases significantly with income, it is totally overshadowed by the fixed money costs of travel. In France, the hypothesis of identical bid-rent functions has not yet been verified (Goffette-Nagot *et al.* 2000). Not all the cities are monocentric (Anas *et al.* 1998), and the strength of housing market is sometimes weaker than that of generalised transport cost (Glaeser *et al.* 2008). The distinction between transport cost by public transport and by car is central in the explication of socio-spatial distribution (LeRoy, Sonstelie 1983).

Ross *et al.* (2011) have shown the inability to fit more than two distance variables into hedonic regression model arguing that two points in space triangulate the optimal position by fundamental geometry. Beside distances "as the crow flies", network distances and travel times to urban centres, integral centrality and accessibility measures are applied in hedonic modelling of housing values. The centrality concept is an objective one; it takes into account the location of opportunities and potential access to them (e.g. Krizek 2005). The accessibility measure in the interpretation of Thériault *et al.* (2005, 2007) is subjective one, based on trip duration thresholds (Kim, Kwan 2003); it is the ease with which persons, living at a given location, can move in order to reach activities and amenities which they consider as important.

Thériault *et al.* (2007) analyse links among mobility, accessibility and housing markets and pay attention to perceptual issues, which depend on self-valuation of time and ability and willingness to pay a premium for better home location. They argue that these values, ability and willingness related to specific constraints define a utility functions, which are somewhat different for each household and are likely to differ among social groups. Moreover, Thériault and colleagues speculate that it could be argued that in modern cities, social gradients are progressively prevailing over access factors as major price determinants. Thériault *et al.* (2007) calculate accessibility indexes for men and woman and find significant differences in centrality and accessibility estimates among house types in hedonic models. In our study we do not calculate different measures for population groups, but focus on differences in price premiums for the same attributes among different groups and locations.

3. THE STANDARD MONOCENTRIC CITY MODEL FOR TWO INCOME GROUPS

The monocentric city model has been proposed by Alonso (1964) and generalized in many ways by Mills (1967), Muth (1969) and Fujita (1989). A comprehensive overview can be found e.g. in Anas *et al.* (1998).

While we deal with two income groups of households and with apartments, the following designations for the standard bid-rent model are used hereafter:

– z_r, z_p – composite goods representing all consumer goods except housing and transport for the rich and the poor respectively;
– A_r, A_p – apartment floor area for the two income groups;
– $u_r(z_r, A_r)$, $u_p(z_p, A_p)$ – utilities from a composite good and apartment floor area for the two income groups;
– $T_r(x)$, $T_p(x)$ – transport costs, which include the value of travel time, for households living x units from the CBD and belonging to the two income groups;
– W_r, W_p – exogenous incomes of households belonging to the two income groups.

Each household has an income, which covers its expenditures on the composite good, transport and apartment rent. The residential bid rent at location x is the maximum rent per floor area unit that a rich or a poor household is able to pay and still receive utility $\overline{u}$:

$$b(x,\overline{u}_r) = \max_{z_r,A_r} \frac{W_r - z_r - T_r(x)}{A_r} \quad \text{s.t. } u_r(z_r, A_r) \geq \overline{u}_r;$$

$$b(x,\overline{u}_p) = \max_{z_p,A_p} \frac{W_p - z_p - T_p(x)}{A_p} \quad \text{s.t. } u_p(z_p, A_p) \geq \overline{u}_p. \tag{1}$$

By the envelope theorem, the slopes of the bid-rent functions are:

$$\frac{db(x,\overline{u}_r)}{dx} = -\frac{T_r'(x)}{A_r[W_r - T_r(x), \overline{u}_r]};$$

$$\frac{db(x,\overline{u}_p)}{dx} = -\frac{T_p'(x)}{A_p[W_p - T_p(x), \overline{u}_p]}, \tag{2}$$

where: $A_r[\cdot]$, $A_p[\cdot]$ are the solutions to the maximisation in (1). For brevity, the square brackets are not used hereafter. The ratio of the slopes of the bid-rent functions is the following:

$$\frac{\frac{db(x,\overline{u}_r)}{dx}}{\frac{db(x,\overline{u}_p)}{dx}} = \frac{A_p}{A_r} \cdot \frac{T_r'(x)}{T_p'(x)}. \tag{3}$$

Transport cost for the rich and the poor can be the same. It means that they not only use the same amount of gasoline per distance unit for their cars or the same tickets for public transport, but also evaluate their time, comfort, safety, etc. in the same manner. If this is the case, i.e. $T_r(x) = T_p(x)$, then:

$$\frac{db(x,\overline{u}_r)}{db(x,\overline{u}_p)} = \frac{A_p}{A_r}, \tag{4}$$

or the ratio of the bid-rent functions of the two income groups is inversely proportional to their apartment floor areas, which are the maximisation solutions. When $A_r > A_p$, i.e. the rich have larger apartments:

$$\frac{db(x,\overline{u}_r)}{db(x,\overline{u}_p)} < 1. \tag{5}$$

If $T_r(x) \neq T_p(x)$, the ratio $\frac{T_r'(x)}{T_p'(x)}$ from (3) can be less than unity if the additional transport cost for the rich located a small additional distance dx from the CBD is lower than for the poor. If both conditions $A_r > A_p$ and $T_r'(x) < T_p'(x)$ take place, the inequality (5) is true again.

We should note that both assumptions contradict a standard view that the value of travel time increases with income. However, it is not always easy to grasp the difference in its evaluation by income groups. First, it can be overshadowed by fixed travel costs (Wheaton 1977). Second, different car-ownership rates for social groups (Korsu, Wenglenski 2010) and thus different modes of travel can lead to shorter travel times for the rich. What is probably more important is that location amenities (which are not only the proximity to the CBD) not presented in the aforementioned model can outweigh the travel time component of the location choice of high-income households.

Thus, ignoring location amenities and assuming that the rich prefer larger apartments and either the transport cost for both income groups are the same or the marginal transport cost for the rich is lower than for the poor, the bid-rent gradient for the rich is lower. In other words, under the mentioned conditions, with each additional distance unit from the CBD the bid-rent for the rich decreases slower than for the poor. It is worth to repeat again that in this simple derivation the difference among income groups is mainly manifested in apartment floor area units, while the categories of geographical peculiarities, prestige, racial composition, etc. are ignored. We will deal with some of them in the empirical exercise in the next Section.

4. THE EMPIRICAL MODEL

4.1. The study area and data

The Lyon metropolitan area is the second largest by population in France. In 2005, its population counted about 1.75 million inhabitants. The centre of the agglomeration is formed by the adjacent cities of Lyon and Villeurbanne (Fig. 1) with total population of more than 600 thousand inhabitants.

In the Lyon agglomeration, the share of car in mode choice composes 66.0%, while those of public transport 12.6% (Mignot *et al.* 2009). The rich and the poor households in this study are determined as occupying the highest 20% and the lowest 20% in the income range respectively. According to the household travel survey conducted in the agglomeration in 2006, the rich and the poor have the same number of home-to-shop trips per person, and trip duration is only 4% lower for the poor. The maximum difference between the poor and the rich for trip duration is observed for home-to-work trips, and it is only 7%.

It is a well-known phenomenon that western suburbs of Lyon are prosperous, while eastern ones are poor. The selected four municipalities are Sainte-Foy-lès-Lyons and Oullins in the west and Vénissieux, and Vaulx-en-Velin in the east (Fig. 1).

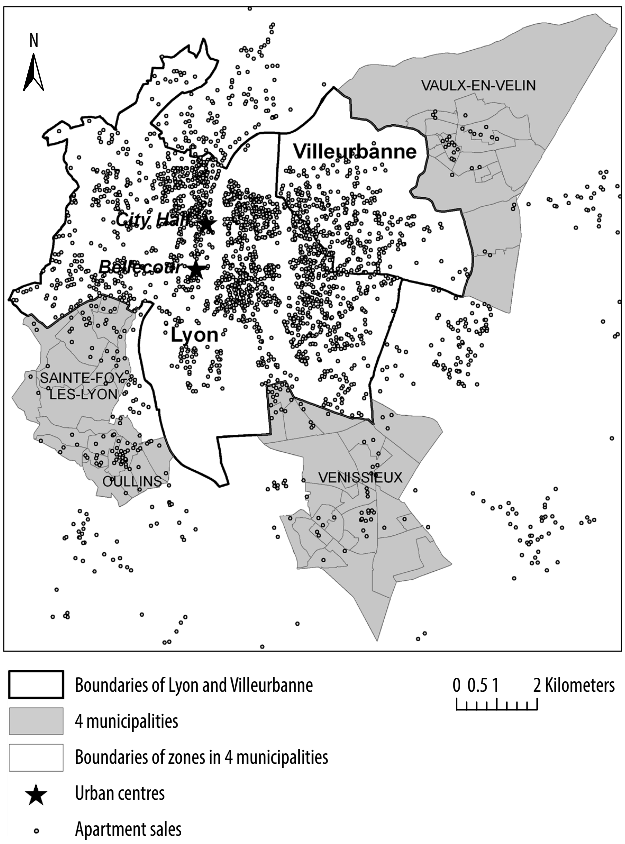

Fig. 1. The four suburbs and apartment sales

All these municipalities are located in the Greater Lyon, or the first ring of suburbs, and experienced quite similar general demographic trends: positive dynamics till the 1980s, slight fall in the 1980s and 1990s (which was sharper in Vaulx-en-Velin and Vénissieux) and modest increase in recent years.

In the poor eastern suburbs, where the population is mainly formed by immigrants and their descendants, ethnic dimension overlays with socio-economic one (Fitoussi *et al.* 2004), but it plays an important role in the perception of the area including the stigmatisation process. According to the last census in 1999, in the eastern Lyon *banlieues* the share of foreign nationals reached 22%, while in some rich neighbourhoods in more western locations it composed only 3%. The analysis of the demographic evolution of foreigners in disadvantaged neighbourhoods and their residential migration demonstrates the behaviour patterns, which are similar to the population average. Foreigners leave or avoid these neighbourhoods as well as French nationals, despite difficulties of relocation specific to them. This "all run" reality (Pan Ké Shon 2009), which is seldom demonstrated explicitly, according to Bouzouina (2008) confirms the socio-economic dominance in the segregation process.

Table 1 contains the statistical description of the four municipalities. The demographic data is referred to 2005, the employment to 2006, and car-ownership rates and incomes to 1999. In the eastern *banlieues*, especially in Vaulx-en-Velin, the average number of persons in household is higher and car-ownership ratio is lower. Lower percentages of high-income households and much higher percentages of low-income population live in the eastern suburbs (note that in 2008, by average household income Vaulx-en-Velin occupied the 31286th place among 31604 French municipalities with more than 50 households). The most visible contrast however is highlighted by the two indicators of social insecurity: unemployment rate among active population and the percentage of households living in social housing. The unemployment rate in Vaulx-en-Velin is three times higher than in Sainte-Foy-lès-Lyons.

According to legislation, municipalities in France are obliged to have not less than 20% of their housing stock social. In fact, almost the same percentage of households lives in social housing. Based on several sources, Bouzouina (2009) and Pan Ké Shon (2010) argue that implementing this policy, decision-makers in France can reserve the least-desirable accommodations for the poor and immigrants and thus contribute to segregation.

The described four suburbs are the examples of the uneven distribution of social housing stock. In the western suburbs, this percentage is lower than 0.20, especially in Sainte-Foy-lès-Lyons, while in the eastern *banlieues* half of population lives in social housing (Table 1).

Income disparities and social contrasts between the selected suburbs clearly demonstrate that in terms of attractiveness and prestige, "bourgeois" western areas are far surpassing their eastern counterparts. Moreover, both Vaulx-en-Velin and Vénissieux have an image of well-known high-poverty *banlieues*. The following quotation from Korsu and Wenglenski (2010) about the public view of problematic areas in general can be exploited to describe both: "many people associate such neighbourhoods with violence, criminality, unwillingness to work, alcohol and drug addiction, etc." (ibid: 2285).

In respect to public transport, the socialist governance of the Lyon agglomeration tries to favour eastern suburbs. The most expensive investments in public transport, such as the extensions of metro and tramway lines, take place to the east from Lyon, including Vénissieux and Vaulx-en-Velin, while in the western suburbs these types of public transports do not exist. In the eyes of many Lyonnais, the relative underdevelopment of public transport in western suburbs is to same degree a deliberate policy supporting their higher standing. A good illustration of the Not-In-My-BackYard principle of the wealthy population is their protest (though unsuccessful) in the 1990s against prolongation of the metro line directly linking Vénissieux with north-western Lyon.

We use the data on about 10,000 apartment sales selected randomly from all sales in the central part of the Lyon metropolitan area in the period 1997–2008. These data on sale prices and apartment attributes were provided by *Perval*, who collects information about real estate transactions in France. After deleting observations with incomplete data, 4,362 apartments remained. The definition of variables and descriptive statistics are given in Table 2. It contains information about transactions, as well as on apartment attributes and location attributes. It does not include the number of rooms, because the cardinal discrete variables for them are highly correlated with apartment area and are not significant if included in the hedonic model. Many observations contain no data about the number of parking places, number of cellars, and quality of view; therefore the specific dummy variables are created. In the sample, 28% of the apartments were new, sold in a primary market.

The location variables in Table 2 include the percentages of high-, middle-, and low-income households, and dummies for location in one of four *ad hoc* districts. The four *ad hoc* districts are quite large, but relatively homogenous territories, divided by water frontiers and the boundaries of the urbanised area. District 1 includes the most central part of Lyon between the Rhône and the Saône. District 2 is an urbanised area on the left bank of the Rhône. District 3 is an urbanised area on the right bank of the Saône. District 4 is the less urbanised territory.

Table 2 contains the following accessibility measures: travel times by car, travel times by public transport, tertiary employment centrality index, and tertiary employment accessibility index. The origin-destination (O-D) matrix of travel times is estimated for morning peak with the MOSART transportation model developed with the VISUM software (Bonnafous *et al.* 2011). It is a four-step model, which forecasts transportation demand. We account for the travel times to the Lyon City Hall and to Bellecour, which is the main public transport junction located in the central part of Lyon. Both City Hall and Bellecour are among the fifteen (sub) centres identified with a regression of service employment density on travel time (Kryvobokov 2010),

Table 1. Socio-demographic description of the four suburbs

Attribute	Sainte-Foy-lès-Lyons	Oullins	Vénissieux	Vaulx-en-Velin
Population	22,616	26,426	57,566	40,241
Households	9,208	12,032	21,965	14,293
Persons in household	2.46	2.20	2.62	2.82
Cars to households ratio	1.25	1.01	0.95	0.87
Cars to population ratio	0.51	0.45	0.37	0.31
Percentage of high-income households	0.17	0.14	0.11	0.10
Percentage of low-income households	0.21	0.25	0.33	0.37
Percentage unemployed	0.07	0.09	0.18	0.21
Percentage of households in social housing	0.07	0.15	0.50	0.51

Table 2. Descriptive statistics of apartment attributes

Variable	Description	Mean	Minimum	Maximum	Std. deviation
Price	Transaction price, Euro	122,507.50	10,965	1,120,000	77,200
Year97-Year08	Dummies for year of transaction	0.04-0.13	0	1	0.20-0.34
Area	Apartment area, square metres	68.94	8	301	28.12
Bath1-Bath3	Dummies for number of bathrooms	<0.01–0.93	0	1	0.05–0.25
ParkUn	Dummy for cases with no data about parking places	0.26	0	1	0.44
Park0-Park3	Dummies for number of parking places	<0.01–0.49	0	1	0.06–0.50
FloorGr	Dummy for ground floor	0.13	0	1	0.33
Floor1	Dummy for storey 1	0.18	0	1	0.39
Floor2_4	Dummy for storey 2 to 4	0.49	0	1	0.50
Floor5_8	Dummy for storey 5 to 8	0.18	0	1	0.38
Floor9+	Dummy for storey 9 or more	0.02	0	1	0.14
Constr<1850-Constr1992<	Dummies for period of construction	0.03–0.34	0	1	0.17–0.47
CondGood	Dummy for good state	0.81	0	1	0.39
CondMed	Dummy for state when some maintenance is needed	0.16	0	1	0.37
CondBad	Dummy for state when renovation is needed	0.03	0	1	0.17
ViewNo	Dummy for cases with no data about view	0.60	0	1	0.49
ViewGood	Dummy for view increasing value	0.38	0	1	0.48
ViewBad	Dummy for view decreasing value	0.02	0	1	0.13
Cellar0-Cellar2	Dummies for number of cellars	0.02–0.66	0	1	0.13–0.47
Garden	Dummy for existence of garden	0.05	0	1	0.22
Terrace	Dummy for existence of terrace	0.09	0	1	0.29
NewApartment	Dummy for new apartment	0.28	0	1	0.45
%HighIncome	Percentage of high-income households	12.55	4.34	28.77	2.91
%MidIncome	Percentage of middle-income households	57.96	42.70	66.20	3.30
%LowIncome	Percentage of low-income households	29.49	10.24	52.12	5.78
District1-District4	Dummies for location in districts	0.01–0.64	0	1	0.12–0.48
TTBellecour, TTCityHall	Travel time to Bellecour, travel time to City Hall in minutes	11.00–21.73	0.55	29.32–51.02	4.99–11.16
Centrality Index	Centrality index	37.04–42.13	12.15–13.45	100.00	15.68–17.23
Accessibility Index	Accessibility index	63.07–64.70	0.34–0.65	100.00	25.63–27.47

similarly to McDonald and Prather (1994). The centrality and accessibility indexes are integral measures, which take account of tertiary employment. The former is gravity-based and the latter is a "subjective" measure based on satisfaction thresholds and fuzzy logic, for details see Appendix 1. Note that in Table 2 the geographical unit of analysis is not municipality, but smaller zone; that is why the percentages of income groups are lower and higher in comparison with Table 1, which represents municipalities. The zones are French statistical units IRISes (*Îlots Regroupés pour l'Information Statistique*) close to the tracts in the US.

Of this sample, we select four sub-samples from the analysed municipalities (Table 3). The average floor area is the highest in Sainte-Foy-lès-Lyons. Though this attribute is the lowest in Oullins, it becomes the second highest there if calculated per person using the average number of persons in household in municipality. According to the average price per square meter, Sainte-Foy-lès-Lyons is again the leader. The minimum prices in the western suburbs are much higher than in the eastern ones, but relatively high average price and very high maximum in Vénissieux indicates a wide diversity of its housing stock. According to the *t*-test, Vaulx-en-Velin and Vénissieux, unlike western suburbs, have equal means for some attributes, e.g. the percentage of low-income households.

Table 3. Apartment sales and accessibility in the four suburbs

Attribute	Sainte-Foy-lès-Lyons	Oullins	Vénissieux	Vaulx-en-Velin
Apartment sales				
Number of sales	84	100	97	54
Average floor area, m^2	79	63	67	65
Average floor area per average number of persons, m^2	32.1	28.6	25.6	22.9
Average price per m^2, Euro	1,611	1,495	1,464	1,171
Minimum price per m^2, Euro	675	393	226	307
Maximum price per m^2, Euro	3,548	3,442	3,674	2,631
Accessibility by car				
TTBellecour, minutes	12.17	10.62	14.45	21.13
TTCityHall, minutes	14.67	14.46	17.61	17.93
Centrality Index	23.82	25.61	26.02	23.73
Accessibility Index	28.20	33.94	30.77	23.10
Accessibility by public transport				
TTBellecour, minutes	28.61	29.42	29.73	35.41
TTCityHall, minutes	31.48	33.33	35.08	32.69
Centrality Index	20.84	20.03	23.13	21.74
Accessibility Index	31.65	27.44	38.72	35.48

Table 3 gives the average values of accessibility measures in the four municipalities. The eastern suburbs are located in general a bit farther from the two urban centres, but their indexes for public transport are higher at the expense of better developed network. The number of zones in Sainte-Foy-lès-Lyons, Oullins, Vaulx-en-Velin and Vénissieux are 10, 11, 18 and 24 respectively (see Fig. 1).

Besides using the sample of 4,362 observations, we extract the 20% most expensive apartments as well as the 20% cheapest apartments assuming that their buyers belong rather to the rich and the poor households respectively. These sub-samples called hereafter "expensive" and "cheap" are used in further analyses as proxies for the non-geographical submarkets for the rich and the poor, because it is difficult to find information about the income of the buyers of particular apartments in quantity sufficient to create a mass valuation model. For these two sub-samples the equality of means hypothesis is rejected for price, floor area, income levels and all accessibility measures. We admit that this division does not correspond to the rich and the poor household groups described above.

Furthermore, this sampling can be biased as some share of expensive apartments could be expensive just because of their large floor area, but cheap in respect to area unit. Some observations in the cheap segment, on the contrary, can be cheap due to small floor area, but have high price per area unit. In the context of the study, however, it is logical to assume that the poor are not able to buy expensive apartments even if their prices per area unit are low; while the rich prefer rather bigger accommodations. Therefore we suppose that our sampling strategy is less biased than it could be if it was based on price per square meter.

Correlation of apartment price per square meter (deflated to the initial year 1997) with accessibility measures are in line with our hypothesis: prices of more expensive apartments are less correlated with accessibility. If to consider the sales in Sainte-Foy-lès-Lyons and Vénissieux, their correlations behave similarly to the expensive and cheap sub-samples respectively. In Oullins and Vaulx-en-Velin, the sign of correlation coefficient is unstable. To understand the nature of these anomalies, econometric analysis is needed.

4.2. Hedonic regression

Applying the hedonic regression model of price as the dependent variable with willingness to pay for different attributes as independent variables, we continue the tradition proposed by Rosen (1974). If the supply of each characteristic is perfectly elastic, hedonic coefficients reveal demand for characteristics, though in most real-world contexts such a stringent maintained hypothesis is untenable (Malpezzi 2003). Hedonic price model is widely used in real estate research. The recent examples of its application to housing prices in France are

Gouriéroux and Lafarrère (2009) and Baltagi and Bresson (2011).

There is no strong theoretical basis for substantiating the correct functional form of a hedonic regression (Halvorsen, Pollakowski 1981; Malpezzi 2003), but empirical tests found that the log-linear form has a number of advantages over the linear one (see e.g. Follain, Malpezzi 1980). More general and flexible form was proposed by Box and Cox (1964), but this function is beyond our current study.

In our specification, the dependent variable is the logarithm of *Price*. Among the independent variables described in Table 2, the logarithmic transformations of *Area*, *%MidIncome*, *%HighIncome* and travel times are used. The following attributes are the default values: *Year97*, *Bath1*, *Park0*, *FloorGr*, *Constr1981_1991*, *CondGood*, *ViewGood*, *Cellar0* and *District1*.

First, an overall Ordinary Least Squares (OLS) model is built with 4,362 observations. Separate OLS models are created for the expensive and cheap apartment price segments; according to the *t*-test of equality of means of regressors, the null hypothesis is rejected for the majority of variables, including accessibility attributes and apartment floor area.

The observations from each of the four selected suburbs are exploited with separate OLS and Spatial Error models. In the latter, the error term is a function of the residuals in neighbouring areas. The geographically weighted regression methodology (GWR) is applied to all available sales to solve a regression equation in each observation point. For the OLS, a weighted standard error test (Schnare, Struyk 1976) shows that the four submarkets significantly reduce standard error in comparison with the pool model. The *t*-tests of equality of regression coefficients in the four submarkets give the following results: for accessibility measures, the null hypothesis is rejected in most cases, while for some other attributes, e.g. floor area, the coefficients are rather stable.

Each model is run eight times to examine the willingness to pay for each of the accessibility attributes in question, i.e. travel times to two urban centres and centrality and accessibility indexes, while each attribute is measured twice: for car and for public transport. Our hypothesis is that the richer population evaluates travel time to city centres differently from the poor. We examine as well if this is true in respect to the integral indexes. Under the conditions mentioned in Section 2, the absolute value of the estimate for the accessibility in the hedonic price model should be lower for the rich than for the poor.

Table 4 represents the estimated hedonic coefficients as well as model fit for OLS and GWR models. For the OLS models, the maximum variance inflationary factor (VIF) is also reported. All the significant coefficients of the models with *TTBellecour* by car are presented in Appendix 2, where the estimates of the expensive and cheap sub-samples and median GWR results are reported as well.

The three OLS models support our hypothesis. In the expensive segment, the absolute values of the estimates are always lower (often more than twice) than those in the overall model. In the cheap segment, the absolute values of the accessibility coefficients are always higher than those in the expensive segment. The negative effect of increase in travel time to Bellecour by public transport by 1% leads to price reduction in the cheap segment by 0.17%, which is 2.8 times more than the price reduction in the expensive segment.

The four municipalities can also be analysed as submarkets, for which individual models are created. The same variables except construction years and some structural dummies are used in the OLS and Spatial Error (with a threshold distance weighting scheme) models for the submarkets. The Lagrange multiplier (LM) tests, applied for the OLS models, indicate high significance level of spatial errors in each of the four suburbs. The LM tests of the spatial lags are significant in Oullins and Vaulx-en-Velin, but due to difficulty in estimates interpretation, Spatial Lag model is not applied in this study. The estimates for the accessibility measures are presented in Appendix 3. However, this approach is rather useful to study the willingness to pay for accessibility measures *within* submarkets than the differences *between* them. Indeed, the estimates are insignificant and have "wrong" signs in Oullins and Vaulx-en-Velin, where the observations are less dispersed spatially than in Sainte-Foy-lès-Lyons and Vénissieux. The metro station in Vaulx-en-Velin opened in October 2007, by the end of the study period, and this fact can contribute to the "wrong" signs of accessibility variables. The effect of the new station on the price dynamics is however beyond the current study limits. In Sainte-Foy-lès-Lyons, the coefficients have "right" signs, but they are insignificant in most cases. The most intuitive results in Vénissieux with its dispersed observations are obtained with the OLS technique, but when spatial effect is accounted for, the accessibility measures calculated for car lose significance. Thus, *within* Vénissieux public transport has more impact on housing prices.

Table 4. Estimates for the accessibility measures

Model (OLS), extraction (GWR)	Accessibility by car				Accessibility by public transport			
	TTBellecour	*TTCityHall*	*Centrality Index*	*Accessibility Index*	*TTBellecour*	*TTCityHall*	*Centrality Index*	*Accessibility Index*
OLS*								
Overall, 4,362 obs., adj. R^2 = 0.84 – 0.85, Max VIF = 6.27	–0.224 (<0.001)	–0.278 (<0.001)	0.0085 (<0.001)	0.0051 (<0.001)	–0.223 (<0.001)	–0.228 (<0.001)	0.0078 (<0.001)	0.0049 (<0.001)
Expensive, 873 obs., adj. R^2 = 0.84 – 0.86, Max VIF = 8.02	–0.093 (<0.001)	–0.129 (<0.001)	0.0042 (<0.001)	0.0024 (<0.001)	–0.062 (<0.001)	–0.083 (<0.001)	0.0028 (<0.001)	0.0011 (0.017)
Cheap, 872 obs., adj. R^2 = 0.70–0.72, Max VIF = 9.18	–0.176 (<0.001)	–0.217 (<0.001)	0.0069 (<0.001)	0.0043 (<0.001)	–0.173 (<0.001)	–0.157 (<0.001)	0.0060 (<0.001)	0.0038 (<0.001)
GWR**								
Overall average, 4,362 obs., R^2 = 0.87 – 0.88	–0.175 (0.96)	–0.235 (0.97)	0.0071 (0.96)	0.0049 (0.95)	–0.151 (0.93)	–0.159 (0.97)	0.0052 (0.97)	0.0040 (0.91)
Sainte-Foy-lès-Lyons, 84 obs.	–0.106 (0.95)	–0.169 (1.00)	0.0061 (1.00)	0.0025 (0.87)	–0.104 (1.00)	–0.127 (1.00)	0.0044 (1.00)	0.0022 (0.99)
Oullins, 100 obs.	–0.126 (0.73)	–0.173 (0.83)	0.0066 (0.99)	0.0018 (0.56)	–0.202 (1.00)	0.192 (1.00)	0.0088 (1.00)	0.0033 (1.00)
Vénissieux, 97 obs.	–0.169 (0.90)	–0.307 (0.93)	0.0105 (1.00)	0.0049 (1.00)	–0.322 (1.00)	–0.306 (1.00)	0.0125 (1.00)	0.0060 (1.00)
Vaulx-en-Velin, 54 obs.	–0.599 (1.00)	–0.505 (1.00)	0.0133 (1.00)	0.0070 (1.00)	–0.520 (1.00)	–0.398 (1.00)	0.0141 (1.00)	0.0080 (1.00)

Notes: * – significance level is in the parentheses; ** – percentage of cases significant at the 5% level is in the parentheses.

Concerning the geographically weighted results in Table 4, the average estimates among all the observations are reported as well as the four extractions from the examined suburbs taken from the overall GWR models. The absolute values of the average GWR estimates, which are a bit lower than the OLS results, increase from municipality to municipality in the sequence presented in Table 4. The only exception is that for the accessibility index for car in Oullins, whose coefficient is significant for only 56% of observations. In the eastern suburbs, the percentage of significant cases is always higher than 0.90. Vaulx-en-Velin, where this percentage is always equal to unity, demonstrates the biggest difference from Sainte-Foy-lès-Lyons. The ratio of their coefficients is 5.7 for the travel time to Bellecour by car. The absolute values of the estimates for the western suburbs are, as a rule, lower than the GWR average, though Oullins is an exception in the three cases of public transport (travel times to Bellecour, City Hall and centrality index), which can be explained by relative underdevelopment of public transport at the time, for which the data have been collected. In the eastern suburbs, the absolute values of the accessibility estimates are almost always higher than the overall GWR averages.

5. CONCLUSIONS

The monocentric-based hypothesis that willingness to pay for better accessibility for the poor is higher than for the rich is empirically supported with a hedonic model of apartment prices. Monocentric models with travel times to two versions of city centre are supplemented with integral centrality and accessibility indexes. The results of hedonic models with different accessibility measures are quite similar. First, the hypothesis is supported with the cheap and expensive apartment segments.

Second, the support is shown with the example of the suburbs representing the patterns of residential segregation: the inhabitants of poor suburbs are willing to pay several times more for the accessibility components of apartment price. Moreover, spatial differences in perception of accessibility are much higher than those between the expensive and cheap non-geographical apartment segments.

The spatial dispersion of observations in the examined four sub-samples is important, when the attributes *within* sub-sample are examined. Within one poor suburb, accessibility measures are found significant for public transport, but not for car. The GWR methodology allows comparing the effect *between* sub-samples in the overall model.

In the selected eastern Lyon suburbs we have not found, in general, poorer accessibility, especially when public transport is taken into account. What is really different is the willingness to pay for accessibility: the more socially problematic is the area, the higher is the price for better accessibility. This can be connected with lower car-ownership rate and other problems of disadvantaged neighbourhoods. From this viewpoint, the priority of public transport development in the eastern suburbs of Lyon looks reasonable as here its positive impact is more significantly capitalised in housing prices. Thus, investment in transport infrastructure in poor areas, which decreases travel time and simultaneously increases housing value, can be regarded in terms of economic efficiency and not only in those of social justice.

The standard theoretical model presented in the paper does not include location amenities other than the proximity to the CBD. Some empirical extension is possible with integral measures of centrality and accessibility considering service employment. In future study, more attention should be paid to other location amenities and their place in the trade-off with accessibility in the utility functions of household location choice of social groups. The techniques of Location Value Response Surface and Market Basket Value (McCluskey *et al.* 2000; Borst, McCluskey 2007; D'Amato 2010) can be potentially useful to identify value influence centres and to be applied as a stage of market segmentation.

ACKNOWLEDGEMENTS

This study is part of project PLAINSUDD sponsored through French ANR (number ANR-08-VD-00). The authors are grateful to *Perval* and Pierre-Yves Péguy for providing data on apartment prices and attributes and to Nicolas Ovtracht for calculating the coordinates of apartment blocks and travel times with MOSART. The paper has been benefited from the discussions with Alain Bonnafous, Yves Crozet and Charles Raux as well as from valuable comments of anonymous reviewers.

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APPENDIX 1

Centrality index and accessibility index

A service centrality index for zone i is calculated with a simple gravity-like model as an "objective" measure of *potential* access to opportunities:

$$CI_i = \sum_{j=1}^{N} \frac{A_j}{tt_{ij}},$$

where: A_j – the attraction (service employment density) of zone j; tt_{ij} – the travel time from zone i to zone j; N – the number of zones.

A service accessibility index is a "subjective" concept based on the *realisation* of potential access. Calculating this measure, we mainly follow the approach of Thériault *et al.* (2005). We estimate a suitability index applying fuzzy membership and using the 50th percentile and 90th percentile satisfaction thresholds from the household survey for home-to-shop travel times from the O-D matrix. A suitability index S_{ij} for travelling from zone i to zone j is calculated as follows:

$$S_{ij} = 1 \quad \forall \quad tt_{ij} \leq C_{50},$$

$$S_{ij} = 1 - \left(\frac{tt_{ij} - C_{50}}{C_{90} - C_{50}} \right) \quad \forall \quad C_{50} < tt_{ij} < C_{90},$$

$$S_{ij} = 0 \quad \forall \quad tt_{ij} \geq C_{90},$$

where: tt_{ij} – the travel time from zone i to zone j; C_{50} – the 50th percentile of the observed travel time; C_{90} – the 90th percentile of the observed travel time.

The fuzzy membership function of the suitability index is graphically explained in Fig. A1.

A service accessibility index for zone i is calculated as follows:

$$AI_i = \sum_{j=1}^{N} S_{ij} A_j,$$

where: S_{ij} – the suitability index for travelling from zone i to zone j; A_j – the attraction of zone j; N – the number of zones.

The values CI_i and AI_i for each zone are divided correspondingly by the maximum values in the area and multiplied by 100.

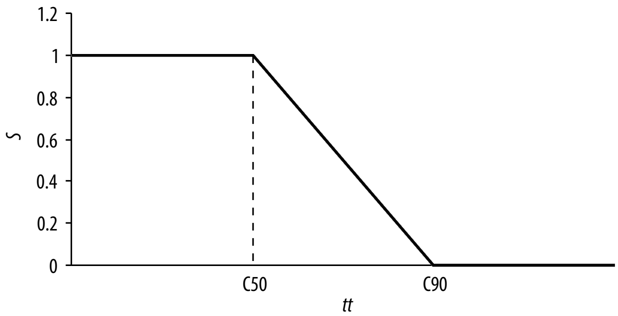

Fig. A1. The fuzzy membership function of the suitability index

APPENDIX 2

OLS and GWR models with *TTBellecour* by car

Variable, parameter	OLS			GWR
	Overall	Expensive	Cheap	
Constant	4.552 (<0.001)	7.186 (<0.001)	6.947 (<0.001)	4.255
TTBellecour	–0.224 (<0.001)	–0.093 (<0.001)	–0.176 (<0.001)	–0.136
Year99	0.092 (0.001)	0.090 (0.02)	–0.087 (0.26)	0.062
Year00	0.162 (<0.001)	0.157 (<0.001)	–0.029 (0.71)	0.136
Year01	0.249 (<0.001)	0.281 (<0.001)	0.204 (0.01)	0.220
Year02	0.310 (<0.001)	0.330 (<0.001)	0.223 (0.004)	0.279
Year03	0.474 (<0.001)	0.485 (<0.001)	0.402 (<0.001)	0.451
Year04	0.633 (<0.001)	0.589 (<0.001)	0.590 (<0.001)	0.611
Year05	0.801 (<0.001)	0.748 (<0.001)	0.749 (<0.001)	0.764
Year06	0.933 (<0.001)	.801 (<0.001)	0.912 (<0.001)	0.897
Year07	1.011 (<0.001)	0.900 (<0.001)	1.055 (<0.001)	0.983
Year08	1.003 (<0.001)	0.916 (<0.001)	1.010 (<0.001)	0.963
Area	0.932 (<0.001)	0.690 (<0.001)	0.383 (<0.001)	0.937
Bath2	0.094 (<0.001)	0.046 (0.001)	0.053 (0.78)	0.081
ParkUn	0.092 (<0.001)	0.016 (0.48)	0.043 (0.09)	0.043
Park1	0.154 (<0.001)	0.039 (0.20)	0.090 (0.001)	0.099
Park2	0.193 (<0.001)	0.080 (0.01)	0.067 (0.58)	0.139
Floor1	0.067 (<0.001)	0.027 (0.36)	0.078 (0.01)	0.072
Floor2_4	0.104 (<0.001)	0.038 (0.16)	0.103 (<0.001)	0.118
Floor5_8	0.133 (<0.001)	0.073 (0.01)	0.134 (<0.001)	0.147
Floor9+	0.132 (<0.001)	0.166 (0.002)	0.194 (0.01)	0.165
Constr1850_1913	–0.092 (<0.001)	0.042 (0.18)	–0.119 (0.01)	–0.083
Constr1914_1947	–0.082 (<0.001)	0.112 (0.001)	–0.110 (0.01)	–0.062
Constr1948_1969	–0.153 (<0.001)	0.008 (0.73)	–0.122 (0.002)	–0.119
Constr1970_1980	–0.123 (<0.001)	–0.005 (0.83)	–0.088 (0.03)	–0.083
Constr1992<	0.099 (<0.001)	0.099 (<0.001)	–0.085 (0.12)	0.104
CondMed	–0.109 (<0.001)	0.009 (0.63)	–0.072 (0.001)	–0.107
CondBad	–0.215 (<0.001)	–0.092 (0.04)	–0.197 (<0.001)	–0.225
ViewNo	–0.040 (<0.001)	–0.027 (0.03)	–0.017 (0.37)	–0.035
ViewBad	–0.098 (0.001)	<0.001 (0.99)	–0.002 (0.96)	–0.083
Cellar1	0.099 (0.001)	–0.002 (0.88)	0.092 (<0.001)	0.076
Cellar2	0.032 (0.001)	0.001 (0.98)	0.021 (0.84)	–0.005
Garden	0.049 (0.02)	–0.011 (0.73)	0.101 (0.16)	0.046
Terrace	0.043 (0.01)	0.049 (0.01)	0.037 (0.69)	0.041
NewApartment	0.046 (0.01)	–0.067 (0.001)	0.256 (<0.001)	0.047
District2	–0.109 (<0.001)	–0.035 (0.01)	–0.013 (0.64)	–0.053
District3	–0.130 (<0.001)	–0.104 (<0.001)	0.021 (0.54)	–0.088
District4	–0.229 (<0.001)	–0.188 (0.01)	0.093 (0.01)	–0.189
%MidIncome	0.671 (<0.001)	0.313 (0.05)	0.558 (0.01)	0.770
%HighIncome	0.136 (<0.001)	0.097	0.029 (0.61)	0.028
Adjusted R^2	0.838	0.839	0.705	0.875
N observations	4,362	873	872	4,362

Note: Significance level is in the parentheses.

APPENDIX 3

OLS and Spatial Error models for sumbarkets

Submarket	Accessibility by car				Accessibility by public transport			
	TTBellecour	*TTCityHall*	*Centrality Index*	*Accessibil-ity Index*	*TTBellecour*	*TTCityHall*	*Centrality Index*	*Accessibil-ity Index*
OLS								
Sainte-Foy-lès-Lyons, 84 obs., adj. $R^2 = 0.83 – 0.84$, Max VIF = 3.25	–0.525 (0.02)	–0.381 (0.11)	0.022 (0.12)	0.006 (0.06)	–0.304 (0.05)	–0.203 (0.21)	0.013 (0.19)	0.003 (0.13)
Oullins, 100 obs., adj. $R^2 = 0.88 – 0.89$, Max VIF = 3.35	0.098 (0.62)	0.306 (0.25)	–0.008 (0.39)	–0.003 (0.33)	0.307 (0.18)	0.396 (0.03)	–0.020 (0.08)	–0.005 (0.06)
Vénissieux, 97 obs., adj. $R^2 = 0.78 – 0.85$, Max VIF = 5.56	–0.237 (0.17)	–0.478 (0.02)	0.022 (<0.001)	0.006 (<0.001)	–0.935 (<0.001)	–0.911 (<0.001)	0.061 (<0.001)	0.013 (<0.001)
Vaulx-en-Velin, 54 obs., adj. $R^2 = 0.66 – 0.68$, Max VIF = 2.82	1.970 (0.19)	0.016 (0.99)	–0.014 (0.74)	–0.005 (0.69)	0.559 (0.54)	–0.355 (0.67)	–0.007 (0.87)	–0.004 (0.72)
Spatial Error								
Sainte-Foy-lès-Lyons, $R^2 = 0.88$	–0.599 (0.01)	–0.427 (0.10)	0.027 (0.10)	0.007 (0.05)	–0.486 (0.01)	–0.268 (0.17)	0.021 (0.10)	0.005 (0.07)
Oullins, $R^2 = 0.91$	0.117 (0.59)	0.311 (0.27)	–0.008 (0.43)	–0.003 (0.35)	0.318 (0.18)	0.422 (0.02)	–0.022 (0.06)	–0.005 (0.05)
Vénissieux, $R^2 = 0.87 – 0.89$	0.284 (0.39)	–0.260 (0.45)	0.022 (0.04)	0.005 (0.11)	–0.947 (<0.001)	–1.162 (<0.001)	0.061 (<0.001)	0.014 (<0.001)
Vaulx-en-Velin, $R^2 = 0.84$	0.147 (0.94)	–0.562 (0.65)	0.019 (0.70)	0.003 (0.81)	0.685 (0.50)	0.499 (0.57)	–0.008 (0.86)	–0.005 (0.65)

Note: Significance level is in the parentheses.