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The value of naturalness of urban green spaces: Evidence from a discrete choice experiment

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Abstract

The wide range of benefits for humans and biodiversity conservation provided by urban green spaces (UGS) are receiving substantial attention in relation to urban planning and management. However, little is known about to which extent people value the naturalness and biodiversity of urban green spaces. We study how citizens value the naturalness of and the walking distance to their closest UGS in 22 major German cities. For this purpose, we develop a unique measurement scale for the naturalness of UGS, which is embedded in an online survey and in a discrete choice experiment. Results of Mixed Logit estimates and willingness to pay values indicate clear preferences regarding the naturalness of urban green space. For our national representative sample, we elicit a mean marginal WTP for the naturalness of UGS of € 2.31 per month with a standard error of € 0.12. Moreover, the results show that WTP varies between cities. These figures underline the importance of biodiversity in urban areas and can inform urban planning.

Keywords: Biodiversity, discrete choice experiments, non-market valuation, urban green space, willingness-to-pay

JEL-codes: C81**,** H41, Q51, Q57, R21, R58

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1 Introduction

Globally, the biodiversity change is accelerating (IPBES 2019) and concerns about the loss of biodiversity are widespread.[1] Cities with their fragmented structure of gardens and parks have received increasing attention as a place for biodiversity conservation. These urban green spaces (UGS) provide a wide range of benefits for humans, e.g. for health and recreation, and biodiversity conservation (Aronson et al., 2017). While many studies have quantified a positive willingness-to-pay (WTP) for UGS close to the place of residence, little is known whether and to what extent people value and are willing to pay for urban biodiversity and naturalness of urban green spaces.

Hedonic price modeling (Rosen, 1974) has been accepted as an appropriate method to estimate the implicit prices of nonmarket environmental amenities, such as biodiverse UGS, of private goods. In the context of UGS, hedonic price studies treat housing prices as an implicit measurement for the extent to which environmental amenities are valued. Many studies have applied hedonic pricing of residential housing to determine the value of living close to an UGS. Recently, there is increasing evidence in the literature that the properties of the UGS play an important role for its hedonic value on residential housing. For instance, Czembrowski et al. (2016) compared the impacts of various green spaces on property prices. The authors find that the biocultural value of UGSs does not have a significant impact on residential prices, whereas other characteristics of green spaces (such as their proximity and percentage in the specific vicinity) appeared to be of importance. Liebelt et al. (2018a) find that UGS residential prices for sold and rented flats and houses increase with the size of the closest green space (Liebelt et al., 2018b). Franco and Macdonald (2018) examined the impact of open space accessibility as well as its size and vegetation level on residential prices. The study supports that UGS lead to higher housing prices, depending on the composition of greenery. Łaszkiewicz et al. (2019) applied a three-step analysis based on hedonic pricing for investigating how the marginal WTP for UGS proximity varies within residential price sub-segments. Authors detected that proximity does not cause a rise of

[1] For instance, in Germany 82% of the population agree that biodiversity is decreasing globally, and 89% state that biodiversity contributes to their personal well-being and quality of life (BMU/ BfN 2020).

apartment prices for all UGS; whereas for the estimated marginal WTP for the proximity to selected UGS increase residential price sub-segments.

In this paper, we follow an alternative approach, and use a stated preference method to elicit preferences for the environmental amenity stated in a hypothetical market. Bertram and Rehdanz (2015) compared attitudes regarding ecosystem services provision in four European cities and analyzed the stated preferences of several characteristics of urban parks for their visitors. The authors investigated the perception towards the naturalness of urban parks, which describes biodiversity-related characteristics (such as, for example, plant species richness and animal richness). Besides the ranking of ecosystem services according to visitors' perceptions, the study concluded that naturalness is rated by the respondents as the second most important component of the park characteristics (after cleanliness and low level of crime). Moreover, several Discrete Choice Experiments (DCEs) have found a positive WTP for the access to UGSs, complementing the evidence from hedonic studies. Lanz and Provins (2013) find a substantial WTP for the access to UGS for Seaham (UK), mainly hold by households living close to the respective UGS indicating a limited share of non-use values. In a DCE conducted in Beijing, Liu et al. (2020) find a significant, positive WTP for the access to neighborhood parks, central city parks, or national parks outside the city. They detect substantial spatial heterogeneity in the respondent's WTP. Fruth et al. (2020) find a substantial WTP for street level greening with additional trees in a district of Berlin.

However, neither revealed nor stated preference studies have so far investigated whether there is beyond the proximity to and size of UGS, also a WTP for the biodiversity of UGS. With our study, we aim to give at a better understanding of preferences for biodiverse UGS in the context of housing. To this end we provide the first discrete-choice study eliciting the willingness-to-pay for biodiverse urban green, using a nationally representative sample for 22 large cities over whole Germany. The magnitude of the WTP not clear a priori, as biodiversity could be perceived as a "bad" associated with untidiness or since it comes at the cost of lost space in parks for alternative uses such as sport. This is particularly relevant since almost three quarters of the EU's population is living in urban areas (Eurostat, 2016) and cities might therefore be the environment where people experience and learn biodiversity.

With our study, we also make two methodological contributions: First, we develop a scale on which participants are asked to subjectively assess the biodiversity of their closest UGS. We operationalize biodiversity by drawing on the term 'naturalness' or 'nearness to nature', previously used in surveys (Bertram and Rehdanz, 2015) and measure it with a unique graphical 5-point Likert scale. As biodiversity is a complex and relatively young concept, with which most Germans are not familiar,[2] we refer to the term 'naturalness', as a bridging concept. Second, stated preference studies often face the

[2] According to a representative survey, only 45 percent of the German population know the meaning of the term biodiversity (BMU/ BfN 2020, p.42).

difficulty of finding an appropriate payment vehicle in a hypothetical market. Here, we use changes to the housing rent as an innovative payment vehicle, as numerous hedonic pricing studies have shown that changes in UGS characteristics affect the housing market, making this a credible payment vehicle to which participants are very familiar to.

We find that participants show a significant and substantial WTP for an increase in the biodiversity of their closest UGS over all considered cities, with a monthly mean WTP by € 2.31. However, the monthly WTP varies between cities, from a very high monthly WTP of €4.41 in Kiel and a relatively low monthly WTP of € 0.71 in Dresden. Furthermore, we can confirm that respondents have a negative WTP for an increase in the distance to the closest UGS, with a monthly mean WTP of € 4.5 for an additional walking minute.

The outline of our study is as follows: We describe the experimental and survey design in section 2, introduce the sample in section 3, and our econometric approach in section 4. Our results are presented in section 5. Finally, section 6 summarizes and concludes.

2 Experimental Design

Discrete choice experiments (DCEs) are a common tool to reveal determinants of people's behavior and allow investigating the WTP for specific attributes. In the period from June 16, 2020 to June 29, 2020 as well as from July 20, 2020 to July 28, 2020, we conducted an online survey to investigate preferences for the access to and biodiversity of urban green space (UGS). The survey addressed respondents that rent a flat in the capitals of the 16 federal states of Germany (Berlin, Hamburg, Munich, Stuttgart, Duesseldorf, Hannover, Dresden, Bremen, Potsdam, Magdeburg, Mainz, Wiesbaden, Kiel, Saarbruecken, Schwerin), Cologne, Frankfurt, Halle, Leipzig, Dortmund, Essen or Nurnberg (figure 1).

The survey consists of four parts. In the first part, we ask questions regarding the housing situation of the respondents. In the second part we ask questions about the perceptions and attitudes towards biodiversity in the neighborhood and their use of UGS. The third part asks (incentivized) to upload a photo of the immediate neighborhood of the flat and contains a discrete choice experiment. In the last part of our survey, we collect sociodemographic characteristics and personality traits of the respondents.

To improve our survey questionnaire in a whole as well as the DCE, the design of the questionnaire was discussed with focus groups in three two-hour online sessions with five participants each. A professional moderator from the marketing agency facilitated the forum discussions. The survey was revised according to the feedback. One issue of particular importance in the focus group discussions was to gauge our graphical representation of the 'naturalness' of UGS, shown in figure 2.[3] Moreover, the survey

[3] Unanimously the focus group participants agreed to the intended interpretation and ranking of the five degrees of "naturalness".

was pretested from April, 2020 to April, 2020 with 520 participants, of which 264 respondents answered the pretest completely and were considered to assess the suitability of our survey. Thus, we could ensure the comprehensibility of the questions and choice sets.

In total, 6,984 respondents were encouraged to participate in the online survey by a marketing agency, of which 1,791 respondents answered the survey completely.[4] Among the remaining, we excluded responses with implausible answers and obvious misstatements.[5] This procedure left us a total of 1,570 responses, which were included in the analyses. The final sample is representative on the national level for age (>18), gender and income. On average, the survey required approximately 16 minutes to be completed (median time of the survey: 13 min). The number of respondents in each of the cities included in the survey is presented in figure 1.

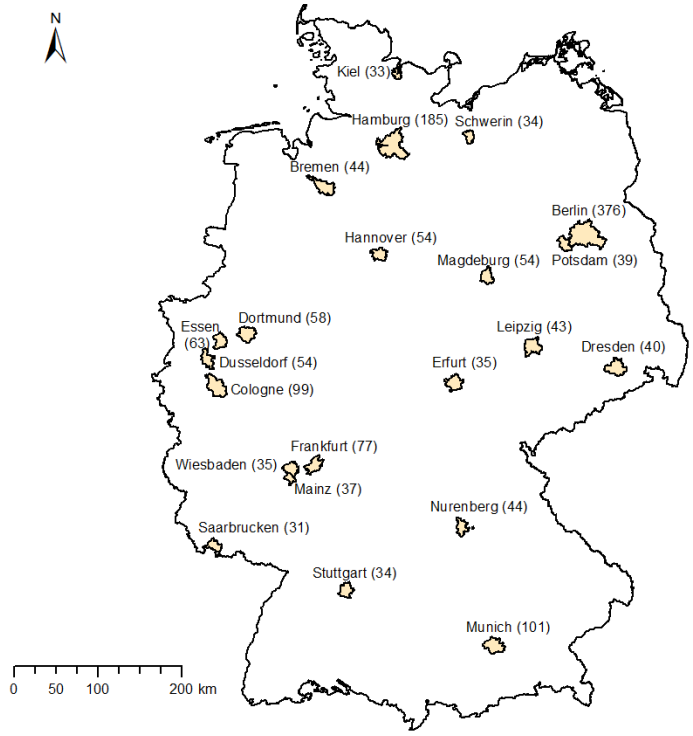


Figure 1: Number of respondents per city

In the discrete choice experiment (DCE) the respondents should consider that the UGS which they state to use most often, will be restructured in terms of naturalness and that the walking distance to the UGS will be changed by modifying roads or walks. The cost of the rebuilding will be charged through the monthly rental payment, which can result in additional costs or savings. In the DCE the participants have the choice between two programs of the rebuilding of their closest UGS and their current situation

[4] Of all participants who did not complete the survey, 45.1% left the survey when they received the welcome message, 20.6% when we asked for the address and 11% when they had to upload a photo and 23.3% at one of the other questions.

[5] For instance, we dropped if rents are smaller than 50€ per month and unrealistic high considering the stated flat size as well as if the walking time to the next UGS is more than 450 minutes and daily window time exceeds 12 hours.

(status quo). The attribute levels for the status quo were computed in the online survey based on the respondents' answers to previous questions in the questionnaire, where they were asked to indicate their monthly rent and the walking distance from their flat to the nearest green space.

Furthermore, the respondents were asked to assess the naturalness of the UGS they are using most often on a 5-point Likert scale, ranging from hardly naturally to very naturally, which we designed for our survey. The Liker Scale is described graphically, as shown in figure 2.

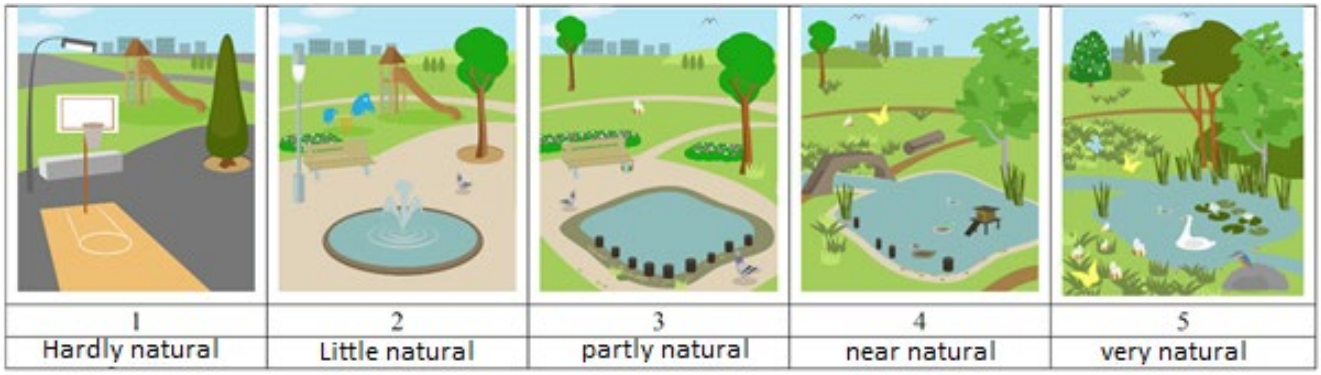


Figure 2: Naturalness of the closest green space

Again, the information provided by the participants forms the status quo. For the other alternatives, we define levels of the attributes, which can be found in table 1.

The levels of the attribute *walking distance* were calculated following Kolbe and Wüstemann (2015), who estimate a mean distance to UGS on average in German cities of 300 m with a standard deviation (SD) of also 300 m. Moreover, other studies also suggest that 300 m are an appropriate buffer zone to UGS (Kong et al., 2007; Liebelt et al., 2018a; Grunewald et al., 2019).[6] We define a 100% change from the stated walking distance as 1 SD (300 m). Changes of the original rental payments are derived from previous hedonic price studies, examining the price premiums for the distance to the closest UGS on the rent (Kolbe and Wüstemann, 2015; Schläpfer et al., 2015; Liebelt et al., 2018a).

[6] According to google maps, a walking distance of 300 m is referenced to 4 walking minutes.

Table 1: Attributes and levels included in the DCE

Attribute	Level
Naturalness of the closest UGS	hardly natural, little natural, partly natural, near natural, very natural as shown in figure 1
Walking distance to the closest UGS in minutes	-50% from actual walking distance reported in the survey, +50% from original walking distance, +100% from original walking distance, +200% from original walking distance, +400% from original walking distance. Figures were presented in absolute values.
Monthly rental payments for the flat in €	-1% from actual rent reported in the survey, -0.5% from original rent, +0.5% from original rent, +1% from original rent, +2% from original rent, +5% from original rent. Figures were presented in absolute values.

For two programs and the status quo, the levels for the attribute *naturalness* were described graphically as shown in figure 2.

Once the attributes and levels have been determined, these were combined into choice sets. A full factorial design included 150 (=5X5X6) program profiles. We selected a subset of these combinations using a fractional factorial Bayesian D-optimal design computed by means of the *NGene* software. To build the choice sets for the final experiments, a multinomial logit model (MNL) was estimated using the pre-test data. The estimates served as priors to generate 30 choice sets creating an efficent design, such as to maximize the D-efficiency measure. The final design had a D-error of 0.051. Following Loureiro and Umberger (2007), the 30 choice sets were randomly allocated between the respondents to mitigate any potential ordering impacts. Each respondent was faced with 10 choice sets during the questionnaire. Figure 3 shows an example of a choice set, in which the current situation shows the average over all respondents used for the analyses.

Descriptive analyses show that out of the n = 1570 respondents, 117 (8%) respondents have always accepted one of the rebuilding schemes, 411 (26%) respondents have never accepted a scheme and a majority of 1042 (66%) respondents had decided selectively.

	program 1	program 2	My current situation
Naturalness of the closest UGS			
Walking distance to the closest UGS in minutes	**11.25 min (+25%)**	**4.5 min** (-50%)	9 min
Monthly rental payments in €	**€ 784.08 (-1%)**	**€ 788.04 (-0.5%)**	€ 792
I choose:	□	□	□

[a] Only the absolute values have been shown to the respondents. These have been calculated as percentage changes (examples indicated in brackets) from the status quo values obtained from previous answers in the online survey.

Figure 3: Example of a choice set.

3 Data description

The median respondent is a 40 years old female, married, living in a two-person household without kids. Moreover, she has an academic degree, works in a full-time job with on average 37.5 hours a week and has a monthly net income of €2098. The descriptive statistics of the socioeconomic characteristics are shown in table 2.

Table 2: Descriptive statistics of sociodemographic variables

Variable	Description	Mean	Median	Std.Dev.	Min	Max
Age	Age of the respondent in years	41.98	40	13.58	18	70
Household Size	Number of Persons living in the household	2.21	2	1.16	0	9
Income	Monthly net income of the respondent in €	2686.03	2098	1500.31	441	6353
Kids	Number of kids in the household	0.43	0	0.8	0	9
Working hours	Average weekly woking hours	30.09	37.5	17.81	0	160
Gender	**share of the respondents, which...**	**Percentage**				
Female	are female	58.95				
Male	are male	40.8				
Divers	are divers	0.26				
Level of education						
Secondary school	have a secondary school degree	4.28				
Comprehensive school	have a comprehensive school degree	16.22				

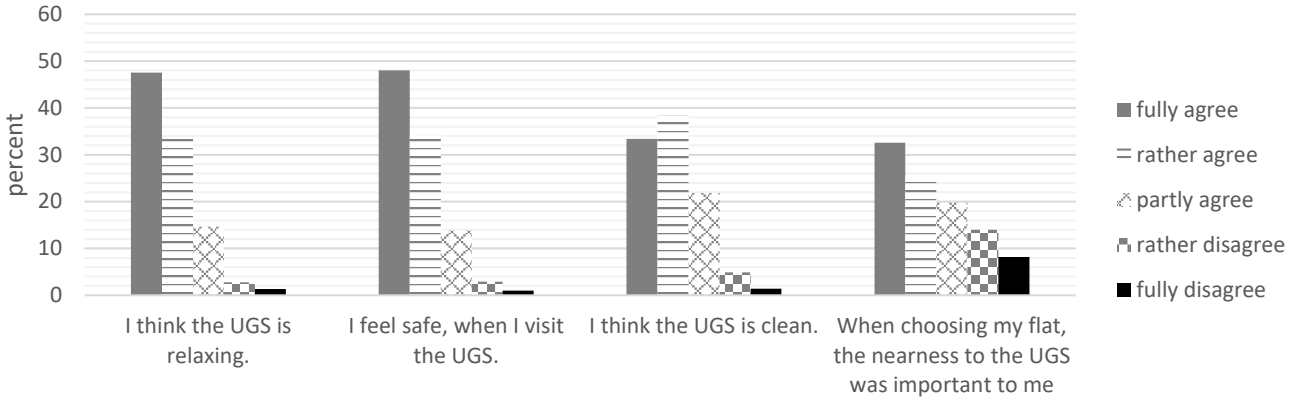
High school	have a high school degree	17.98
Vocational training	have a completed vocational training	27.97
Academic degree	have an academic degree	32.51
Other degree	have another graduation	1.04
Employment		
Full-time job	are in full-time employment	49.04
Part-time job	are part-time employment	15.88
Trainee	are student/trainee	10.52
Unemployed	are unemployed	3.89
Self-employed	are self employed	4.21
Retired	are retired	11.03
Other employment	other employment	5.42
Family Status		
Married	are married	33.33
Living in a partnership	are living together with a partner	21.97
Single	are singles	32.82
Separated	are divorced/separated/widowed	11.88

In the second part of the survey, we ask questions regarding the UGS the respondents are using most often, as well as perception questions related to biodiversity of this UGS. We are interested in, whether the two public environmental amenities, namely the access to UGS and the degree of UGS biodiversity, have some value for the respondents and if so to what extent.

The average walking distance from the rented flat to the UGS they are using most often is 9.35 minutes (table 3). Most of the respondents visit this UGS on a weekly basis (47%), followed by a daily (29%) and a monthly basis (17%). Just 7% of the respondents stated that they visit this UGS on a yearly basis or never. Most of the respondents (42%) indicated, that they stay there between 31 and 60 minutes or less than 30 minutes (28%).

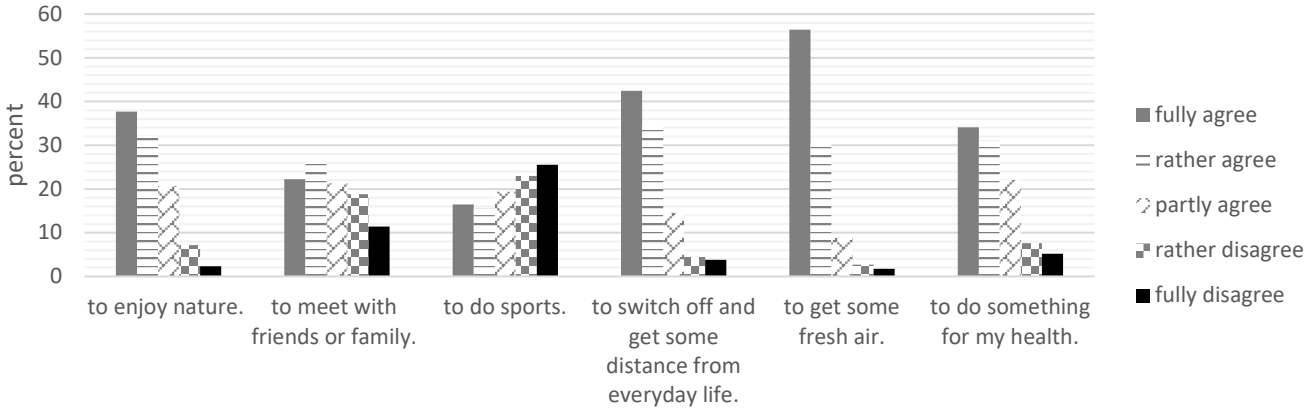
Figures 3 and 4 illustrate respondents' perceptions regarding the UGS they use most often. The statements were scored on a 5-point Likert-scale with categories ranging from "fully agree" (1) to "fully disagree" (5).

Figure 3: Respondents perceptions regarding the UGS they use most often



Nearly half of the respondents fully agree to the statement that the UGS is relaxing (48%) and they feel safe while visiting it (48%). 72% of the respondents fully and rather agree to the statement that the UGS is clean. Furthermore, 58% of the respondents stated that they fully or strongly agree, that having UGS in the vicinity was an important factor for choosing their flat. Figure 4 represents respondents' reasons for their last visit of the closest UGS.

Figure 4: Statements to "The last time I visited the UGS I am using most often, I wanted…."



The reasons for visiting the UGS they use most often were divers and represent a combination of several possible answers. Mostly, the respondents indicated as reasons for the last visit the following: "to get some fresh air", "to switch of and get some distance from the everyday life" or "to enjoy the nature". Based on the graphical 5-point Likert scale shown in figure 2, 29.49% of the respondents rate the naturalness of their closest UGS as partly natural, followed by near natural (27.26%) and very natural (24.33%). However, 10.89% state that their most-often used UGS is little natural and 8.03% think that itis hardly natural. As shown in table 3, the mean respondent states her most-often used UGS as partly natural (3.49). The distribution of the variables is shown in figure A1 in the appendix.

Table 3 descriptive statistic choice variables

Variable	Mean	Std. Dev.	Min	Max
Naturalness	3.49	1.20	1	5
Walking distance (min)	9.35	16.81	0	240
Monthly rental payments (€)	600.38	329.18	50	4000
Utility costs (€/month)	192.32	168.03	1	3000

The average monthly rental payment is € 600 and the average utility costs, the respondents pay, are €192 per month.

4 Econometric Approach

Discrete-choice models (DCM) are based on the theory of utility maximization and draw upon Lancaster's argument that it is the attributes of goods that determine the utility they provide (Lancaster, 1966) and random utility theory (McFadden, 1974). According to the random utility theory, utility is a latent construct that cannot be directly observed. Participants are considered to be utility-maximizers, who choose their most preferred alternative. The latent utility (U) that participant n obtains from attribute j in choice situation t can be decomposed into two components: a systematic or predictable component of the overall utility (V) and a random component (ε), described as

$$U_{njt} = V_{njt} + \varepsilon_{njt} = \boldsymbol{\beta}'_n \boldsymbol{x}_{njt} + \varepsilon_{njt} \quad (1)$$

V_{njt} represents the observed part of the utility. $\boldsymbol{x_{njt}}$ is a vector of the observed variables and $\boldsymbol{\beta_n}$ is a vector of the corresponding coefficients which are now specific to the decision maker *n*.

The probability of the choice of the attribute j over i for choice situation *t* can be written as:

$$P_{njt} = prob(V_{njt} + \varepsilon_{njt} > V_{nit} + \varepsilon_{nit}) = prob(\varepsilon_{nit} - \varepsilon_{njt} < V_{njt} - V_{nit}) \quad (2)$$

and describes the cumulative distribution function of the random variable $\varepsilon_{nit} - \varepsilon_{njt} = \varepsilon^*_{njit}$. Different discrete choice models are obtained from different assumptions about this probability distribution. By assuming that 1) each of the ε_{njt} is independently and identically distributed according to the extreme value distribution, otherwise known as the Gumble distribution (Greene, 2012), and 2) allowing the systematic utility to comprise individual taste preference β_n (taste heterogeneity), as shown in equation (1), one obtains a mixed multinomial logit (MMNL) model, also known as the random parameter logit (RPL) model. The parameter β_n is assumed to follow a normal distribution with mean b and standard

deviation σ_b, to be estimated, where a significant σ_b indicates that households have heterogeneous preferences for the respective attribute. [7,]

In addition to estimating taste heterogeneity, the RPL model has an advantage over the standard multinomial logit model by relaxing the independence from irrelevant alternatives (IIA) assumption (Hensher and Greene, 2003). The probability of participant n choosing alternative j in choice situation t can be computed as

$$P_{njt} = \int \left(\frac{e^{\boldsymbol{\beta}_n' \boldsymbol{x}_{njt}}}{\sum_j e^{\boldsymbol{\beta}_n' \boldsymbol{x}_{njt}}} \right) f(\boldsymbol{\beta_n}|\boldsymbol{\theta}) d\boldsymbol{\beta_n}. \quad (3)$$

As described by Bonnet and Simioni (2001), the choice probability P_{njt} becomes the integral over all possible values of β_n, which varies in the population with density $f(\boldsymbol{\beta}_n|\boldsymbol{\theta})$ and where θ are the population parameters for the distribution of β_n.

Our basic model is specified as:

$$U_{njt} = \alpha_C + \beta_{rent} rent_{njt} + \beta_{1n} naturalness_{njt} + \beta_{2n} walkingdistance_{njt} + \varepsilon_{njt}, \quad (4)$$

where α_C is the alternative specific constant (ASC). The ASC represents an indicator variable that is α_C=1 if the status quo is chosen and α_C=0 if one of the programs is selected. A statistically significant positive coefficient associated to the ASC dummy variable indicates a preference for the status quo alternative. The β's are vectors of the coefficients for the attribute. β_{rent} is the sensitivity parameter for the rent and $rent_{njt}$ is the rent of alternative j. The basis specification treats the effect of the ASC and the rent variable as fixed across participants, whereas the coefficients for variables $naturalness_{njt}$ and $walkingdistance_{njt}$ assumed to be random in our base model. As commonly assumed in the literature (Hensher and Greene, 2003) the coefficient associated with the monetary attribute (βrent) is considered to be constant across participants. The random coefficients are assumed to be independently normal distributed.

Once coefficients are estimated, the marginal willingness to pay (WTP) can be determined by estimating the marginal rate of substitution between each non-monetary attribute and the monetary attribute (Louviere et al., 2010; Lancsar et al., 2017).

The total derivative of U_{njt} with respect to changes in attribute X_k $k \in \{1,2\}$ and rent is given by (as the utility function is specified to be linear in parameters)

[7] An assumption of homogenous taste preferences ($\forall n: \beta_n = \beta$) transforms the RPL model into the standard multinomial logit (MNL) model. Note that some parameters can be assumed fixed in the estimation of the random parameter logit model.

$$dU_{njt} = \beta_k dX_k + \beta_{rent} drent \quad (5)$$

When we set this to zero and solve for $\frac{drent}{dX_k}$, we get the marginal WTP as the change in rent that keeps utility unchanged given a change in X_k

$$WTP_k = -\frac{\beta_k}{\beta_{rent}} \quad (6)$$

where β_k is the coefficient of any of the attributes $k \in \{1,2\}$ and β_{rent} is the coefficient of the monetary attribute, in our case the rent.

5 Empirical Results

For a more transparent and clearer interpretation of the WTP for naturalness we set up a naturalness index for UGS. To this end, we transform our 5-point Likert scale into a natural index of UGS, ranging from 0 (absolutely artificial) to 100 (absolutely natural = wilderness). Thus, we define natural as the antonym of artificial. The state absolutely artificial is achieved when 100% of the elements are of anthropic origin and naturalness is minimal. This state is a zero on the Likert scale (i.e., one step below "hardly natural"), whereas wilderness is the opposite and is a six on the Likert scale (i.e. one step beyond "very natural").

The index is linear in the Likert scale, and is defined as:

$$Natural\ Index\ of\ UGS = 100 * (value\ on\ Likert\ scale)/6 \quad (7)$$

Thus, one point on the Likert scale corresponds to 100/6 points on the naturalness index, which is used in the following analyses.

Table 4 presents the estimation results of the Random Parameter Logit models and the resulting WTP, which have been calculated using the sample mean. The Alternative Specific Constant (ASC) parameter can be interpreted as the respondents' variation in utility due to staying in the status quo. Hence, a positive coefficient parameter associated with the status quo means that respondents reject the rebuilding option of their closest UGS.

Model 1 shows the results of our basic model. Indeed, we detect a positive and significant ASC. A significant ASC might indicate that a status quo effect occurs (Adamowicz et al., 1998). According to Meyerhoff and Liebe (2009) status quo effects are a well-known phenomenon in individual decision making. Possible motivations are protest beliefs, attitude towards the environmental change, and perceived task complexity (Meyerhoff and Liebe, 2006; Meyerhoff and Liebe, 2009). Furthermore, the status quo effect can be referred to loss aversion (Kahneman et al., 1991).

Table 4: Mixed logit estimates basic model

	(1) Coef.	Std. Err	WTP	Std. Err	(2) Coef.	Std. Err.
Mean						
ASC *(SQ)*	0.768***	(0.03)			0.965***	(0.06)
Rent	-0.026***	(0.01)			-0.030***	(0.01)
Naturalness	0.060***	(0.02)	2.31***	(0.12)	0.054***	(0.02)
Walking distance	-0.116***	(0.01)	-4.51***	(0.27)	-0.079***	(0.04)
SD						
Naturalness	0.044***	(0.02)			0.037***	(0.02)
Walking distance	0.111***	(0.01)			0.067***	(0.01)
ASC (SQ)					2.053***	(0.07)
Obs.	47025				47025	
AIC	20296.77				18833.49	
Log likelihood	-10142.38				-9409.74	

[a] We used the delta method Greene (2012) to generate the standard errors for the WTP estimates.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In model 2, which is shown on the right-hand side of table 4, we treat the ASC as a random coefficient to address the possible present status quo effect more precisely and investigating who mainly chooses the status quo. The large and significant standard deviation parameter for the ASC indicates heterogeneity of preferences regarding the status quo: some respondents are strongly willing to pay to rebuild their most often used UGS, whereas others are indifferent or unwilling to pay for a change over the status quo.

We find that on average, a higher degree of naturalness of the most often used UGS influences people's choice significantly positive. Respondents value naturalness positively. We analyze this in further detail below. The coefficient for the choice attributes *walking distance* shows the expected sign and is significantly negative. In addition, an increasing rental payment significantly lowers the probability that a program is chosen. We can show that the average respondent is willing to pay € 2.31 with a standard error of € 0.18 more per month for a one-point increase on the naturalness index of UGS from their status quo situation. Moreover, the average respondent has a negative monthly WTP of € 4.5 with a standard error of € 0.41 for an additional minute he/she must walk to this UGS.

The monthly WTP vary between the considered cities. We estimated the models for all cities separately and computed the WTP of the average respondent for a marginal increase in naturalness and walking distance, as shown in table 5.

Table 5: Mean monthly WTP in € for a one-step increase in naturalness and walking distance by city

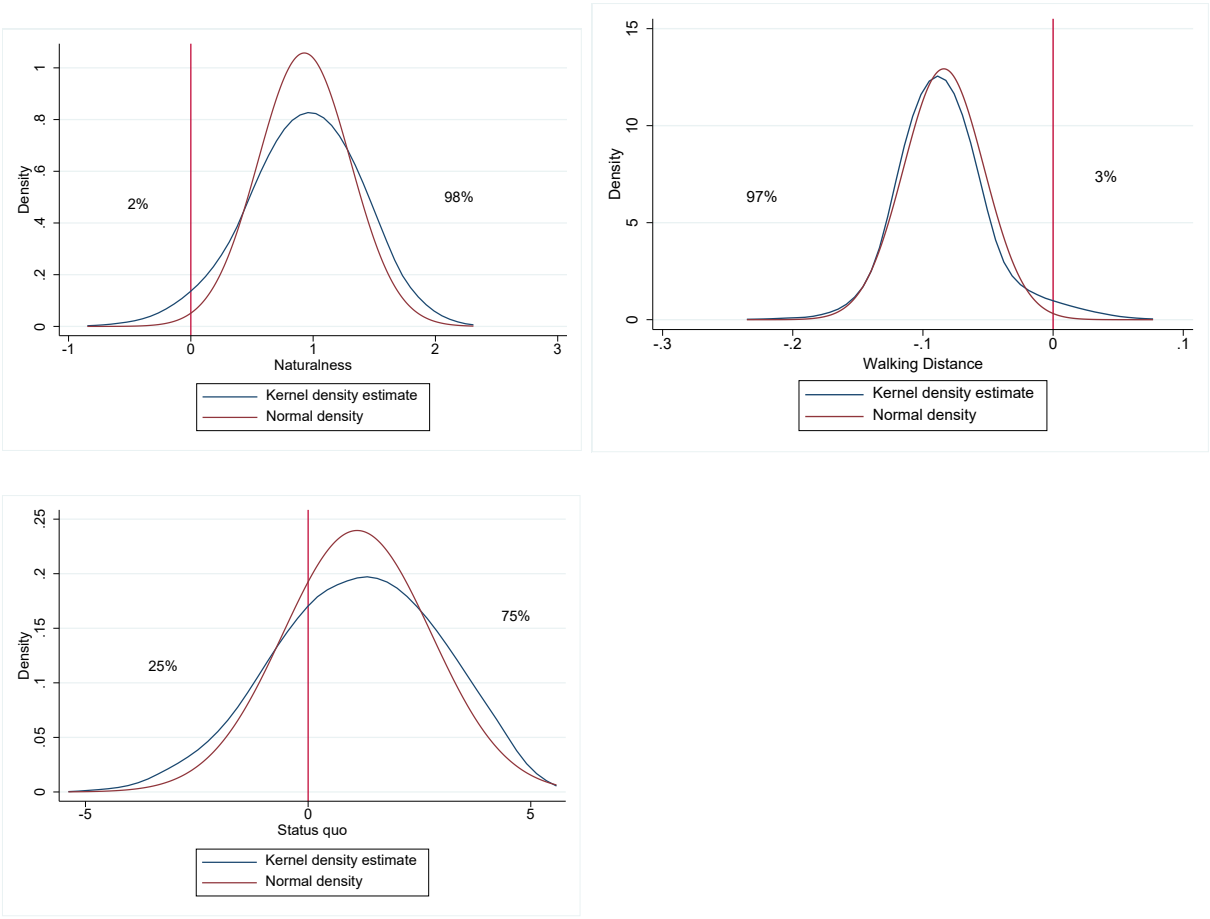
City	Naturalness	Walking Distance
Berlin	2.59*** (0.31)	-5.17*** (0.70)
Bremen	2.09*** (0.61)	-4.77*** (1.72)
Dortmund	1.31*** (0.33)	-2.91*** (0.95)
Dresden	0.71*** (0.22)	-2.28*** (0.68)
Duesseldorf	2.07*** (0.51)	-3.66*** (1.21)
Erfurt	2.57*** (0.85)	-4.86** (1.94)
Essen	1.88*** (0.36)	-4.47*** (0.13)
Frankfurt	1.14*** (0.20)	-2.95*** (0.67)
Hamburg	3.68*** (0.62)	-6.97*** (1.28)
Hannover	1.56*** (0.42)	-2.03*** (0.61)
Kiel	4.41* (2.53)	-8.51 (5.27)
Cologne	4.39*** (1.06)	-6.76*** (1.93)
Leipzig	1.16*** (0.38)	-2.93** (1.38)
Magdeburg	2.14*** (0.77)	-5.72** (2.21)
Mainz	1.44*** (0.35)	-3.50*** (0.95)
Munich	3.01*** (0.72)	-3.08*** (0.79)
Nuremberg	1.36*** (0.35)	-3.18*** (1.03)
Potsdam	1.41*** (0.45)	-5.04*** (1.80)
Saarbrucken	3.01** (1.33)	0.01 (0.86)
Schwerin	0.83*** (0.22)	-1.85*** (0.46)
Stuttgart	3.25*** (1.15)	-8.14*** (3.90)
Wiesbaden	2.29*** (0.75)	-0.19 (0.20)

[a] We used the delta method Greene (2012) to generate the standard errors for the WTP estimates.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

For most of the cities, the WTP measures are significant. However, we can also detect some WTP which are not significant. The WTP values vary between the considered cities. The significant WTP for naturalness range from €0.71 in Dresden to €4.41 in Kiel. The lowest WTP for walking distance is shown for Stuttgart.

For *naturalness* and *walking distance*, we can only detect less preference heterogeneity. Figure 5 depicts the distributions of the random parameters for model 2.

Figure 5: Distributions of the individual level coefficients



The distribution of the individual-level coefficient for *naturalness* indicates that most of the respondents (98%) prefer a UGS with a high level of *naturalness*. Furthermore, nearly all respondents (97%) prefer a short walking distance from their flat to the UGS they use most often. Regarding the status quo, figure 5 shows, that 75% of the respondents prefer their current situation over one of the suggested programs of rebuilding the UGS they use most often.

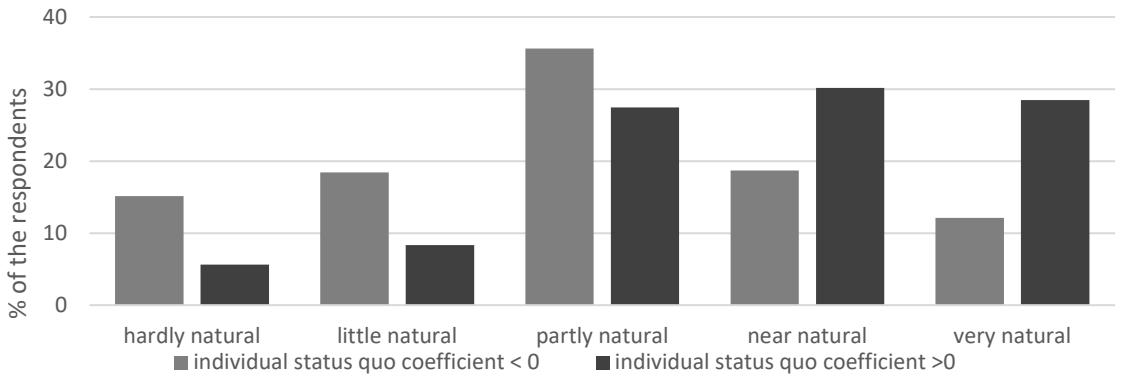


Figure 6: Distribution of naturalness of respondents' most-often used UGS by individual status quo coefficients

In the sample, the probability to prefer the status quo is associated with a less natural most-often used UGS as shown in figure 6. The group with a positive individual coefficient for the status quo (respondents who prefer the status quo over the rebuilding schemes) evaluate the UGS they use most often as more natural than the group with a negative individual status quo coefficient.

Table 6 shows the distribution of sociodemographic variables by individual status quo coefficients. Respondents with a positive individual status quo coefficient pay a little more rent than the respondents with a negative individual coefficient for the status quo. Furthermore, they have a higher monthly net income and are on average older.

Table 6: Distribution of sociodemographic variables by individual status quo coefficient.

		Individual status quo coefficient	
Variable		**< 0**	**> 0**
Average monthly rental payment in €		597.70	601.28
Average walking distance to the closest UGS in min		9.58	9.28
Average monthly net income in €		2513.54	2744.56
Average age in years		39.21	42.91
Average years living in the rented flat		9.34	9.54
Percentage			
Household members	1	30.56	30.18
	2	33.33	39.73
	3	19.70	17.22
	4	10.10	9.89
	5 and more	6.31	2.98
Kids in the household	0	65.01	73.40
	1	22.19	16.75
	2	9.40	7.86
	3	3.13	1.21
	4 and more	0.26	0.78
Gender	male	40.74	40.97
	female	58.92	59.03
	divers	0.34	0

Additionally, we estimate a model, which includes interaction effects with the ASC and socioeconomic variables as well as different variables associated to respondents' perceptions, taken out from questions out of the questionnaire. In the questionnaire we also used the big five personality traits scale (Rammstedt and John, 2007). The BFI-10 is a 10-item scale measuring the Big Five personality traits extraversion, agreeableness, conscientiousness, emotional stability, and openness.[8] A five-level rating scale ranging from "strongly disagree" (1) to "strongly agree" (5) is available for the respondents' answers. We include the questions related to Extraversion (E1 "I see myself as someone who is reserved", E2 "I see myself as someone who is outgoing, sociable") and Openness (O1 "I see myself as

[8] The BFI-10 Scale can be found in table A1 in the appendix.

someone who has few artistic interests", O2 "I see myself as someone who has an active imagination") in the mixed logit model. The variables Extraversion and Openness are coded as dummy variables, where they take on the value on when respondents scale E1 and O1 with 1 or 2 and E2 and o2 with 4 or 5, otherwise the dummy takes the value zero.

Table 7 shows the results of the mixed logit estimates of Model 3. Also, in this model, the ASC representing the current situation of the respondent is significant, and the positive sign indicates that moving away from the current situation may have a negative effect on respondents` utility. Again, the walking distance has a negative influence on the choice probability and the respondents prefer a UGS which is natural. For these variables the standard deviations are significant and similar to the magnitudes of our basic model, indicating heterogeneity among the respondents.

Looking at the sociodemographic variables, one can see that on average living in a larger household and having kids correspond with a lower likelihood of choosing the status quo. Being unemployed and retired increase the probability of choosing the status quo. The respondents' statement that the "UGS they use most often is relaxing" influences the likelihood of choosing the status quo positively. Doing sports, meeting friends, and visiting the most-often used UGS for some health reasons influence the choice probability for the status quo negative.

With respect to the BFI-10 scale, a person who is open more likely chooses the status quo. In contrast, Extraversion influences the probability of choosing the status quo negatively.

Table 7: Results of the mixed logit estimates including interaction effects

	Coef.	**Std. Err**
Mean		
ASC(SQ)	0.461**	(0.187)
Rent	-0.026***	(0.001)
Naturalness	0.061***	(0.027)
Walking distance	-0.124***	(0.005)
Sociodemographic Variables		
Houshold Size_ASC	-0.091***	(0.030)
Income_ASC	0.001***	(0.001)
Male_ASC	-0.030	(0.053)
Kids_ASC	-0.188**	(0.073)
unemployed_ASC	0.285*	(0.147)
retired_ASC	0.301***	(0.088)
Respondents perception regarding their closest UGS (see figure 3)		
UGS Relaxing_ASC	0.412***	(0.144)
UGS Safe_UGS	0.085	(0.150)
UGS Clean_ASC	0.007	(0.117)
UGS Important_ASC	-0.292***	(0.069)
Respondents reason last vistit UGS (see figure 4)		
Nature_ASC	-0.035	(0.068)
Meet friends_ASC	-0.091*	(0.054)
Sports_ASC	-0.263***	(0.059)

Realax_ASC	0.063	(0.073)
Frash Air_ASC	0.105	(0.091)
Health_ASC	-0.161**	(0.064)
Big 5		
Openness_ASC	0.205***	(0.060)
Extra_ASC	-0.156***	(0.053)
SD		
Naturalness	0.044***	(0.024)
Walking distance	0.097***	(0.004)
Observations	46,221	
AIC	19770.24	
Log likelihood	-9861.12	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6 Conclusion

In this study, we investigate how citizens value different characteristics of the urban green space (UGS) they use most often. While it is well known that public amenities like UGSs generate price premiums on housing markets (e.g. (Liebelt et al., 2018a) much less is known on how individual preferences look like. With our study, we contribute to a better understanding of preferences for biodiverse UGS in the context of housing. Therefore, we developed a discrete choice experiment and calculated WTP for the naturalness of the respondents' most-often used UGS as well as the walking distance to this UGS. The naturalness of the UGS is measured on a newly developed, graphical 5-point Likert scale, which we transform into a naturalness index ranging from 0 (absolutely artificial) to 100 (absolutely natural wilderness) and use as a proxy for the biodiversity of the UGS. We conduct our analyses via an online survey distributed among 22 major cities in Germany with in total 1,570 responses. Our sample is representative for Germany and clearly shows that German citizens do have preferences for biodiversity of the UGS they use most often. Moreover, they value a short walking distance to the UGS.

The analyses show less heterogeneity in preferences, nearly 100% of the respondents have a positive preference for naturalness and a negative preference for the walking distance. On average, we found that people are willing to pay €2.31 per month for a one-point increase on the naturalness index of UGS. On the other hand, they have an average negative WTP for an additional minute of walking to their closest UGS of €4.5. Looking at the different cities, we can show that the WTP measures differ among the cities. For naturalness, they range between a monthly mean WTP of €0.71 in Dresden to €4.41 in Kiel.

Future research may use this as a starting point for gaining a better understanding of what drives the inter-city differences in the mean WTP for biodiverse urban green. Among others, this might depend on the level and spatial distribution of urban green in cities as well as how this is correlated with income (Meya, 2020) or on the availability of substitutes, such as environmental amenities outside the city or

private gardens. Understanding heterogeneity in the WTP for biodiversity in cities on the respondent level could thereby inform benefit transfer and add to an emerging literature on spatial heterogeneity in the WTP for environmental public goods (Czajkowski et al., 2017; Liu et al., 2020).

Overall, our results highlight the importance of access to biodiverse urban green spaces for the city life and human well-being. Thus, our results are relevant for urban planning and management as they provide evidence for the importance of preserving and improving biodiversity in cities in particular in those areas where citizens use UGS in their daily life around their place of residence.

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Appendix

Table A1: Big Five Inventory-10 (BFI-10)

Instruction: How well do the following statements describe your personality?

I see myself as someone who…	Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
. . . is reserved	(1)	(2)	(3)	(4)	(5)
. . . is generally trusting	(1)	(2)	(3)	(4)	(5)
. . . tends to be lazy	(1)	(2)	(3)	(4)	(5)
. . . is relaxed, handles stress well	(1)	(2)	(3)	(4)	(5)
. . . has few artistic interests	(1)	(2)	(3)	(4)	(5)
. . . is outgoing, sociable	(1)	(2)	(3)	(4)	(5)
. . . tends to find fault with others	(1)	(2)	(3)	(4)	(5)
. . . does a thorough job	(1)	(2)	(3)	(4)	(5)
. . . gets nervous easily	(1)	(2)	(3)	(4)	(5)
. . . has an active imagination	(1)	(2)	(3)	(4)	(5)

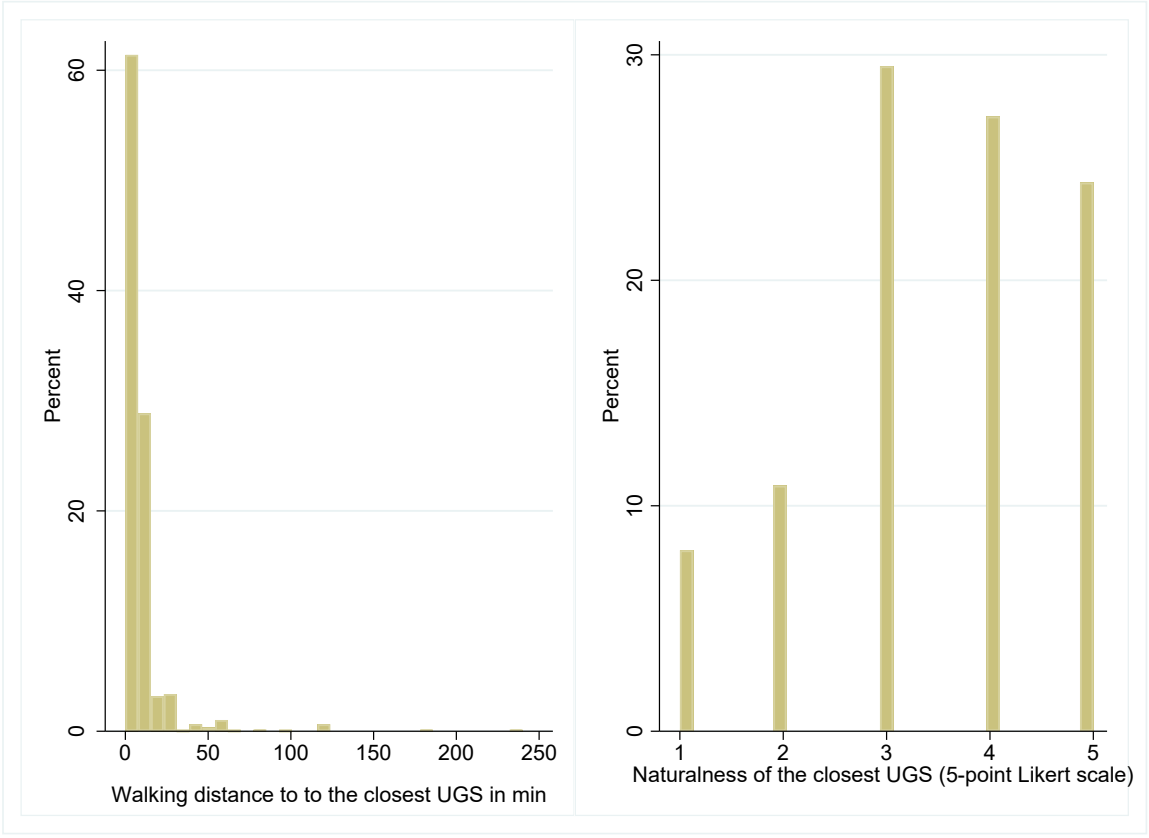

Figure A1: Distribution of the walking distance and the naturalness of the closest UGS over all respondents