Stated preferences of French citizens for urban green spaces and forest: A discrete choice experiment on residential location choice

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Abstract

In this study, we estimate the non-market value of urban green spaces for local population through their residential location choice. A choice experiment is developed. The choice alternatives are created by changing the attributes of actual residential location. The data is analyzed by mixed logit model to account for preference heterogeneity. At last, we measured the willingness to pay applying both “preference-spaces” method and recent “willingness-to-pay-spaces” method. Our results show that there are both direct use value (recreation) and indirect use value (scenic view) of parks and forests. We find that parks/public gardens and urban forest are not substitutes. We find, in addition to a significant variance in the preferences for location attributes, a significant scale heterogeneity which should be considered when analyzing preferences for urban green space.

Keywords: Choice experiment, residential location, urban green spaces, willingness-to-pay-space, mixed logit

JEL: Q26, Q510, C5

1. Introduction

Forests have a significant non-market value to the local population (Hand et al. 2008). In one hand, having forests in the vicinity of the home is important for recreational and leisure activities. The recreational value of a forest depends on the structure and equipment of the forest (marked footpaths, parking, etc.) but also the location of the forest. Normally, the value decreases with distance to the forest because of travel costs. Other spatial aspects could also affect the recreational value of the forest. If there are other recreational sites in the vicinity of the forest value will decrease if this site is a substitute but increase if an additional site is complementary (e.g., a historical building/funfair near the forest). These kinds of value, in our opinion, can be called direct use value of the forest.

In the other hand, proximity of forests provides not only a recreational value to local residents but also other types of additional gain. This value can be related to the view from the residence, quiet, fragrance of flowers or reduced air pollution. Unlike the forest recreational value, these types of value do not depend on access to forest. In the evaluation of a private forest which can be closed to the public, it is important to distinguish between the value of access to the forest and the value of a forest without access which can be considered as indirect use. In addition, there exist numbers of different approaches for estimating the forest's spatial effect on the well-being of the population and it is important to take into account various relevant scales in the assessment (Abbott & Klaiber, 2010). Opposite to direct use value, these kinds of value are called indirect use value.

As a result, one will have a better estimate result if he is able to analysis the direct use value and non-direct use simultaneously. Beside environmental amenity, people consider other attributes of their residence, like size and price. Actually the list of attributes considered by people choosing their residence is very long.

Our study aims to use a novel approach to estimate the non-market value of urban green spaces, especially urban forest, parks and public gardens, for local population of "Grand Nancy". In particular, we estimate people's willingness to pay (WTP) for having urban green spaces near the residence. Distinguishing the direct use value and the indirect use value is other important issue of this study. The potential substitutes of forest such as parks and public gardens will affect the value of forest (Abildtrup et al., 2010). This issue will also be taken into account in our model. Despite the possible impacts of other aspects such as public infrastructures, this study is more focus on the environmental aspect.

With these purposes, first, we decided to apply a choice experiment approach in the form of face to face survey in Nancy. The main element of this experiment is to propose alternative residences to the respondents and ask them to choose between the alternatives. We applied a certain type of choice experiment where one of the alternatives is the current residence and the characteristics of the alternatives are pivoted around the characteristics of the current residence. Second, in the empirical step, using the mixed logit model, we estimate the impact of attributes on people's choice of residential location. Finally, we analyzed the marginal

WTP to live close to forests and their substitutes such as parks and gardens with both traditional "preference space" method and recently popular "WTP space" method.

Our study area is Nancy city and its agglomeration. Nancy city has a strong impact in department Meurthe-et-Moselle, which is a heavily forested region. Forest covers nearly 166,000 ha (INSEE), representing more than 32% of the territory (this rate is 26% at the national level). According to INSEE, between 2006 and 2021, the number of households in Nancy and its agglomeration will increase by 5% to 6%. This tendency will result in increasing housing needs of the local population, both in terms of quantity and quality. To have a better quality of life, places with natural characteristics, such as urban forests, are thought to be attractive residential locations. Although it is important to know the value of green spaces for local population and its impact on residential location choice, so far, studies are quite few on this subject in France. For this study, we carried out a face to face survey in Nancy during July, 2013.

We find that people really willing to have more amenities provide by urban green spaces and forest. And for the first time, we demonstrated the direct use value and the indirect use value of the urban green space exist independently. We have not discovered the substitution effect between urban forest and urban green spaces, but found that their amenity values for local population are significant and independent. Except the significant willingness to pay for attributes, we found significant scale heterogeneity in people's amenity preference for urban green spaces and forest.

2. The Design and survey

2.1 The design of the survey

The centerpiece of the survey was a choice experiment. This procedure is called "pivoting" since the attribute in the state preference experiment are created by changing the attribute of the chosen revealed preference alternative. This induces more realism and can provide greater specificity then the standard approach where all alternatives are hypothetical. Many studies have applied this method. (Henser and Green, 2003; Henser, 2004, 2006; Henser and Rose, 2007, Train and Wilson,2008) In our case, respondents are firstly asked to tell their current houses' characteristics and then choose between 3 hypothetical residences. One is the current residence the other two are hypothetical in which we changed some attributes' levels relative to the attribute levels of their current residence.

Our first attributes chosen is the distance to green spaces, such as forests and parks. Numbers of research find that this distance affects people's residential localization choice. In this study the benefit of being close to urban green space is described in two ways: The distance and the view of the green spaces.

The scenic view amenity has a typical indirect use value. We expect that it will make our model capable to separate the indirect use from direct use of the forest.

At last, we add the size and price as housing characteristic attribute. With these important housing attributes, we are finally possible to observe people's trade-off between housing amenities and environmental amenities. Note that we do not include all the other important attributes, like public infrastructure, which may influence the choice of residence. We are allowed do this as we carry out an experiment where we tell the respondent that the hypothetical alternatives are exactly the same as the current alternative – except with respect to the five alternatives in Table 1.

Table 1

Attributes	level
Distance to forest	**1.** Current **2.** 2km further **3.** 4km further
Distance to park/garden	**1.** current **2.** 500m further **3.** 1000m further
Scenic view to green space	**1.** With view **2.** No view
Size of house (m^2)	**1.** -10% **2.** current **3.** +10%
Price/rent of house	**1.** -15% **2.** -10% **3.** -5% **4.** current **5.** +5% **6.** +10%

The choice experiment presented tree alternatives to a respondent, each of them have the same 5 different attribute with different levels. The five attributes, with their different levels, have 324 combinations using a full factorial design. This is not realistic to include all alternatives in a choice experiment. Therefore we use a fractional factorial design which only allowed estimating main effects and the interaction between the two attributes of distance. This interaction term was included to investigate the substitution between parks and forests. Applying D-optimal designs with SAS (Kuhfeld 2010), we constructed a D-efficient design with 12 different choice sets of 3 alternatives. Each choice set contains a "state quo" option. We separated these 12 different situations in to four groups. In each survey, respondent will face to 3 different choice experiments. The form of our choice situation is described in table 2.

Table 2 example of choice situation

Attributs	Current house	Alternative 1	Alternative 2

Distance to forest	Current distance	2km further	Current distance
Distance to parks/public garden	Current distance	500m further	1000m further
Scenic view of green space	Current view	No view	With view
Size of the house	Current size	10% more	10% more
Price/rent of the house	Current price/rent	15% less	5% less
I prefer (choose only one please !) →	□	□	□

2.2 The survey data

Our face to face survey is realized in numbers public places of Nancy city (table 1). The respondents are all adults (+18 years old) who live in Nancy city and its agglomeration which is our study area. Our questionnaire include questions about people's housing/environmental characteristics (e.g. Size of the house, distance to the parks and forest, scenic view, etc.), recreational activities, and finally a 3 time repeated choice experiment descripted in previous section. During July 2013, although the acceptance rate was low, 226 respondents accepted our survey and 180 among them were sufficiently complete to be used for our analysis.

Table 3

Survey places	Number of surveys
bus	6
Library	1
canteen	67
Social assurance	4
forest	3
Tain station	13
Publice garden 1	8
Publice garden 2	3
Road 1	5
park	35
Road 2	3
City train 1	10
City train 2	23
Total	**180**

We survey only one person per household. We use the dummy variable "owner" to capture the variance of preference between owners and renters. As we wanted to combine renters and owners in the same database we had to make the same residence cost unit. Therefore, we

would have to convert a house price into a monthly rent or capitalize the monthly rent to make have the same unit for renters and owners. However, this transformation would be based on a number of assumptions, like the choice of interest rate. Therefore, we decided to use the percentage change in house price/rent directly in our estimation. Therefore, the wtp estimated in this paper is measured as percentage of their current housing costs and not in euros. This approach avoids the problem of combining prices of owners' housing price with the rent paid by the renters. When the respondents tell the distance from their home to nearest forests (parks and public gardens), we ask them to inform us the name of the forest and parks. All the forests that people mentioned in our survey are near Nancy, within a radius of 25 kilometer. So the forests in our study can be considered as urban forests. The number of visit of forest (nbvf) and parks & public gardens (nbvpj) is investigated. The size is a typical characteristic of house, and it is normally related to many other characteristics such as number of rooms, number of garages, and other household equipment. We use this attribute to observe the individual's weight when they have to choose between housing and environmental attributes.

Table 4 Description of database

Variable	description	Obs	Mean	Std. Dev.	Min	Max
owner	1 if owner; 0 if renter	180	.4722222	.499382	0	1
RSdisF	distance to forest (km)	180	5.592867	5.066392	.01	28
RSdisPJ	distance to park/garden (km)	180	2.209144	3.86141	.001	20
nbvf	number of visit to forest	180	15.36111	33.79468	0	245
nbvpj	number of visit to parks/garden	180	32.97778	63.39692	0	300
RSsurf	size of the house (m^2)	180	88.75821	72.61366	26	715
price	price WTP for +or- attribute (%)	180	-.018364	.0649567	-.15	.1
sview	scenic view of green spaces(dummy)	180	.6246914	.484352	0	1

3. Methodology

First applied by Boyd and Mellman (1980) and Cardell and Dunbar (1980), mixed logit is frequently used as it is capable to account for heterogeneity in individuals' preference. So far, it is considered to be the most promising state of art of discrete choice modeling. By using this random parameter model, we tent to avoid estimation bias due to unobservable heterogeneity of respondents' preference. Proved by McFadden and Train (2000), any discrete choice random utility model can be approximated by an appropriately specified mixed logit model.

In a sample, assume *N* respondents face to *T* situations with a choose set of *J* alternatives. The utility for respondent *n* choose alternative *j* in the choice set in situation *t* is: $U_{njt} = \beta_n X_{njt} + \varepsilon_{njt}$, where X_{njt} is the observed attributes vector. β_n is a vector of individual-specific coefficients. The probability for individual *n* choosing alternative *i* in situation *t* can be expressed by the conditional logit formula:

$$P_{nit}(\beta_n) = \frac{\exp(\beta_n X_{nit})}{\sum_{j=1}^{J} \exp(\beta_n X_{njt})} \quad (3.1)$$

The parameter β_n varies among respondents with a distribution with density$f(\beta|\theta)$.

Then, knowing β_n , the conditional probability of the observed sequence of choices is given by:

$$\Gamma_n(\beta_n) = \prod_{t=1}^{T} P_{nit}(\beta_n) \quad (3.2)$$

The unconditional probability of the observed sequence of choices, as the β_n is unknown, is the conditional probability integrated over the distribution of β:

$$\Lambda_n(\theta) = \int \Gamma_n(\beta_n) f(\beta|\theta) d\beta \quad (3.3)$$

The log likelihood function is given by

$$LL(\theta) = \sum_{n=1}^{N} \ln \Lambda_n(\theta) \quad (3.4)$$

As this function cannot be solved, it is approximated through simulation (McFadden and Train,2000). The simulated log likelihood is given by

$$SLL(\theta) = \sum_{n=1}^{N} \ln \left\{ \frac{1}{R} \sum_{1}^{R} \Gamma_n(\beta^r) \right\} \quad (3.5)$$

Where *R* is the number of replications and $\beta^r$is the rth draw from $f(\beta|\theta)$.

Applying mixed logit model in the estimation, our empirical model is:

$$U(x) = STATUSQUO + b1 * RSsurf2 + b2 * nbvF * RSdisF + b3 * O_{RSDISF} + b4 * RSdisF + b5 * RSdisPJ + b6 * RSsurF + b7 * sview + b8 * mprice \quad (3.6)$$

Random parameters

Where X is a vector of alternatives, $U(x)$ denote people's utility of choosing the alternative.

The constant "status quo" is specified with value 1 if status quo option and 0 otherwise.

Our 5 random variable is the "distance to forest" (RSdisF), "distance to parks and gardens" (RSdisPJ), "scenic view"(sview), "price", "size" (RSsurf). We specify the random coefficient of price with a log-normal distribution. We expected that face to our 5 attribute of choice experiment, people will have different individual preferences.

We use 3 nonrandom parameters for three variables. The "size square" (RSsurf2) is used to capture the scale effect of the size of the house. The interaction terms "owner∗distance of forest" (O_RSdisF), "number of visit of forest ∗ distance of forest" (nbvf_RSdisF) are also in our model. They allowed us to investigate the sample so-called deterministic heterogeneity around the means of the estimated parameters. We wonder that respondents with to the same distance from home to forest, the house owner, as well as people who visit forest quite frequently will have difference a higher utility of living close to a forest.

4. Results

Data were analyzed with Stata 12 software. We used the module –mixlogit- which is developed by Hole (2007). The bias of on-site/off site sample selection was tested, but it isn't significant. Then the hypothesis off IID was tested. As the result is significant, it is not consistent to apply multinomial logit model. Our result of mixed logit is presented in the table 5. The pseudo R^2 of the mixed logit model is 0.23, which proved that the specified model fits the data well. Beside, to avoid different individual-coefficients', we specified the coefficients of "price" to be log-normal distributed. The price is multiplied by "-1".

Generally, all the fixed parameter variables give us expected sign. But one of the random parameter variable, the distance to forest is not significant. The stand deviation of "RSdisF", "RSdisPJ", "sview" is significant, which indicate the existence of preference heterogeneity of this three attributes.

The positive parameter estimated for the "statu quo" captures a systematic status quo effect. All the things being equal, respondents prefer the status quo alternative, i.e. their current house.

Now, let's see the results of distance to forest. The variable "O_RSdisF" and "nbvf_RSdisF" are significant. Their parameters have both negative sign. It implies the house owners and people who visit forest a lot are specifically willing to live closer to the forest. But the random parameter variable "RSdisF" is not significant. It implies, generally, the distance of forest does not affect people's choice of residential location.

Continue with the result with the variable "distance to the parks and gardens". This random variable is significant with a negative coefficient. Our result show that generally, the citizens of Nancy city really like to live close to the parks and public gardens.

Then, let's pass to the result with the variable "size of the house". The variable "RSsurf2" is significant and its parameter is negative. Look at the random parameter variables, the "RSsurf" is significant with positive sign. We can deduce that people generally like bigger house, but this preference coexist with a scale effect.

At last, the random variable "scenic view" is significant. Follow the method given by Hole (2007), we can obtain that 81.5% of Nancy citizens' have a positive utility with scenic view.

Tables 5. Mixed logit estimation

Nb obs=1620 ; -log liklihood=449.80; Pseudo R^2=0.23;						
Y=choice	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Mean						
statu_quo	1.266194	.181708	6.97	0.000	.9100531	1.622336
Nonrandom parameters						
O_RSdisF	-.2059885	.1291832	-1.59	0.111	-.4591829	.0472059
RSsurf2	-.0003272	.0000837	-3.91	0.000	-.0004912	-.0001631
NBVFdisF	-.186471	.0876261	-2.13	0.033	-.3582149	-.0147271
Random parameters						
RSdisF	.169057	.1247237	1.36	0.175	-.075397	.413511
RSdisPJ	-1.618803	.4703087	-3.44	0.001	-2.540591	-.6970149
RSsurf	.1157705	.0304632	3.80	0.000	.0560637	.1754773
sview	.9616547	.2381854	4.04	0.000	.4948199	1.42849
price	-1.379508	.416691	3.31	0.001	.5628091	2.196208
SD						
RSdisF	-.3265537	.1687309	-1.94	0.053	-.6572602	.0041527
RSdisPJ	-2.659583	.6091534	-4.37	0.000	-3.853502	-1.465664
RSsurf	.010085	.0239337	0.42	0.673	-.0368242	.0569942
sview	-1.069067	.4273056	-2.50	0.012	-1.906571	-.2315639
price	-1.793464	.2852908	6.29	0.000	1.234304	2.352624

5. Social welfare analyses – the willingness to pay

The common practice to estimate the marginal traditional WTP for an attribute is calculated by the ratio of the attribute coefficient to the price coefficient. As a result, the WTP is given by the ratio of two randomly distributed terms which cause skewed distribution of WTP. Some approaches such as fixing the price's coefficient, specifying the price coefficient as log-normally distributed have been applied, but they all have shortcomings (Meijer and Rouwendal, 2006). Train and Weeks (2005) suggest estimating the mixed logit model in WTP space method. The WTP is directly estimated by re-formulating the model in such a way that the coefficients represent the WTP measures. Many studies have shown that this approach provides more realistic WTP result, and we would like to compare the WTP results of the two methods in the sector of residential choice studies.

5.1 The preference space method

With the standard preference space method, WTP is estimated in two stages. After obtaining the estimated coefficient, the WTP for an attribute is given by the ratio of the attribute coefficient to the price coefficient.

$$WTP_x = \frac{\beta_x}{\beta_p} \tag{5.1}$$

As we already discussed in the section 1, restricting the sign of the coefficients to be either positive or negative for all individual is desirable in our case. Hence, we specify the coefficient of price to be log-normally distributed.

5.2 The WTP space method

With the WTP space method, WTP estimates can be estimated directly in a reformulated mixed logit model that the estimated parameters represent the parameters of the WTP distribution rather than the parameter of coefficients. (Train and Weeks, 2005) The advantage of this approach is that one can specify the WTP distribution directly and therefore avoids the rather arbitrary choice of WTP distribution that arise from the coefficients of the non-money attributes by the cost coefficient, like we did for the price's coefficient in the previous section.

In our case, assume the utility for a citizen n derives from choosing house j in choice situation t is specified by the function,

$$U_{njt} = \alpha_n p_{njt} + \beta_n X_{njt} + \varepsilon_{njt} \tag{5.2}$$

Where $p_{njt}$is the housing price, and X_{njt} denotes a vector of other non-monetary attribute of our model. α_n and β_n are individual random parameters, and ε_{njt} is extreme value distributed with variance $Var(\varepsilon_{njt}) = k_n^2(\pi^2/6)$, where γ_n is the scale parameter for citizen n. Dividing equation (5.2) by k_n doesn't change the citizen's behavior and gives us a new error term with IID distribution which has the variance $\pi^2/6$:

$$U_{njt} = \lambda_n p_{njt} + c_n X_{njt} + \varepsilon_{njt} \tag{5.3}$$

Where $\lambda_n = \alpha_n/k_n$, $c_n = \beta_n/k_n$. Setting the non-monetary attribute parameter equals to $\gamma_n = c_n/\lambda_n$, the equation can be rewritten as:

$$U_{njt} = \lambda_n[p_{njt} + \gamma_n X_{njt}] + \varepsilon_{njt} \tag{5.4}$$

It is the model in WTP space developed by Train and Weeks (2005).

5.3 The results comparison

The willingness to pay coefficient in the preference space and WTP space models can be estimated by using maximum simulated likelihood or Bayesian method.(Train, 2003) Recently, Thiene and Scapa (2009) estimated the model using maximums simulated likelihood. We decide to apply the same method.

Table 6. Comparison of WTP results

	WTP pref space	WTP space fixed coeff		WTP space rand coeff			
var	Coeff.	mean	Std.	mean	Std.	S.D.	Std. Err.

			Err.		Err.		
Disf	.0178633	-.0386627 (***)	.010327	-.046017 (***)	.004993	.0260698 (***)	.0058087
disPJ	-.1484598***	-.2322693 (***)	.043794	-.2993208 (***)	.034615	.4232479 (***)	.0442396
view	.10467608***	.1090501 (***)	.025866	.121088 (***)	.022387	.1869055 (***)	.028395
Surf	.00600261***	.0004303	.001479	.0026736 (**)	.001239	-.0066705 (***)	.0011061

In the table 6, we compared the WTP of our 5 attributes in the choice experiment. The first column is the results of preference space method. We estimated two types of WTP space method. One is WTP space with non-random coefficients (WTPSF), which means the γ_n is a fixed parameter. The other is WTP space with random parameters (WTPSR), which implies the γ_n is a random parameter. The "random parameter WTP space" method is a more advanced than the fix parameter one. It can capture the scale heterogeneity across individuals by supposing$\gamma_n = \bar{\gamma}_n + \sigma$. Greene and Henser (2010) have recently discussed this issue.

For the variable "distance to forest", WTP obtained by preference space is not significant. The WTPSF method gives us negative sign, which implied living far away to forest gives people negative utility. It is measured that people want to pay 3.8% of their housing price or rent for living 1 km closer to forest. The WTPSR method shows us that people have significant difference preference in living close to forest. This can explain the result in our mixed logit model (table 3) that house owners prefer to live close to forest.

For the variable "distance to parks and public gardens", WTP obtained by preference space has a negative sign. Nancy citizens want to pay 15% less to live 1 km further to parks and public gardens. Knowing Nancy's surface is not quite big (15 km^2), 1 km can make a big difference. The WTPSF give us higher WTP, about 23%. And at last, through the WTPSR method, we know that people is ready to pay 29% for living closer to parks and gardens, but with variation of preference that even higher than WTP (0.42). This result shows that even generally Nancy citizens are willing to live closer to parks and gardens, their preference level is very different. There is a nontrivial group of people who are willing to pay enormous amount of money for this attribute.

For the variable "scenic view", the WTPs estimated by three methods are quite close. The preference space method indicates that people is willing to pay 10% more to have a green space's view outside their window. And the WTPSF method gives us a result of 11%. Again, the WTPSR method point out that there is a big variance of individual WTP for green space scenic view. It illustrates that the mean of WTP is 0.12, but the variation is 0.18.

6. Discussion

We present a study on Nancy citizens' preferences for environmental attributes of their houses, especially the distance to urban green spaces (e.g. urban forest, parks, and public gardens) and the green spaces' scenic view. To observe the way how they weight urban green space during the resident location choice procedure, we applied a choice experiment.

We analyzed the willingness to with tree different methods: preference space method, WTPSF method, and WTPSP method. The results from the mixed logit model illustrate strong evidence of preference heterogeneity face to these environmental attributes.

Our model allows testing the substitute effect between forest and parks & gardens. The preference space method indicates that, facing to the two attributes at the same time, most people prefer living close to parks & gardens, but they are not sensible with distance to forest. The two WTP space methods both give us a better result. They show that people really do willing to pay more to live close to forest, as well as parks & gardens. Furthermore, the WTPSR shows individual-scale heterogeneity, which means not only individuals' preference are different, but also their scale of preference. Besides the unobserved preference heterogeneity we also find significant observed preference heterogeneity. Two groups of people are especially willing to live close to the forest: people who visit a lot forest and the house owners.

We also achieve to estimate the indirect use value of the green space with the variable "scenic view". In France, there are numbers of private forest which are not open to public. Our study shows that people can benefit the amenity of green spaces without visiting them. And they are actually willing to pay for this indirect use value. That closed forests also have an amenity value to the local population.

We applied 3 types of methods to estimate the willingness to pay. For all attributes, the mean of coefficients' absolute value increase from left to right. It is mainly because with the traditional preference space method, the mean of the parameter of WTP cannot take the individual scale heterogeneity (the γ_n, see section 5.3) into account. By only estimate the mean of coefficient, the preference space put a constrain on the value the WTP that it cannot exceed the average value of the population. Likewise, the WTP with the fixed coefficient cannot estimate the scale heterogeneity randomly. So the individual-scale heterogeneity is restrained by the mean value and the effect of scale heterogeneity is weakened. The random parameter approach gives us the highest mean coefficient of WTP with a significant large standard deviation (e.g.$\gamma_n = \bar{\gamma}_n + \sigma$). It is quite obvious that the WTP space with random parameter is more consistent when there is the extreme of price sensitivity implied by nontrivial group in the population. Our comparison result is quite similar with other recent studies. (Scapa, 2010; Pancras,2011)

It is obvious that people's residential location choice could be strongly affected by other unobserved factors such as schools, hospitals, etc. The preferences for green spaces attributes perhaps could be negatively correlated with these structures. Secondary data is required for further study.

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