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Title: Willingness-to-Volunteer and Stability of Preferences between Cities: Estimating the Benefits of Stormwater Management[1]

Running title: Willingness to Volunteer and Preference Stability

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Willingness-to-Volunteer and Stability of Preferences between Cities: Estimating the Benefits of Stormwater Management

Abstract: Urbanization strains existing stormwater systems, yielding high flood rates, degraded urban aquatic habitat, and low water quality in lakes and rivers. Cities increasingly rely on green infrastructure stormwater solutions that can be maintained in part by volunteers. This paper uses a choice experiment survey in two major U.S. cities – Chicago, Illinois and Portland, Oregon – to estimate the benefits of stormwater management improvement in terms of stated willingness to pay (WTP) money and willingness to volunteer (WTV) time. We find that stormwater management can produce large bundles of benefits. Estimates of WTP are largely (though not comprehensively) stable across cities, but WTV for several benefits is higher in Portland. Finally, while people are willing to volunteer time for some amenities consistent with time valued at 1/3 the average wage rate, a person's WTV time is not correlated with their own wage rate and people appear to gain positive utility from volunteering.

Keywords: value of time; choice experiment; willingness to pay; willingness to volunteer; stormwater management; flooding; aquatic habitat; water quality; Chicago; Portland

1. Introduction

Urban populations are growing faster than the overall population in the United States (U.S. Census Bureau, 2012). That urbanization places pressure on existing stormwater systems, producing high flood rates, degraded urban aquatic habitat, and low water quality in urban lakes, rivers, and streams (Yeakley, 2014). The potentially low cost of decentralized approaches for stormwater management (Braden and Ando, 2011), collectively known as "green infrastructure" (GI), and the ability of some projects to generate ancillary environmental benefits has made this an attractive approach for many cities (U.S. EPA, 2013). However, maintenance is critical for GI to achieve optimal performance (Liptan, 2017; Thorne et al., 2018). Property owners must maintain their own projects, such as rain barrels, while cities encourage residents to help maintain public infrastructure, such as green streets (U.S. EPA, 2015). To find the optimal intensity of stormwater management policies, and to understand whether volunteer effort will be available to maintain GI, estimates of the benefits that people glean from such programs are needed.

Previous research on the economic effects of decentralized approaches for stormwater management focuses on the relationship between projects and nearby property values (Netusil et al., 2014) and valuing project outcomes such as reduced flooding (Kousky and Walls, 2014). Two studies estimate the monetary value of multiple effects of using decentralized approaches using a choice experiment (Brent et al., 2017; Londoño Cadavid and Ando, 2013) and find that investments in decentralized approaches may generate large total benefits. We enrich the literature informing urban environmental policy by using a choice experiment survey to estimate residents' willingness to pay (WTP) to support projects that improve aquatic health and reduce flooding in Chicago and Portland.

We also inform stated preference valuation methodology by quantifying residents' stated willingness to volunteer (WTV) to help improve stormwater management outcomes. Research in developing countries, reviewed and extended by Gibson et al. (2016) has estimated respondents' willingness to pay and "willingness to work," and Larson et al. (2004) carry out contingent valuation research with both time and money costs to estimate the scarcity value of time. Our research is, to the best of our knowledge, the first to estimate a stated willingness to volunteer labor in a developed country using a choice experiment. Volunteering is important in its own right for GI and other decentralized environmental investments for which maintenance is critical to achieve optimal performance (Liptan, 2017). We also test hypotheses regarding the validity of using conventional measures of the scarcity value of time to monetize estimates of people's willingness to volunteer time to help provide environmental goods.

Finally, we test for the stability of preferences regarding stormwater management between two geographically distant urban areas. Federal policy regarding urban stormwater management requires a benefit-cost analysis of policy effects across the entire U.S. Our case study of two cities provides a direct evaluation of estimate stability when the same survey is carried out in two cities at the same time. Chicago and Portland, respectively the third and twenty-sixth largest metropolitan areas in the United States by population (U.S. Census Bureau, 2017), are leaders in GI implementation (U.S. EPA, 2010). Both cities have a combined sewer system that conveys sewage and stormwater to treatment facilities in the same pipe, and thus face similar problems in managing stormwater and water quality. Both cities have made significant investments to increase engineered stormwater management capacity (Burko, 2008; City of Chicago, 2014; Slovik, 2011) and taken leading roles in using decentralized approaches for stormwater management (U.S. EPA, 2010). However, the two cities have different baseline stormwater fees, flood prevalence, and species affected by habitat and water quality. Demand for stormwater management improvements could be very different in these two areas; we test whether that is so.

Thus, this paper makes four contributions. First, we find values for the outcomes of improved stormwater management. Second, we explore willingness to volunteer labor for local public goods in a developed country using a choice experiment. Third, we test for the stability of both WTP and WTV regarding stormwater management between two geographically distant urban areas. Finally, we test hypotheses regarding the direct utility people gain from volunteering and the validity of conventional measures of the scarcity value of time.

2. Framework, Hypotheses, and Methods

2.1 Single cost choice-experiment models

Our conceptual framework is the standard model for the choice experiment literature (Holmes et al., 2017). The consumer chooses from a set of environmental scenarios that vary in several attributes including monetary cost. We use information about those choices to quantify the consumer's preferences over attributes.

Specifically, consumer i chooses one scenario j from a set of N choices. Each scenario has a set of K environmental attributes in vector x_j and the monetary cost P_j. The indirect utility for person i from scenario j is modeled as a linear function

$$V_{ij} = \sum_{k=1}^{K} \beta_k x_{jk} + \lambda_M P_j + \varepsilon_{ij}, \quad (1)$$

where λ_M is the marginal utility of money and ε_{ij} is a random error term. The marginal willingness to pay (MWTP) for attribute k is

$$MWTP_k = -\frac{\beta_k}{\lambda_M} \quad (2)$$

and the total WTP for having a bundle of attributes in scenario j instead of a baseline scenario is the compensating variation (CV_{j0}) given by

$$CV_{j0} = \frac{1}{\lambda_M}(V_j - V_0), \quad (3)$$

where V_0 is the indirect utility of a baseline scenario and V_j is the indirect utility of alternative scenario j. A person will choose one scenario over the others in a choice opportunity if the utility they gain from it is the highest. The probability that person i chooses scenario j instead of scenario g in a particular choice opportunity, π_{ij}, is:

$$\pi_{ij} = \Pr(\sum_{k=1}^{K} \beta_k x_{jk} + \lambda_M P_j + \varepsilon_{ij} > \sum_{k=1}^{K} \beta_k x_{gk} + \lambda_M P_g + \varepsilon_{ig} \,\forall g \neq j). \qquad (4)$$

Following much of the choice modeling literature, we employ the Random Utility framework to estimate the parameters of equation 4. We accommodate individual heterogeneity by allowing the parameters themselves to vary across the individuals in the sample by estimating a fully correlated mixed multinomial logit (MMNL) (Hess and Train, 2017).[1] We specify the coefficients on the environmental attributes to be distributed normal. However, we constrain the coefficient λ_M on the price variable so its distribution is non-positive.[2] We implement that specification as follows. We define the cost-related variable in the regression to be minus the dollar cost and specify its distribution to be lognormal. Thus, coefficients reported for that variable, δ_M and σ_M^2, respectively, are the mean and standard deviation of the natural logarithm of minus the preference parameter λ_M in equation 1. The mean of λ_M is equal to $\exp(\delta_M + \sigma_M^2/2)$.[3] The mean of λ_M is the value used in the denominator of equation 2. Estimates of MWTP are derived using the Krinsky-Robb method (Hole, 2007b).

2.2 Value of time

The choice experiment literature overwhelmingly expresses cost in terms of money to obtain a measure of value. However, many papers in the travel cost valuation literature attach a money value to the time spent traveling to a recreation site. One-third of the wage rate is often

[1] We estimate the MMNL via maximum simulated likelihood with the *mixlogit* program in Stata 16 (Hole, 2007a). For the money-cost sample, we also estimate the model in willingness-to-pay-space using *mixlogitwtp*. These results are similar to estimation in preference-space. The time-cost sample failed to converge in WTP-space.

[2] See Carson and Czajkowski (2019) for a concise discussion of this transformation.

[3] The mean of λ_M can be recovered with $\exp(\delta_M + \sigma_M^2/2)$, and the mean MWTP for attribute k in equation 2 is: $MWTP_k = -\frac{\beta_k}{\exp(\delta_M + \sigma_M^2/2)}$. The transformation of the coefficient was done using *nlcom* in Stata 16. We also use *nlcom* to estimate equation 3.

used as an estimate of the scarcity value of time for this purpose (English et al., 2018), though practice and scarcity value estimates vary widely (Parsons, 2017). Recent research on the value of time has found, as in Fezzi et al. (2014), that the value of time is context specific and may be higher than a third of the wage rate. Some even find there is very little correlation between a person's value of time and their wage rate (Lloyd-Smith et al., 2019).

A set of papers reviewed and extended by Gibson et al. (2016) has carried out stated preference valuation exercises in developing countries that estimate value using both WTP and willingness to work (WTW) hours. The original research in Gibson et al. (2016) finds a ratio of average WTP to WTW that is somewhat close to the full market wage rate for the actual task posed as the vehicle through which people would contribute time in the choice experiment scenarios. However, several recent papers cited in that review explicitly use 1/3 the wage rate to monetize estimates of the time that people are willing to spend helping to provide a public good. We explore the likely validity of that practice in the context of our study in U.S. cities.

If we express scenario cost in terms of hours spent volunteering (T_{vj}), where μ_T is the marginal utility of time, then the equivalent of equation 1 for the time cost treatment is

$$V_{ij} = \sum_{k=1}^{K} \beta_k x_{jk} + \mu_T T_{vj} + \varepsilon_{ij,} \quad (5)$$

and stated marginal WTV (MWTV) to improve attribute *k* in units of time is:

$$MWTV_k = -\frac{\beta_k}{\mu_T}. \quad (6)$$

Note that time "payment" is fundamentally voluntary. A volunteer time attribute may not be viewed by survey respondents as binding or consequential, and may be prone to upward bias (Carson and Groves, 2007). Thus, while we follow the practice of previous research in this vein by estimating a stated MWTV in a manner analogous to MWTP, these numbers should be interpreted with caution and may be higher than true Hicksian WTV.

We use the subsample of the data in which respondents reported a positive wage to explore several scenarios about the relationship between MWTP and stated MWTV. First, (following Gibson et al., 2016), we estimate MWTP and MWTV for each attribute in that subsample and compare the ratio of MWTP/MWTV to the average wage rate in the subsample. Second, we estimate equation 5 with an additional variable that interacts the hours-volunteered attribute with the individual's wage rate to test how the net marginal utility of time varies with the wage rate. Third, we carry out a joint test of a set of hypotheses: the scarcity value of time is equal to the standard 1/3 of the wage rate, respondents gain no direct (dis)utility from volunteering, and other responses to the survey are not sensitive to the choice of time or money framing.

The estimation process proceeds as follows. The basic regressions for the money sample and time surveys with the subsample of individuals reporting a positive wage are carried out in the same manner described in sections 2.1 and 2.2. For the third analysis we convert the time costs in the time-cost version of the survey into individualized money costs by multiplying hours by 1/3 the person's wage rate, run a MMNL regression on the resulting data to estimate MWTP for the attributes, and test for structural differences in the results depending on whether cost was expressed in the survey in units of money or time.

As described in section 2.1, we specify the coefficients on the environmental attributes to be distributed normal and -λ_M and -μ_T to be distributed lognormal. When testing how the marginal utility of time varies with wage, we allow the interaction of the hours-volunteered attribute with the individual's wage rate to be distributed normal, as we have no a priori reason to believe that this relationship is strictly positive or strictly negative. The same transformations discussed with respect to λ_M apply to the preference parameter μ_T in equations 5 and 6.

2.3 Dual cost choice experiment model

Our paper differs from previous research as we frame the time cost in our choice experiments as time spent volunteering in one's neighborhood rather than as time working. WTV could differ from WTW if consumers derive "warm glow" from volunteering, especially if the volunteering is in the respondent's community and may produce social capital from the activity (Salamon et al., 2011) or if volunteering to maintain an area could increase property values (Netusil et al., 2014). People do volunteer time or demand public goods even when it is more efficient for them to donate or accept money (Handy and Katz, 2008); on the other hand, Larson et al. (2004) find that if the scarcity value of work time equals the wage, people in the contingent valuation survey sample actually have disutility of \$3-5 per hour spent working. Researchers in this literature have developed models in which time spent volunteering enters a consumer's utility function directly (Feldman, 2010; Lilley and Slonim, 2014).

Following that work, we explore a hypothesis using a dual constraint model. Suppose the consumer maximizes utility from a good X , leisure L, and time spent volunteering T_v subject to a money budget constraint and a time constraint in which P_x is the money cost of X, w_i is the wage rate for person i, T_H is hours worked, $\overline{T}$ is the endowment of time, and I_0 is nonwage income:

$$\text{Max}\, U(X, L, T_v) \quad s.t. \quad P_x X = I,\ \ \overline{T} = L + T_v + T_H,\ \ I = I_0 + w_i T_H. \tag{7}$$

In a choice experiment with both a time and money cost, indirect utility for person i from scenario j is given by equation 8, where β_T is the direct marginal utility of volunteering:

$$V_{ij} = \sum_{k=1}^{K} \beta_k x_{jk} + \beta_T T_{vj} + \mu_T T_{vj} + \lambda_M P_j + \varepsilon_{ij}. \tag{8}$$

The partial derivative of indirect utility with respect to volunteer hours in equation 8 is:

$$\frac{\partial V_{ij}}{\partial T_v} = \beta_T + \mu_T, \tag{9}$$

so the coefficient estimated for the time cost attribute, T_{vj}, would capture the sum of β_T (the direct marginal utility of volunteering, which is independent of the wage rate) and μ_T (the marginal value of scarce time). The two are not separately identifiable. However, we can explore this model by defining the marginal scarcity value of time as $\mu_T/\lambda_M = \alpha w_i$, where α is a fixed parameter, and collecting all the monetized costs together as

$$V_{ij} = \sum_{k=1}^{K} \beta_k x_{jk} + \beta_T T_{vj} + \lambda_M (P_j + \alpha w_i T_{vj}) + \varepsilon_{ij}. \tag{10}$$

We estimate equation 10 with a MMNL assuming $\alpha = 1/3$ (as is common in the literature), the β_K coefficients are distributed normal, and λ_M is distributed lognormal. We allow β_T to be distributed normal, allowing respondents to derive either positive or negative marginal utility from volunteering. Consistent with all other specifications in this paper, the coefficient reported for $(P_j + \alpha w_i T_{vj})$ is the mean of the natural logarithm of $-\lambda_M$.

2.4 Preference stability between cities

The attributes of stormwater management improvement we study are flooding, aquatic habitat, and water quality. In this section, we describe the methods we use to estimate the stability of preferences over those between cities (more details about the attributes themselves are in section 3). Chicago and Portland face similar challenges in stormwater management, but also have some striking differences. The annual household cost of stormwater services in Portland is over three times higher than Chicago (Black & Veatch, 2013). In Portland, seven fish species are listed as threatened or endangered under the federal Endangered Species Act but there are no listed species in Chicago (NOAA Fisheries, 2017), so we expect the coefficients on aquatic habitat and water quality to be larger for Portland. Flooding in Portland is only seasonal, localized, and shallow (Bureau of Environmental Services, n.d.) while flooding in Chicago is widespread and very costly (Chicago Metropolitan Agency for Planning, 2017), so we expect flood reduction to be more valuable for Chicago. We test whether the parameters of the indirect utility equations (equations 1 and 5) are the same for respondents from the two cities.

We do this in two ways. First, we test whether the point estimates of MWTP and MWTV for each attribute have statistically significant differences between the two cities.[4] Second, we test an overarching null hypothesis of preference stability in the means of the parameters and the variance/covariance matrix of their joint distribution across the two cities. One issue that arises when comparing preferences estimated in a simple MMNL framework is that the scale parameter can confound a test for differences in the preference parameters (Swait and Louviere, 1993). However, we allow for full correlation across the model parameters, so scale, along with other forms of correlation, is captured in the covariance matrix and allowed to vary among individuals. Thus, the pooled model should not be confounded by having an omitted scale parameter that varies systematically between the two samples.[5] We test the joint preference stability hypothesis in two ways, using a conventional likelihood ratio test and by carrying out a procedure developed by Swait and Louviere (1993); a complete discussion is in Appendix 3.

3. Data

We developed an online choice experiment survey for residents of Chicago, Illinois and Portland, Oregon. The survey instrument provided respondents with background information about stormwater management problems and controls and then presented respondents with a number of discrete-choice questions, each of which asked them to choose between a pair of hypothetical stormwater-control scenarios and a status quo option.

We developed the survey attributes and levels with focus groups conducted in both

[4] We also pool the data for the two cities and run a regression that includes an interaction term with a “Chicago” dummy for each of the parameters estimated. We use those results to test whether a respondent in Chicago has different marginal utilities for the attributes of the choice experiment than a respondent in Portland. That regression is reported in Appendix Table A2-2.
[5] See Hess and Train (2017) for a complete discussion on the role of the scale parameter and its relationship with other forms of correlation among choice attributes.

Portland and Chicago[6]. The focus groups were moderated by hired experienced professionals in each city, with the participation of 6-7 people per group and a total duration of 90 minutes each. The participants replied to advertisements posted in Craigslist and were rewarded with a $25 gift card. The recruitment method resulted in a diverse group of people of different ages, education levels and areas of the cities. In each focus group, participants were given 20-25 minutes to answer a complete questionnaire and, after they had finished, they were asked about aspects such as their perceptions of the general purpose of the survey, level of difficulty, language, amount of questions, attribute levels, own flooding experience and general suggestions. The final survey was also refined with input from water management experts in both Chicago (the Center of Neighborhood Technologies, the Department of Water Management, and the Department of Transportation) and Portland (Bureau of Environmental Services). Each survey had eight choice questions that were followed by a demographic questionnaire and questions about respondents' experiences with stormwater issues.

The final attributes of the choice questions in the survey are water quality, quality of aquatic habitat, flood frequency and cost to the household either in terms of money or time. For the water quality attribute we used a modified version of the water quality ladder developed by Carson and Mitchell (1993), which translates technical water quality measures into simple categories which non-experts can easily understand. The status quo scenarios have water that is only "boatable"; scenarios with improvements can have water quality that is "fishable" or "swimmable." In the survey's background information we introduce the concept of aquatic health to assess other values that are not captured by the water quality ladder. The description of each level includes ecosystem functions such as the population of fish, erosion of river banks and

[6] Relevant sections of the survey are in Appendix 1.

presence of vegetation. Status quo scenarios have habitat in “fair” condition. Scenarios with improvements can have habitat that is either “good” or “excellent.”

We also include a reduction of flood frequency as an attribute. This attribute captures consumer benefits from lower levels of damage and inconvenience from street, backyard and basement flooding. The attribute levels are presented as percentage reductions from the status quo experienced by the respondent (25%, 33%, and 50%). We chose not to use absolute numbers of floods reduced because the frequency people experience varies among respondents according to factors such as where they live, how they commute, and what type of housing they live in.

One survey treatment specifies a monetary household cost attribute. We use slightly different payment vehicles for the two cities since their utility bills are different. For Portland, the utility bill expressly shows a stormwater fee so the payment vehicle is an increment to the stormwater utility fee. In Chicago, the stormwater charge is currently embedded in the water and sewer fee so the payment vehicle in the survey is a new stormwater fee.

The second survey treatment has a time cost attribute instead of money cost. This is the time the respondent would spend doing volunteer work maintaining decentralized stormwater technologies, such as bioswales and green streets, in their own neighborhood. We explain that there would be activities suited for every person regardless of ability and the city would keep track of the work people do. It is not possible to compel people to work as it is possible to compel them to pay a fee, but previous studies using a time cost attribute had no features beyond our own to ensure respondents view this attribute as consequential. The third survey treatment has both a time cost and a money cost attribute.

We followed a standard practice in choice modeling experimental design with the attributes and levels allocated to non status-quo options in choice questions according to an orthogonal fractional factorial main effects design (Holmes et al., 2017) generated using SAS (Kuhfeld, 2009). The final design consists of 24 choice questions that were grouped in three blocks of eight choice questions each.

Focus groups in these cities that are pioneers of GI objected to scenarios other than the status quo in which elements of environmental quality did not improve. Thus, the two non-status-quo options in each choice question have at least some improvement in every environmental attribute. This feature of the design limits the ability of a regression to separately identify all possible dummy-variable attributes. We include a dummy variable, “Status Quo”, that is equal one when the alternative is the status quo scenario in each question, and equal to zero for all improved scenarios. Status quo scenarios have water quality that is just boatable instead of fishable and habitat that is only fair instead of good. We include a dummy variable for whether or not water quality is swimmable; that captures the marginal effect of going from fishable to swimmable. We also include a dummy variable for whether or not habitat quality is excellent; that captures the marginal effect of going from habitat that is good to excellent.

We administered the survey online in February 2013 through the company Qualtrics, which provided both the software and the respondents’ panel. The question-order flexibility and relative low cost of web-based surveys make them a good option for choice-experiment research, though future researchers would do well to evaluate whether people who volunteer to answer surveys have a higher than average WTV.[7] We randomized the order of the choice questions to minimize bias in the estimates from respondents learning from early choice questions and experiencing survey fatigue in later questions; respondents could not change their answers to earlier questions. Data from all choices are used in the analyses. We obtained 334 usable surveys in Chicago (167

[7] It is possible that respondent selection bias might have a different effect on estimates of WTV than on WTP, and thus complicate comparisons of the two.

in the time treatment and 167 in the money treatment) and 351 surveys in Portland (185 in the time treatment and 166 in the money treatment).[8]

Our main results use data from the single-cost treatments. Summary statistics for respondent characteristics from the Chicago and Portland subsamples of the single-cost treatments, along with the pooled sample, can be found in Table 1. The respondents in our sample had an average of almost seven volunteering hours a month; this is high given that national statistics report only a quarter of adults volunteer at all (Bureau of Labor Statistics, 2016) and provides some evidence of the possibility that survey respondents might be more likely to volunteer than average adults in the U.S.

Tests of means (reported in Table A1-1) find no difference across study areas for respondent age or household size, but we do find a few statistically significant differences. Respondents from Portland had a higher number of volunteer hours, saw fewer floods in the last year, had lived in their house for less time, were less likely to be employed, and were less likely to have seen GI than those from Chicago. The percentage of respondents in the highest income category is higher in Chicago (51%) than Portland (42%). Chicago respondents are more likely to have basements than crawl spaces (61% and 9%) while the opposite is true in Portland (22% and 60%). These differences might lead to differences in the MWTP and MWTV across cities.[9]

4. Results

4.1 Pooled MMNL Results

The main MMNL results are in Table 2. The first set of columns contain estimated coefficients for observations in Chicago and Portland pooled together. The top set of results use

[8] Each respondent was offered eight choice questions; not all respondents completed all of them.
[9] The Appendix reports comparisons of other subsets of the data used in this paper in Tables A1-2, A1-3, and A1-4.

data from the money treatment version of the survey. The signs of the coefficients on the attributes are all significant and of the expected sign. People prefer to have some kind of stormwater management program improvement rather than none at all. Additionally, people gain utility from flood reduction, aquatic habitat that is excellent instead of just good, and water quality that is swimmable instead of just fishable. The coefficient on the money cost variable is significant.[10]

The bottom panel of column 1 shows the results using the time-treatment survey data from both cities. Results are consistent with findings from the money-treatment survey, that is, coefficients on environmental and flood improvements are positive, the coefficient on status quo is negative, and all findings are significant.

Table 3 and Figure 1 show calculations of MWTP and MWTV values along with their 95% confidence intervals. The pooled set of respondents in the two cities have an average MWTP of $23 to move away from the status quo. They also have additional MWTP of $0.50 per month for a ten-percent reduction in flooding, $1.90 per month to improve habitat from good to excellent, and $0.47 per month to improve water quality from fishable to swimmable. People also have high stated MWTVs. The pooled set of respondents have a WTV of 3.9 hours per month to avoid the status quo, 0.1 hours per month for a ten-percent reduction in flooding, 0.42 hours per month to improve habitat from good to excellent, and 0.2 hours per month to improve water quality from fishable to swimmable.

These findings add up to sizable total benefits from scenarios that include major improvements. For example, as shown in Table 4, improving aquatic habitat to excellent and water quality to swimmable increases average household welfare by $281 per year. If floods are

[10] The sign of the coefficient on cost is not particularly meaningful since a transformation is needed to obtain the underlying coefficient on money cost which is constrained to be negative.

also cut by 50% the annual benefit increases to $302 per year.

4.2 Cross-city comparison

Columns 2 and 3 of Table 2 have the basic MMNL results estimated separately for Chicago and Portland. As discussed in section 2.4, we test for structural differences between Chicago and Portland in two ways. We perform a conventional likelihood ratio test of joint parameter stability. This test, distributed χ^2 with 45 degrees of freedom (the restricted number of parameters in a fully correlated model), is not rejected for either the money or the time cost regressions. Similarly, we fail to reject the hypothesis of joint similarity in the parameters and scales for the two cities when we use the method of Swait and Louviere (1993).[11,12]

But do any differences in parameters translate into statistically significant differences in estimated MWTV or MWTP for attributes? Figure 1 shows that the 95% confidence intervals for MWTP and MWTV for the attributes overlap between the two cities except for MWTV for excellent aquatic habitat, which is higher in Portland. A complete summary of tests for the significance of these differences can be found in Table A2-4 in the appendix. In the money cost treatment, we find that Chicago has a statistically higher MWTP for a one percent reduction in flooding ($.06 vs. $.02) but the MWTP for the other environmental attributes are not different between the two cities. For the time cost treatment, we find that Portland has a higher MWTV to move from the status quo, improve aquatic habitat to excellent, and improve water quality to swimmable. This suggests that while the monetary values of most attributes are similar in the two cities, people in Portland may have MWTV for habitat and water quality improvements as much as three or four times larger than those in Chicago.

[11] An in-depth discussion of this procedure, tests, and results can be found in Appendix 3.
[12] The related pooled regression that includes an interaction term with a "Chicago" dummy for each of the parameters estimated is reported in Appendix Table A2-2. One of the Chicago interaction terms is significant at the 5% level and two are significant at the 10% level.

4.3 Time vs. Money

Of 685 respondents to the single-cost surveys, 422 reported a wage between $8 and $500 (summary statistics are in Table A1).[13] Table 5 uses data from that subsample of respondents to test whether we can monetize the time cost as 1/3 of a respondent's wage and obtain the same results as if we had used that amount of money cost as an attribute in the survey. The first two regressions replicate the analyses from Table 2 on this sub-sample as a baseline; column 1 of Table 5 presents the results of a MMNL regression using money cost as stated in the money cost treatment and column 2 does the same for the time sample using number of volunteer hours. The results from this sub-sample are similar to the results using the full sample reported in Table 2.

Column 3 expands the time cost regression by introducing an interaction term between time volunteering and the respondent's wage. That interaction term is not statistically significant; a person's net marginal utility of time is not correlated with their wage rate. This is consistent with the findings of Lloyd-Smith et al. (2019) and casts doubt on the validity of assuming a person's scarcity value of time is given by a fraction of their wage rate.

To test that more directly, column 4 shows MMNL regression results using data from the time-treatment survey such that the time cost in each choice scenario is monetized using 1/3 of the individual's wage. A relative likelihood test using the AIC values for columns 2 and 4 show

[13] We choose to use an individual's actual reported wage. This means that 263 respondents are dropped from our sample for these analyses. It is common practice in the recreation demand literature to impute a wage equal to household annual income divided by 2080 hours (e.g. English et al. 2019) to avoid dropping observations. In our sample, 74% of people without reported wages are retired or are students. Household income for those people might be very disconnected from the opportunity cost of their personal time, so we chose not to do imputation. However, imputed wages might be higher than reported wages, and thus the results might change if that approach were used. Future research could explore how the results of these analyses change with use of imputed average (rather than reported) wage.

that the regression fits the data less well when time is monetized in this way.[14] Then column 5 pools the data from columns 1 and 4 and includes variables that interact every attribute with a dummy variable for whether the observation is from the time treatment data. The coefficient on cost is significantly different if that cost is monetized using time rather than actual monetary cost, and two of the three other interaction terms are significant as well. These results also do not support the practice of monetizing an individual's time cost as one third of that person's individual wage rate.

These regression findings are complemented by a comparison of the estimates of MWTP money for attributes estimated from the money treatment data and MWTV time estimated from the time treatment data. Column 3 of Table 6 and Figure 2 show the MWTP/MWTV ratio ranging from 5.52 (for the marginal value of swimmable water quality) to 8.91, 10.21, and 12.87 (for status quo, habitat, and flood reduction, respectively). While an individual's value of time may not be correlated with their personal wage rate, most of the average values of time reflected here are not far from 1/3 of the average wage rate in this sub-sample of about $27/hour.[15]

4.4 Utility from Volunteering

The results in Table 7 use data from the survey treatment with both a time and money cost to explore whether volunteer hours are both a cost and a utility-producing attribute.[16] Column 1 presents a simple MMNL regression on the whole sample; parameters on both costs (money and time) are significant and the coefficients on the environmental good attributes are positive. Column 2 estimates the same model as column 1, but restricts the sample to those with

[14] The probability that the regression in column 4 fits better than column 2 is equal to $\exp((2118.04 - 2130.4)/2) = .002529$.

[15] We omit four outliers who reported a wage less than $8 per hour or more than $500 per hour.

[16] We did regressions that pooled the data from the time-cost treatment and the money-cost treatment (Table A2-1) and all three cost treatments (Table A2-3). The results are very similar to the results we obtain from analyzing the data from the three treatments separately.

a non-zero reported wage. Column 3 presents estimates of the model in equation 10, where total cost is money cost plus monetized time cost (1/3 the respondent's wage multiplied by the hours volunteering), and is constrained to have a distribution that is always non-negative. As specified in equation 10, we also include volunteer time independently as an attribute. In the results, total cost is significant, and volunteer time has a positive and significant coefficient. These findings are consistent with a model in which time spent volunteering conveys positive utility to people.

5. Discussion and Conclusions

Our choice experiment survey in Chicago, Illinois and Portland, Oregon yields several findings that are useful for urban stormwater policy makers and for scholars using choice experiment methodology. People place positive values on improvements in aquatic habitat, water quality, and flood reduction, and the monetized total values of bundles of such improvements in urban areas can be quite large. For example, calculations in Table 4 imply that a very ambitious project to improve aquatic habitat from fair to excellent and water quality from boatable to swimmable could be worth as much as $294 per household per year in Chicago, and $277 per household in Portland. Multiplying this by the number of households in each city, total estimates are $3.7 billion dollars per year in Chicago, and $852 million in Portland. Adding the value of an additional 50% reduction in flood frequency increases aggregate benefits to $4 billion per year in Chicago and to $856 million in Portland.

WTP for environmental improvements are generally stable across the two cities, except that people in Chicago place a higher monetary value on flood reduction than those in Portland. Those results are encouraging for benefit transfer used to apply monetary values from studies in one city to policy analysis in another, though care must still be taken in such research. However, willingness to volunteer time to improve both water quality and aquatic habitat is higher in

Portland (which has more iconic aquatic species than Chicago). It would be interesting in future research to explore the sources of heightened heterogeneity in WTV compared to WTP.

The results also indicate that people may be willing to volunteer non-trivial amounts of time to help provide these urban environmental goods. The hypothetical survey responses imply that an average respondent might be willing to volunteer 50 hours a year for a project to restore aquatic habitat from fair to excellent and improve water quality from boatable to swimmable. These findings are consistent with Shandas et al. (2010) who find the majority of survey respondents in an area of Portland would be willing to volunteer a few hours a month to help reduce stormwater runoff and improve watershed health, and with Portland's Green Street Steward Program which finds that households voluntarily spend as much as once a week to maintain GI in their own neighborhood (Pell, 2019). Our results are cautiously encouraging for urban stormwater managers hoping to muster an army of volunteers to help maintain decentralized GI.

Our research sheds light on the potential usefulness of hypothetical time-cost choice experiments in a developed country setting. We find ratios of MWTP to MWTV for flood reduction and aquatic habitat improvement are roughly what one would expect if time is valued at 1/3 the average hourly wage rate for our sample of respondents (Figure 2, Table 6). However, MWTV is much higher relative to MWTP for water quality improvement, and the impact of volunteer hours on the likelihood that a respondent chooses a scenario does not vary with the respondent's own wage rate (Table 5, column 3). Consistent with Lloyd-Smith et al. (2019) and Larson and Shaikh (2004), people seem to place a reasonably high monetary value on time but the relationship between the marginal value of time and wage appears to be more complex than can be modeled here. Furthermore, our findings indicate that while time has scarcity value, people may gain significant utility from time volunteering in their neighborhoods (Table 7).

Future research would do well to try to disentangle the scarcity value of time from the direct utility of volunteering, since the latter should not be included in a measure of the value of an environmental good. It may also be that respondents in developed countries are less likely to view a currently-hypothetical time cost as potentially binding than respondents in developing countries, or that hypothetical bias is more of a problem when cost is expressed in terms of time rather than money.

Several types of future studies could advance our understanding of these issues. First, to test for external validity, a hypothetical choice experiment study of WTV time for a public good could be paired with a parallel field study in which the volunteer time is not hypothetical. Second, a hypothetical choice experiment study could be paired with a small experiment to elicit a respondent's true marginal monetary value of time independent of any utility or disutility of volunteer activity undertaken. Third, one could test for the effectiveness of cheap talk in a hypothetical time-cost survey instrument, and whether responses are sensitive to the exact nature of the volunteer time proposed (e.g. working alone entering data versus working with other people in your neighborhood.) People may be WTV for public goods, but more research is needed before WTV can be used with WTP to find the total value of a good.

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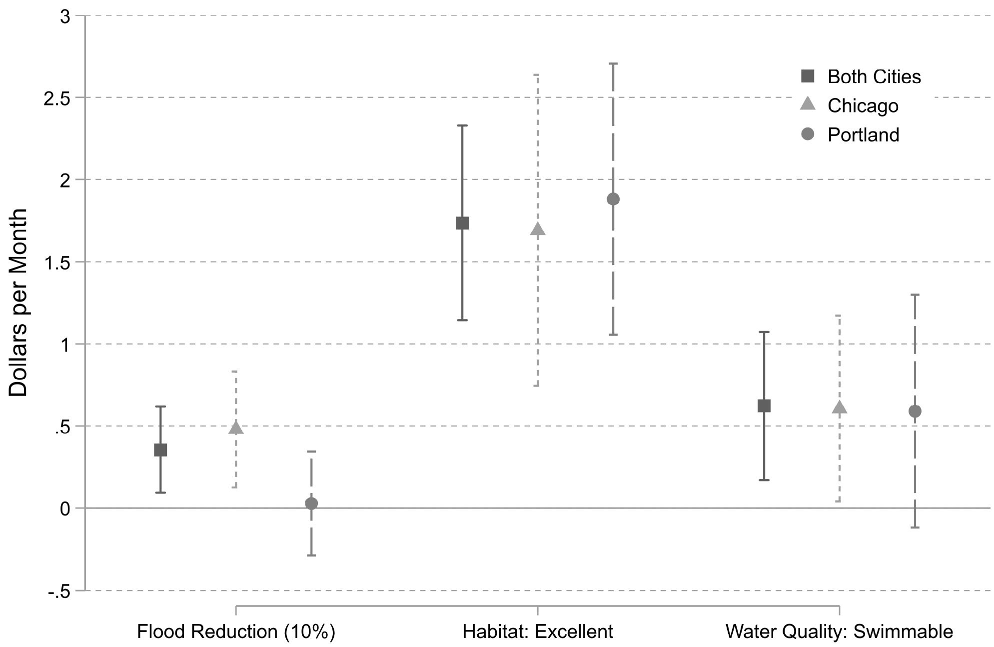
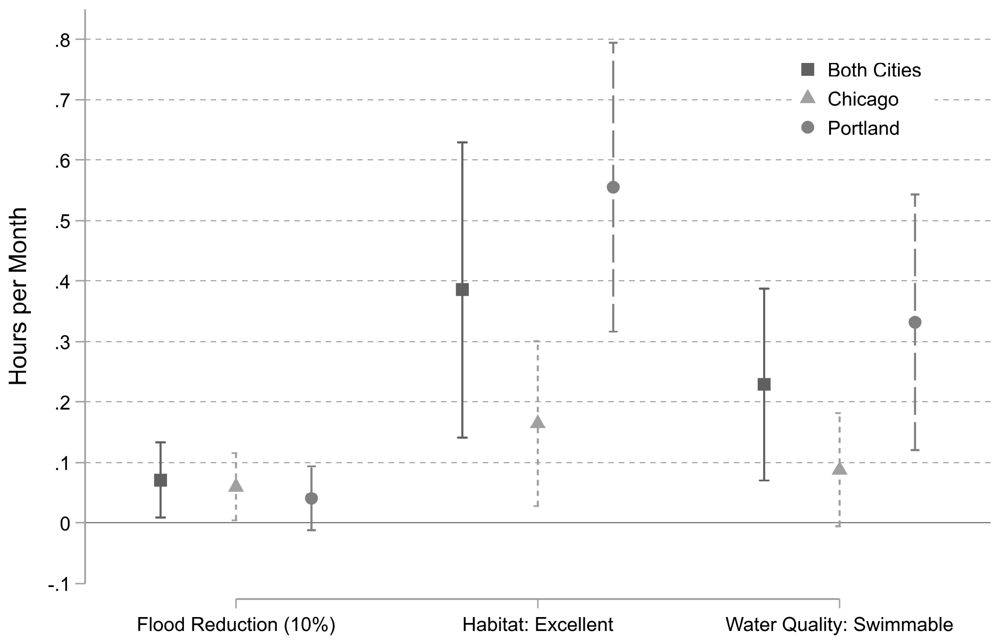
Figure 1: Marginal Willingness to Pay and Willingness to Volunteer

Panel A: Marginal Willingness to Pay for Changes in Attributes



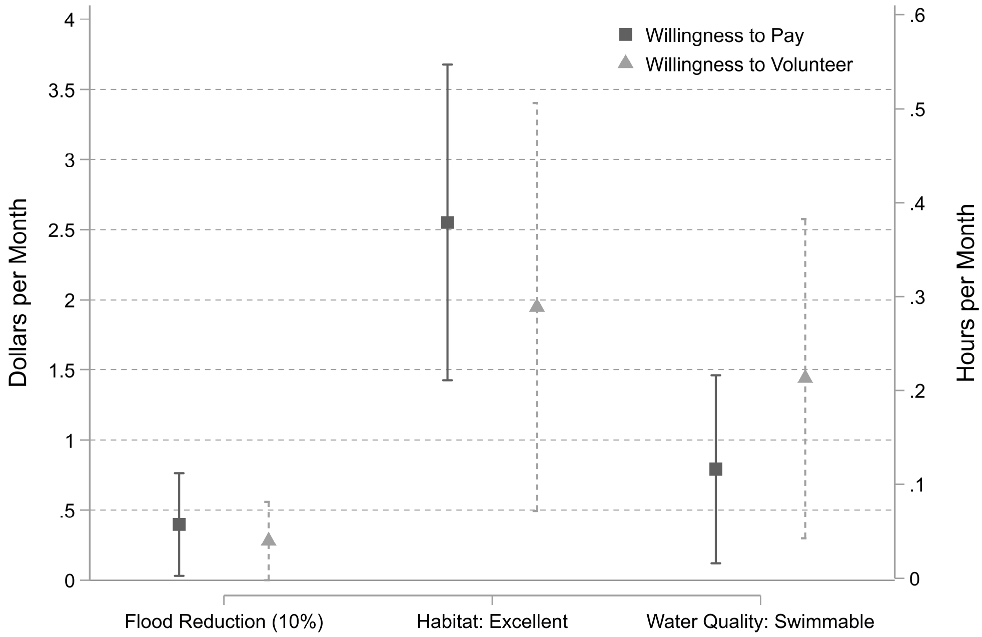
Panel B: Marginal Willingness to Volunteer for Changes in Attributes



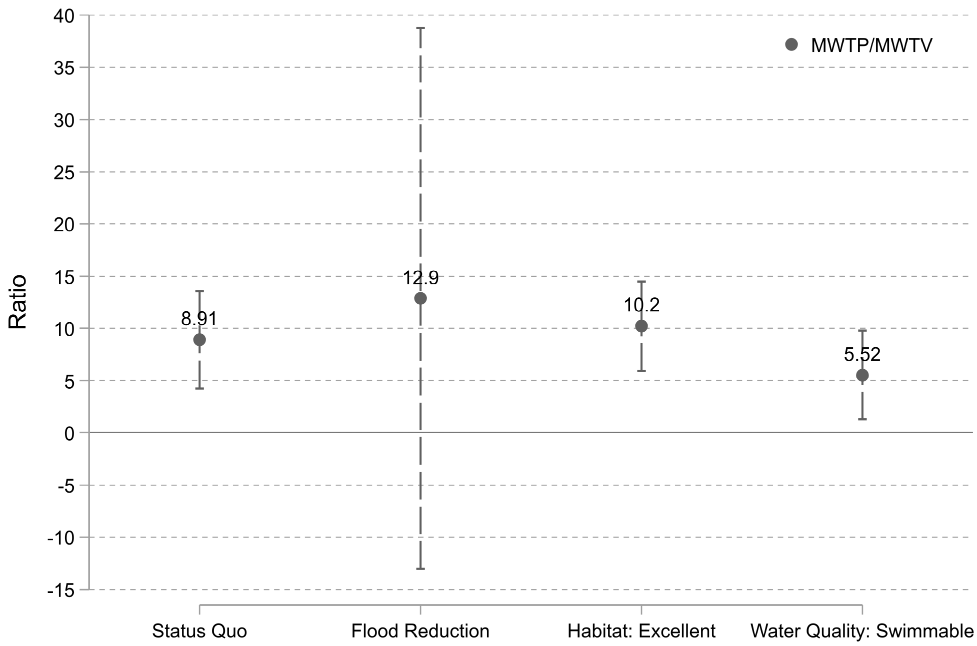
Note: The numbers in this figure are also reported in Table 3, but in this figure, flood reduction has been scaled to represent the marginal value of a 10% reduction in the frequency of floods. 95% confidence intervals are included.

Figure 2: Marginal Willingness to Pay in Subsample with Non-zero Reported Wage

Panel A: Marginal Willingness to Pay for Changes in Attributes



Panel B: Ratio of MWTP (dollars) and MWTV (hours)



Note: The numbers in this figure are also reported in Table 6. In panel A, flood reduction has been scaled to represent the marginal value of a 10% reduction in the frequency of floods. Panel B reports the ratio of MWTP to MWTV. 95% confidence intervals are included.

Table 1: Summary Statistics by City Subsamples

	(1) Both Cities			(2) Chicago			(3) Portland		
Variable	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Age	58.25	18	87	58.31	24	83	58.19	18	87
Household size	2.32	0	7	2.32	0	7	2.31	1	6
Volunteering hours	6.70	0	150	6.08	0	70	7.32	0	150
Number of floods seen	1.94	0	50	2.16	0	35	1.71	0	50
Years in residence	15.64	0	52	18.35	0	52	12.95	0	51
Employment									
Employed	0.44	0	1	0.48	0	1	0.41	0	1
Self employed	0.08	0	1	0.08	0	1	0.09	0	1
Unemployed	0.04	0	1	0.04	0	1	0.04	0	1
Homemaker	0.04	0	1	0.05	0	1	0.04	0	1
Student	0.02	0	1	0.01	0	1	0.02	0	1
Retired	0.37	0	1	0.35	0	1	0.40	0	1
Income level									
$0 - $49,999	0.23	0	1	0.19	0	1	0.26	0	1
$50k - $79,999	0.27	0	1	0.25	0	1	0.29	0	1
$80k +	0.47	0	1	0.51	0	1	0.42	0	1
Experience flood?	0.60	0	1	0.67	0	1	0.54	0	1
Seen GI?	0.56	0	1	0.66	0	1	0.45	0	1
Basement type									
Basement	0.41	0	1	0.59	0	1	0.23	0	1
Crawl space	0.35	0	1	0.10	0	1	0.61	0	1
Both	0.10	0	1	0.14	0	1	0.05	0	1
None	0.14	0	1	0.17	0	1	0.11	0	1
N	662			330			332		

Note: "GI" refers to green infrastructure. These data were collected using the versions of the survey with either a time cost or a money cost, not both. A complete set of tables with summary statistics from each sample can be found in the appendix, Tables A1-1 to A1-4. Comparisons of means and p-values are also reported in these tables.

Table 2: Mixed Multinomial Logit Results

	(1) Both Cities		(2) Chicago		(3) Portland	
	Mean	SD	Mean	SD	Mean	SD
Money cost						
Status Quo	-8.264***	4.183***	-9.363***	5.678***	-8.759***	4.912***
	(1.038)	(0.635)	(1.611)	(1.086)	(1.089)	(0.734)
Flood reduction	0.014**	0.008	0.020**	0.025**	0.001	0.043***
(%)	(0.005)	(0.015)	(0.006)	(0.010)	(0.007)	(0.010)
Aquatic habitat:	0.682***	0.902***	0.712***	0.983***	0.799***	0.991***
excellent	(0.100)	(0.116)	(0.138)	(0.155)	(0.159)	(0.216)
Water quality:	0.245*	0.819***	0.255*	0.711***	0.251	1.070***
swimmable	(0.087)	(0.109)	(0.111)	(0.163)	(0.149)	(0.173)
Money cost [a]	-2.111***	1.534***	-2.408***	1.757***	-1.753***	1.340***
($)	(0.117)	(0.085)	(0.211)	(0.138)	(0.178)	(0.099)
Observations [b]	7839		3936		3903	
LR χ^2	599.88***		237.10***		282.16***	
McFadden ρ^2	0.211		0.206		0.232	
Log-likelihood	-1643.17		-816.25		-802.55	
LR χ^2_{45} [c]	48.73		--		--	
Time cost						
Status Quo	-8.370***	4.766***	-8.662***	5.812***	-11.124***	4.139***
	(0.980)	(0.740)	(1.382)	(0.807)	(1.921)	(0.710)
Flood reduction	0.017**	0.007	0.027**	0.063***	0.009	0.007
(%)	(0.006)	(0.016)	(0.008)	(0.011)	(0.005)	(0.007)
Aquatic habitat:	0.903***	1.087***	0.738***	1.186***	1.158***	1.268***
excellent	(0.116)	(0.113)	(0.147)	(0.162)	(0.186)	(0.193)
Water quality:	0.536***	1.326***	0.395*	1.319***	0.693***	1.612***
swimmable	(0.110)	(0.137)	(0.167)	(0.189)	(0.177)	(0.207)
Time cost	-1.743***	2.278***	-2.054***	2.667***	-1.083***	1.907***
(hours) [a]	(0.277)	(0.155)	(0.355)	(0.229)	(0.202)	(0.093)
Observations [b]	7821		3888		3933	
LR χ^2	1023.84***		577.99***		475.13***	
McFadden ρ^2	0.238		0.256		0.236	
Log-likelihood	-1641.18		-840.60		-770.49	
LR χ^2_{45} [c]	60.18		--		--	

Standard errors in parentheses. Clustered at the individual (respondent) level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] The reported coefficient is the mean of the natural logarithm of minus the parameter on cost.

[b] Observations are the number of individuals N times choice occasions T times alternatives J: $N \times T \times J$.

[c] Likelihood ratio test for the hypothesis of parameter (joint parameter and scale) stability between the two cities. See Appendix 3 for a discussion on parameter and scale independently.

Table 3: Numbers in Figure 1 for Individual Marginal Willingness to Pay and Volunteer [a]

	(1) Both Cities	(2) Chicago	(3) Portland
Willingness to Pay ($/month)			
Status Quo	-22.92	-24.95	-22.43
	[-28.16, -17.67]	[-32.53,-17.36]	[-27.52, -17.35]
Flood reduction (1%)[b]	0.05	0.06	0.02
	[0.02, 0.07]	[0.04, 0.09]	[-0.01, 0.05]
Aquatic habitat: excellent [c]	1.90	1.90	2.12
	[1.40, 2.40]	[1.26, 2.55]	[1.38, 2.86]
Water quality: swimmable[d]	0.47	0.43	0.35
	[0.05, 0.90]	[-0.09, 0.94]	[-0.32, 1.02]
Willingness to Volunteer (hrs/month)			
Status Quo	-3.87	-2.15	-5.99
	[-4.70, -3.04]	[-2.75, -1.54]	[-7.81, -4.16]
Flood reduction (1%)[b]	0.01	0.01	0.007
	[0.005, 0.015]	[0.004, 0.01]	[0.002, 0.01]
Aquatic habitat: excellent [c]	0.42	0.19	0.61
	[0.32, 0.52]	[0.12, 0.25]	[0.44, 0.79]
Water quality: swimmable[d]	0.20	0.06	0.27
	[0.11, 0.29]	[-0.01, 0.13]	[0.11, 0.44]

[a] 95% confidence intervals in brackets. Empirical distributions of WTP and WTV were calculated using the Krinsky-Robb method (2,000 bootstrapped repetitions) on the regressions in the first three columns in Table 2 (Hole, 2007b).
[b] Marginal value of a one percent reduction in flood frequency.
[c] Marginal value of an improvement in aquatic health from good to excellent
[d] Marginal value of an improvement in water quality from fishable to swimmable

Table 4: Benefits per Household and in Total for Hypothetical New Scenarios

	(1) Aquatic Habitat Improved to Excellent & Water Quality Improved to Swimmable	(2) Aquatic Habitat Improved to Excellent & Water Quality Improved to Swimmable & 50% Fewer Floods
Money treatment, data from both cities[a]		
WTP/hhold/yr	$281	$302
WTP/yr, Chicago[b]	$3,489 mill	$3,754 mill
WTP/yr, Portland[c]	$863 mill	$928 mill
Money treatment, data from Chicago[d]		
WTP/hhold/yr	$294	$323
WTP/yr, Chicago[b]	$3,658 mill	$4,015 mill
Money treatment, data from Portland[e]		
WTP/hhold/yr	$277	$279
WTP/yr, Portland[c]	$852 mill	$856 mill
Time treatment, data from both cities[a]		
WTV/hhold/yr	50 hrs	55 hrs
WTV/yr, Chicago[b]	625 mill hrs	678 mill hrs
WTV/yr, Portland[c]	155 mill hrs	168 mill hrs
Time treatment, data from Chicago[d]		
WTV/hhold/yr	26 hrs	29 hrs
WTV/yr, Chicago[b]	325 mill hrs	369 mill hrs
Time treatment, data from Portland[e]		
WTV/hhold/yr	75 hrs	77 hrs
WTV/yr, Portland[c]	229 mill hrs	237 mill hrs

[a] Uses WTP values from Table 3 column 1.

[b] WTP/household multiplied by 1,035,436 households (Source: U.S. Census Bureau (2017))

[c] WTP/household multiplied by 254,167 households (Source: U.S. Census Bureau (2017))

[d] Uses WTP values from Table 3 column 2.

[e] Uses WTP values from Table 3column 3.

[f] This table uses the results in Table 3 to estimate total WTP or WTV per household of several hypothetical projects. Baseline is the scenario with no improvements. Column (1) is the value of a move from "no program" to a program with the most improved quality for aquatic habitat (excellent) and water quality (swimmable). Column (2) builds on this to include a 50% reduction in the frequency of floods. The calculations are based on the compensating variation equation $CV = 1/\lambda(V^1 - V^0)$(Holmes et al., 2017).

Table 5: MMNL Mean Coefficients, subsample with Reported Non-Zero Wage

	(1)	(2)	(3)	(4)	(5)
				Monetized Time $\left(\alpha = \frac{1}{3}\right)$	
Treatment sample (unit of cost)	Money ($)	Time (hours)	Time (hours)	Time[a] ($)	Time[a] and Money ($)
Status Quo	-7.803***	-8.988***	-9.764***	-8.088***	-8.872***
	(1.308)	(1.712)	(1.994)	(1.327)	(1.067)
Flood reduction (%)	0.013*	0.014*	0.012	0.011	0.015**
	(0.005)	(0.006)	(0.008)	(0.006)	(0.005)
Aquatic habitat:	0.824***	1.034***	1.051***	1.063***	0.725***
excellent	(0.131)	(0.177)	(0.154)	(0.161)	(0.114)
Water quality:	0.255*	0.762***	0.812***	0.812***	0.165
swimmable	(0.109)	(0.176)	(0.191)	(0.169)	(0.104)
Cost (hours or $)[b]	-2.220***	-1.361***	-1.711**	-3.789***	-2.210***
	(0.170)	(0.306)	(0.662)	(0.233)	(0.147)
Hours × Wage			-0.000		
			(0.004)		
Time dummy[c] × Status Quo					-3.187*
					(1.442)
Time dummy[c] × Flood					-0.000
					(0.009)
Time dummy[c] × Habitat					0.649*
					(0.329)
Time dummy[c] × Water Quality					0.766***
					(0.232)
Time dummy[c] × Cost					-0.095***
					(0.019)
Observations [d]	4935	5037	5037	5037	9972
LR χ^2	462.86***	567.31***	577.12***	604.44***	1118.41***
McFadden ρ^2	0.183	0.214	0.218	0.224	0.214
AIC	2105.57	2118.04	2121.94	2130.40	4234.87
Log-likelihood	-1032.78	-1039.02	-1033.97	-1045.19	-2052.44

Standard errors in parentheses. Clustered at the individual (respondent) level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] The cost of scenarios in this regression is calculated as the time cost in hours multiplied by 33% of the individual's hourly wage rate.

[b] The reported coefficient is the mean of the natural logarithm of minus the parameter on cost.

[c] The time dummy is a dummy variable for whether the observation comes from the time-treatment version of the survey instead of the money-treatment version of the survey.

[d] Observations are the number of individuals N times choice occasions T times alternatives J: $N \times T \times J$.

[e] Standard deviations of parameters not shown; full results available from corresponding author.

Table 6: Individual Marginal WTP, Marginal WTV, and Ratio of MWTP/MWTV, Subsample with Non-zero Reported Wage [a]

Treatment (unit of value)	(1) MWTP ($/month)	(2) MWTV (hours/month)	(3) MWTP/MWTV [e]
Status Quo	-24.17	-2.51	8.91
(no program)	[-37.16, -15.36]	[-6.89, -1.20]	[4.27, 13.55]
Flood reduction (%) [b]	0.04	0.004	12.87
	[0.01, 0.09]	[0.0005, 0.01]	[-13.05, 38.78]
Habitat: excellent [c]	2.55	0.29	10.21
	[1.67, 4.15]	[0.15, 0.82]	[5.91, 14.51]
Water quality: swimmable [d]	0.79	0.21	5.52
	[0.15, 1.53]	[0.10, 0.59]	[1.26, 9.78]

[a] 95% confidence intervals in brackets. Empirical distributions of WTP and WTV were calculated using the Krinsky-Robb method (2,000 bootstrapped repetitions) on the regressions in the first three columns in Table 5 (Hole, 2007b).
[b] Marginal value of a one percent reduction in flood frequency.
[c] Marginal value of an improvement in aquatic health from “good” to “excellent”
[d] Marginal value of an improvement in water quality from “fishable” to “swimmable”
[e] Ratio of Column (1) to Column (2)

Table 7: Regression Results on Data from Survey with Both Time and Money Costs [a]

	(1) Whole Sample	(2) Respondents with non-zero wage	(3) Respondents with non-zero wage
Status Quo	-7.718***	-7.250***	-6.637***
(no program)	(0.723)	(0.792)	(0.698)
Flood reduction (%)	0.011*	0.005	0.004
	(0.005)	(0.007)	(0.005)
Aquatic habitat: excellent	0.695***	0.799***	0.806***
	(0.097)	(0.171)	(0.116)
Water quality: swimmable	0.258*	0.212	0.193
	(0.116)	(0.180)	(0.137)
Money cost ($) [b]	-2.117***	-2.135***	
	(0.142)	(0.144)	
Time cost (hours) [b]	-1.534***	-1.378***	
	(0.230)	(0.207)	
Money cost + Monetized Time [b, c]			-2.736***
			(0.189)
Volunteer Hours			0.641***
			(0.117)
Observations [d]	7905	4770	4770
LR χ^2	1142.37***	627.73***	662.18***
McFadden ρ^2	0.243	0.226	0.225
AIC	3606.98	2202.09	2334.57
Log-likelihood	-1776.49	-1074.04	-1140.29

Standard errors in parentheses. Clustered at the individual (respondent) level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] Data from both cities are pooled and included in each model.
[b] Total cost of a scenario is calculated as the cost in dollars plus the time cost in hours multiplied by 33% of the individual's hourly wage rate.
[c] The reported coefficient is the mean of the natural logarithm of minus the parameter on cost.
[d] Observations are the number of individuals N times choice occasions T times alternatives J: $N \times T \times J$.
[e] Standard deviations of parameters not shown; full results available from corresponding author.

Appendix Contents

Appendix 1: Survey Information

I. Survey Attributes

Below are verbatim descriptions of attributes in the survey.

1) Aquatic health: For the purpose of this survey, "aquatic health" is a measure of a river or stream's biological condition. It is an overall measure that includes things like: how many types of fish and wildlife live in the water; how many of each type; how much plant life grows alongside the water; what chemicals are in the water, and overall habitat quality.

The biological health of streams in your area is directly influenced by human activity. In particular, urban development affects the flow of water in streams and how much pollution is carried in the water. This affects the health of streams and the plants, fish and wildlife that live in them. The possible levels in this category are:

Excellent: The health of streams near you is the same as what would be found in a "natural" system in that area. Condition can be "undisturbed" even if a stream was restored after having been damaged. In Illinois there would be 15-20 different types of fish, including rare species.
Good: Most features of streams are the same as a natural stream but there is some degradation. There are fewer types of fish, no more than 15.
Fair: Streams have a few plants and animals. There are between 5 and 10 types of fish. The banks of rivers and streams are somewhat washed away and are missing patches of plant growth
Poor: Streams are very unhealthy so that very few fish and other animals can live in them. Fewer than 5 types of fish are found. Fish are sick or not growing at normal rates. Plant growth around rivers and streams is almost absent.

The rivers and the lake in and around Chicago have *Fair* aquatic health right now.

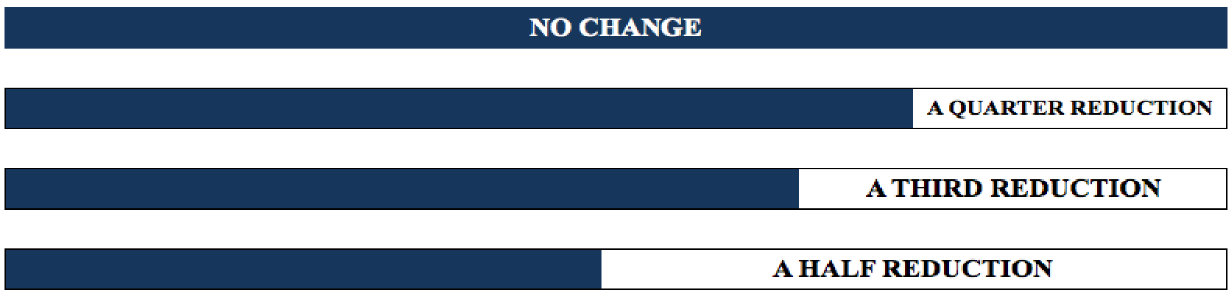
2) Pollution level in the water: Rain from storms can carry pollution from developed areas to streams and rivers and have long term effects on water quality. Storms can also cause CSOs which sometimes contain high levels of pollution that cause beach closures, shellfishing bans, or fish kills. The worst effects of CSOs are usually temporary; but in the Chicago area there are currently dozens of CSO events each year. Streams, rivers and lakes can have different pollution levels. From best to worst they are:

Drinkable: So clean it is safe for drinking without any treatment
Swimmable: Safe for people to have direct contact
Fishable: Clean enough that fish like bass can live in it
Boatable: Only safe to go boating without touching the water
Polluted: Worst possible quality - not fit for any use

Additional stormwater management could increase the quality of the water in the streams near you compared to the current pollution level. The rivers and streams in your area are on average "*boatable*" right now.

3) Frequency of floods: This feature refers to the likely number of floods in the city. For the purpose of the survey, flooding includes street, basement or backyard flooding. Improved stormwater management could reduce the frequency of floods in the city. This survey considers the following flood reduction outcomes:

Half as many floods will occur
A third fewer floods will occur
A quarter fewer floods will occur
No change



In all cases, assume that areas that currently have no flooding will not change.

4) Monthly stormwater utility fee: Households might have to pay money to support city or MWRD efforts to control stormwater. In this survey, assume any such cost is a fee added to the current water and sewer bill. The money raised will go to a dedicated program for stormwater management. This feature ranges in the survey as follows:

$0 (no extra fee)
$5 each month (equals $60 each year)
$10 each month (equals $120 each year)
$15 each month (equals $180 each year)
$20 each month (equals $240 each year)

5) Time spent monthly: A stormwater control plan may mean the city puts rain gardens and bioswales in your neighborhood. Some stormwater management plans might allow you to commit to spending some time every year taking care of these devices so they keep working. There would be volunteering activities suited for everybody regardless of their physical ability. The city would be in charge of training people and keeping track of the work. Stormwater control plans could vary in how many hours you spend each **month** in activities taking care of rain gardens or bioswales in your neighborhood. In the survey, this ranges as follows:

0 hours
1 hour each month (same as 12 hours each year)
2 hours each month (same as 24 hours each year)
3 hours each month (same as 36 hours each year)
4 hours each month (same as 48 hours each year)

II. Sample Choice Questions

Below is a sample choice question. In this paper we only analyze data from three treatments. In one, both time and money are attributes (as shown below). In two other treatments, either time or money was an attribute column in the choice questions, but not both.

<u>SECTION ONE</u>: CHOICE QUESTIONS

In each of the next eight questions you will be asked to choose between 3 possible scenarios that vary in the categories described above. Please do your best in each question to choose the combination you prefer.

Suppose the city of Chicago could do a project that would improve stormwater management near you. The project would include installing rain gardens and bioswales in your neighborhood, and you might agree to spend time every month taking care of them. You might also have to pay some money every year for the project to be put in place. Assume that Options A and B are the **only** choices you can have instead of the status quo. Which option would you choose?

Please read all the features of each option and then check the box that represents your choice **below**. If you don't like option A or B, then choose the box "status quo" - that means no project is done, and the baseline (or status quo) situation will hold true.

QUESTION ONE:
Options A and B are the **only** choices you can have instead of the status quo. Which option would you choose?

	Flooding 	**Aquatic Health** 	**Pollution level** 	**Monthly stormwater fee** 	**Hours you spend each month** 
OPTION A	50% less frequent (50% REDUCTION)	Good	Fishable	$10	2 hours
OPTION B	25% less frequent (25% REDUCTION)	Excellent	Swimmable	$15	5 hours
STATUS QUO	Current flooding (NO CHANGE)	Fair	Boatable	$0	None

I choose:

❒ Option A ❒ Option B ❒ Status Quo

Appendix 2: Ancillary Statistics and Results

Table A1: Summary Statistics for Regressions in Tables 5 and 7

	(1)			(2)		
Survey treatment:	Single cost			Dual cost		
Wage restriction:	$8<wage<$500			$8<wage<$500		
Table	Table 5			Table 7		
Variable	Mean	Min	Max	Mean	Min	Max
Age	55.42	20	85	55.032	23	87
Household size	2.37	1	7	2.525	1	7
Volunteering hours	6.54	0	150	6.847	0	70
Number of floods seen	2.081	0	35	2.109	0	30
Years in residence	14.65	0	51	14.079	1	46
Wage	40.86	9	400	35.04	8.25	200
Employment						
Employed	0.673	0	1	0.599	0	1
Self employed	0.118	0	1	0.104	0	1
Unemployed	0.019	0	1	0.025	0	1
Homemaker	0.002	0	1	0.015	0	1
Student	0.009	0	1	0.000	0	0
Retired	0.175	0	1	0.243	0	1
Income level						
$0 - $49,999	0.175	0	1	0.173	0	1
$50k - $79,999	0.289	0	1	0.267	0	1
$80k +	0.512	0	1	0.550	0	1
Experience flood?	0.635	0	1	0.629	0	1
Seen green infrastructure?	0.543	0	1	0.554	0	1
Basement type						
Basement	0.417	0	1	0.446	0	1
Crawl space	0.351	0	1	0.317	0	1
Both	0.090	0	1	0.074	0	1
None	0.140	0	1	0.163	0	1
N[a]		422			202	

Note: Column 1 corresponds to the samples included in Table 5. Column 2 corresponds to samples included in Table 7. Samples include respondents who reported a wage of at least $8 per hour and less than $500 per hour.

Table A1-1: Comparisons of Portland vs. Chicago Single-Cost Treatment Data

Variable	Portland	Chicago	Difference
Age	58.621	57.909	-0.712
	(12.217)	(11.685)	(0.756)
Household size	2.307	2.380	0.074
	(1.115)	(1.127)	(0.071)
Volunteering hours	8.188	6.354	-1.834**
	(15.253)	(9.995)	(0.816)
Number of floods seen	1.599	2.167	0.568***
	(3.445)	(3.371)	(0.216)
Year in residence	13.209	18.215	5.006***
	(11.133)	(12.232)	(0.740)
Employment			
Employed	0.375	0.464	0.089***
	(0.485)	(0.499)	(0.031)
Self employed	0.084	0.076	-0.008
	(0.277)	(0.266)	(0.017)
Unemployed	0.044	0.038	-0.006
	(0.205)	(0.192)	(0.013)
Homemaker	0.044	0.042	-0.002
	(0.205)	(0.201)	(0.013)
Student	0.016	0.008	-0.008
	(0.125)	(0.089)	(0.007)
Retired	0.435	0.363	-0.072**
	(0.496)	(0.481)	(0.031)
Income level			
$0 - $49,999	0.257	0.189	-0.069***
	(0.438)	(0.392)	(0.026)
$50k - $79,999	0.291	0.259	-0.032
	(0.455)	(0.439)	(0.028)
$80k+	0.421	0.508	0.087***
	(0.494)	(0.500)	(0.031)
Experience flood?	0.527	0.649	0.122***
	(0.500)	(0.478)	(0.031)
Seen green infrastructure?	0.467	0.671	0.204***
	(0.499)	(0.470)	(0.031)
Basement type			
Basement	0.224	0.612	0.389***
	(0.417)	(0.488)	(0.029)
Crawl Space	0.599	0.090	-0.508***
	(0.491)	(0.287)	(0.025)
Both	0.052	0.131	0.079***
	(0.222)	(0.337)	(0.018)
None	0.124	0.165	0.041*
	(0.330)	(0.371)	(0.022)
Observations	349	333	682

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A1-2: Comparisons of Time-only and Money-only Single-Cost Treatment Data

Variable	Time	Money	Difference
Age	57.822	58.660	0.838
	(12.630)	(11.154)	(0.925)
Household size	2.261	2.368	0.107
	(1.039)	(1.211)	(0.088)
Volunteering hours	5.804	7.569	1.764**
	(11.392)	(11.318)	(0.881)
Number of floods seen	1.702	2.193	0.491*
	(2.654)	(4.112)	(0.269)
Year in residence	16.183	15.074	-1.108
	(12.256)	(11.780)	(0.933)
Employment			
Employed	0.461	0.422	-0.039
	(0.499)	(0.495)	(0.039)
Self employed	0.072	0.096	0.024
	(0.259)	(0.296)	(0.022)
Unemployed	0.042	0.042	0.000
	(0.201)	(0.201)	(0.016)
Homemaker	0.033	0.054	0.021
	(0.179)	(0.227)	(0.016)
Student	0.018	0.012	-0.006
	(0.133)	(0.109)	(0.009)
Retired	0.373	0.370	-0.003
	(0.484)	(0.484)	(0.038)
Income level			
$0 - $49,999	0.229	0.226	-0.003
	(0.421)	(0.419)	(0.033)
$50k - $79,999	0.259	0.286	0.027
	(0.439)	(0.453)	(0.035)
$80k+	0.479	0.449	-0.030
	(0.500)	(0.498)	(0.039)
Experience flood?	0.590	0.617	0.027
	(0.493)	(0.487)	(0.038)
Seen green infrastructure?	0.527	0.587	0.060
	(0.500)	(0.493)	(0.039)
Basement type			
Basement	0.410	0.410	-0.000
	(0.493)	(0.493)	(0.038)
Crawl Space	0.343	0.361	0.018
	(0.476)	(0.481)	(0.037)
Both	0.093	0.096	0.003
	(0.291)	(0.296)	(0.023)
None	0.148	0.133	-0.015
	(0.355)	(0.340)	(0.027)
Observations	348	334	682

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A1-3: Comparisons of Dual Cost vs. Single Cost Samples with Any Wage

Variable	Dual Cost	Single Cost	Difference
Age	58.317	58.241	-0.076
	(12.054)	(11.913)	(0.802)
Household size	2.400	2.315	-0.085
	(1.106)	(1.129)	(0.075)
Volunteering hours	8.437	6.686	-1.751**
	(15.502)	(11.381)	(0.865)
Number of floods seen	1.752	1.947	0.195
	(3.321)	(3.467)	(0.229)
Year in residence	15.855	15.628	-0.227
	(11.828)	(12.024)	(0.801)
Employment			
Employed	0.376	0.441	0.065**
	(0.485)	(0.497)	(0.033)
Self employed	0.072	0.084	0.013
	(0.258)	(0.278)	(0.018)
Unemployed	0.039	0.042	0.003
	(0.193)	(0.201)	(0.013)
Homemaker	0.042	0.044	0.002
	(0.200)	(0.205)	(0.014)
Student	0.006	0.015	0.009
	(0.077)	(0.122)	(0.007)
Retired	0.454	0.372	-0.082**
	(0.499)	(0.484)	(0.033)
Income level			
$0 - $49,999	0.215	0.227	0.012
	(0.411)	(0.419)	(0.028)
$50k - $79,999	0.281	0.273	-0.008
	(0.450)	(0.446)	(0.030)
$80k+	0.466	0.464	-0.002
	(0.500)	(0.499)	(0.033)
Experience flood?	0.555	0.604	0.049
	(0.498)	(0.489)	(0.033)
Seen green infrastructure?	0.591	0.557	-0.034
	(0.492)	(0.497)	(0.033)
Basement type			
Basement	0.433	0.410	-0.023
	(0.496)	(0.492)	(0.033)
Crawl Space	0.331	0.352	0.021
	(0.471)	(0.478)	(0.032)
Both	0.084	0.095	0.011
	(0.277)	(0.293)	(0.019)
None	0.152	0.140	-0.012
	(0.360)	(0.347)	(0.024)
Observations	336	682	1,018

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A1-4: Comparisons of Dual vs. Single Cost Samples with Wage between $8 and $500

Variable	Dual Cost	Single Cost	Difference
Age	55.033	55.421	0.387
	(12.330)	(11.802)	(1.025)
Household size	2.525	2.376	-0.149
	(1.147)	(1.132)	(0.097)
Volunteering hours	6.847	6.195	-0.652
	(10.055)	(11.367)	(0.938)
Number of floods seen	2.109	2.071	-0.037
	(3.532)	(3.281)	(0.288)
Year in residence	14.079	14.673	0.594
	(11.087)	(11.367)	(0.966)
Employment			
Employed	0.599	0.676	0.077*
	(0.491)	(0.468)	(0.041)
Self employed	0.104	0.117	0.013
	(0.306)	(0.321)	(0.027)
Unemployed	0.025	0.019	-0.006
	(0.156)	(0.137)	(0.012)
Homemaker	0.015	0.002	-0.012*
	(0.121)	(0.049)	(0.007)
Student	0.000	0.010	0.010
	(0.000)	(0.097)	(0.007)
Retired	0.243	0.174	-0.069**
	(0.430)	(0.379)	(0.034)
Income level			
$0 - $49,999	0.173	0.174	0.001
	(0.379)	(0.379)	(0.032)
$50k - $79,999	0.267	0.290	0.023
	(0.444)	(0.455)	(0.039)
$80k+	0.550	0.512	-0.038
	(0.499)	(0.500)	(0.043)
Experience flood?	0.629	0.633	0.005
	(0.484)	(0.482)	(0.041)
Seen green infrastructure?	0.554	0.543	-0.012
	(0.498)	(0.499)	(0.043)
Basement type			
Basement	0.446	0.419	-0.026
	(0.498)	(0.494)	(0.042)
Crawl Space	0.317	0.350	0.033
	(0.466)	(0.478)	(0.041)
Both	0.074	0.090	0.016
	(0.263)	(0.287)	(0.024)
None	0.163	0.138	-0.025
	(0.371)	(0.345)	(0.030)
Observations	202	422	624

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A2-1: MMNL Results Pooling Time and Money Treatments

	(1) Both Cities	(2) Chicago	(3) Portland
Mean			
Status Quo	-8.348***	-9.332***	-8.894***
(no program)	(0.712)	(1.335)	(0.943)
Flood reduction (%)	0.011***	0.023***	0.008
	(0.003)	(0.005)	(0.004)
Aquatic habitat: excellent	0.858***	0.723***	0.972***
	(0.076)	(0.093)	(0.123)
Water quality: swimmable	0.413***	0.382***	0.513***
	(0.071)	(0.092)	(0.112)
Money cost ($) × Money Sample [a]	-2.064***	-2.311***	-1.620***
	(0.123)	(0.228)	(0.176)
Time cost (hours) × Time Sample [a]	-1.759***	-2.013***	-1.259***
	(0.291)	(0.322)	(0.227)
SD			
Status Quo	5.013***	6.375***	4.679***
(no program)	(0.470)	(1.039)	(0.657)
Flood reduction (%)	0.034***	0.047***	0.023***
	(0.006)	(0.007)	(0.006)
Aquatic habitat: excellent	1.029***	0.984***	0.787***
	(0.090)	(0.128)	(0.168)
Water quality: swimmable	1.091***	0.960***	1.192***
	(0.092)	(0.134)	(0.177)
Money cost ($) × Money Sample	0.807***	0.819***	0.725***
	(0.052)	(0.094)	(0.094)
Time cost (hours) × Time Sample	0.206***	1.367***	0.943***
	(0.050)	(0.120)	(0.085)
Observations [b]	15660	7824	7836
LR χ^2	601.78***	275.03***	338.22***
McFadden ρ^2	0.227	0.230	0.230
AIC	6618.21	3387.72	3227.83
Log-likelihood	-3282.11	-1666.86	-1586.91
LR χ^2_{57} [c]	52.05	--	--

Standard errors in parentheses. Clustered at the individual (respondent) level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] The reported coefficient is the mean of the natural logarithm of minus the parameter on cost.
[b] Observations are the number of individuals N times choice occasions T times alternatives J: $N \times T \times J$.
[c] Likelihood ratio test for the hypothesis of parameter (joint parameter and scale) stability between the two cities. See Appendix 3 for a discussion on parameter and scale independently.

Table A2-2: MMNL with Interactions to Test Parameter Differences between Cities

	(1) Money	(2) Time	(3) Both Treatments
Status Quo	-8.547***	-14.610***	-9.345***
(no program)	(1.014)	(2.816)	(0.804)
Flood reduction (%)	0.005	0.008	0.007
	(0.006)	(0.005)	(0.004)
Aquatic habitat: excellent	0.800***	1.255***	0.920***
	(0.150)	(0.192)	(0.106)
Water quality: swimmable	0.211	0.798***	0.510***
	(0.131)	(0.190)	(0.103)
Money cost ($) [a]	-1.776***		-1.723***
	(0.140)		(0.125)
Time cost (hours) [a]		-1.310***	-1.110***
		(0.267)	(0.200)
Chicago × Money cost ($)	-0.082*		-0.062
	(0.036)		(0.036)
Chicago × Time cost ($)		-0.185	-0.284*
		(0.180)	(0.115)
Chicago × Status Quo	-1.969	-0.087	-2.117
	(1.100)	(2.850)	(1.081)
Chicago × Flood	0.012	0.018	0.017**
	(0.009)	(0.010)	(0.006)
Chicago × Habitat	-0.015	-0.353	-0.057
	(0.209)	(0.251)	(0.149)
Chicago × Water quality	0.069	-0.295	-0.162
	(0.175)	(0.277)	(0.142)
Observations [b]	7839	7821	15660
LR χ^2	555.33***	204.45***	994.11***
McFadden ρ^2	0.223	0.250	0.236
AIC	3353.92	3334.87	6642.02
Log-likelihood	-1611.96	-1602.44	-3231.01

Standard errors in parentheses. Clustered at the individual (respondent) level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] The reported coefficient is the mean of the natural logarithm of minus the parameter on cost.
[b] Observations are the number of individuals N times choice occasions T times alternatives J: $N \times T \times J$.
[e] Standard deviations of parameters not shown; full results available from corresponding author.

Table A2-3: Interactions between Payment Vehicle Treatments

	(1)	(2)	(3)	(4)
	Money	Time	Money and Time	All
	Table 2 Col 1	Table 2 Col 1	Table 7 Col 1	
Status Quo	-8.264***	-8.370***	-7.718***	-8.791***
(no program)	(1.038)	(0.980)	(0.723)	(0.573)
Flood reduction (%)	0.014**	0.017**	0.011*	0.013***
	(0.005)	(0.006)	(0.005)	(0.003)
Aquatic habitat: excellent	0.682***	0.903***	0.695***	0.808***
	(0.100)	(0.116)	(0.097)	(0.059)
Water quality: swimmable	0.245**	0.536***	0.258*	0.411***
	(0.087)	(0.110)	(0.116)	(0.061)
Money cost ($) [a]	-2.111***		-2.117***	-2.163***
	(0.117)		(0.142)	(0.109)
Time cost (hours) [a]		-1.743***	-1.534***	-1.747***
		(0.277)	(0.230)	(0.184)
Money × Money Sample				0.010
				(0.027)
Time × Time Sample				-0.070
				(0.082)
Observations [b]	7839	7821	7905	23565
LR χ^2	599.88***	176.74***	488.81***	1105.53***
McFadden ρ^2	0.211	0.238	0.243	0.235
AIC	3326.34	3322.36	3606.98	10185.36
Log-likelihood	-1643.17	-1641.18	-1776.49	-5064.44

Standard errors in parentheses. Clustered at the individual (respondent) level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] The reported coefficient is the mean of the natural logarithm of minus the parameter on cost.
[b] Observations are the number of individuals N times choice occasions T times alternatives J: $N \times T \times J$.
[c] Column 1 and 2 are carried over from Table 2 column 1 panel A, and column 1 panel B. Column 3 is carried over from Table 7 column 1. Column 4 combines the money treatment, time treatment, and the money and time (dual) treatment for both Chicago and Portland. Standard deviations of parameters not shown; full results available from corresponding author, along with code and data.

Table A2-4: Differences in Mean MWTP and MWTV Between Cities

	Chicago	Portland	Difference	Std. Error	p-score
Money					
Status Quo	-24.95	-22.44	-2.52	4.66	0.59
Flood reduction (%)	0.06	0.02	0.04	0.02	0.04**
Aquatic habitat: excellent	1.90	2.12	-0.22	0.50	0.66
Water quality: swimmable	0.43	0.35	0.07	0.43	0.87
Time					
Status Quo	-2.15	-5.99	3.84	0.98	0.00***
Flood reduction (%)	0.01	0.01	0.00	0.00	0.74
Aquatic habitat: excellent	0.19	0.61	-0.43	0.10	0.00***
Water quality: swimmable	0.06	0.27	-0.21	0.09	0.02**

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Tests for differences in means between cities were estimated using *nlcom* and in Stata 16. Empirical distributions of WTP and WTV were calculated using the Krinsky-Robb method (2,000 bootstrapped repetitions) on the regressions in the first three columns in Table 2 (Hole, 2007b). The values correspond to columns 2 and 3 in Table 3 in the main text. The point estimates and confidence intervals can also be found in Figure 1.

Appendix 3: Testing for Structural Differences between Chicago and Portland Samples

A3.1. Methods

To test for differences in preferences parameters between the two cities we use a two-stage variant of the Chow test as outlined in Swait and Louviere (1993). We estimate all models allowing for full correlation across parameters. In doing so, the covariance matrix should flexibly allow for all forms of correlation, both between the preference parameters and scale (Hess and Train, 2017). However, because preference parameters are estimated jointly with the scale parameter, testing for differences between samples can be done more systematically in two steps by exploiting the ratio of the scale parameters between the two cities. The hypothesis we would like to test is: H_1: $\beta_C = \beta_P = \beta$ and $\sigma_C = \sigma_P = \sigma$, where subscripts C and P correspond to Chicago and Portland, β and σ represent the preference and scale parameters. Because these are not separately identified, we instead divide H_1 into two parts: H_{1A}: $\beta_C = \beta_P = \beta$ and H_{1B}: $\sigma_C = \sigma_P = \sigma$.

The first test, H_{1A}, allows the scale parameter to vary between cities. This is done by first estimating regressions for Chicago and Portland separately, which results in a log-likelihood estimate from each model, LL_C and LL_P. We then estimate the pooled model by concatenating the data from both cities and performing a grid search for the optimal scale ratio. Each iteration rescales each covariate of the Portland sample from $\sigma_P \in (0.025, 2)$ in increments of 0.025. The model that maximizes the log-likelihood of the pooled sample is then assumed to be the best fitting scale ratio. We denote this log-likelihood as LL_σ^*. We can then recover a test statistic, $\hat{\chi}_{H_{1A}}$, distributed chi-squared with $(K + 1)$ degrees of freedom. K is the number of parameters constrained in the pooled sample (45), plus 1 for the scale parameter σ. The test statistic is similar to a conventional likelihood ratio test such that $\hat{\chi}_{H_{1A}} = 2[(LL_C + LL_P) - LL^*_\sigma]$. The critical value for us in this case is $\chi^2_{46,\alpha=0.05} = 62.83$. Moreover, if our test statistic is less than the critical value, we would fail to reject H_{1A}, suggesting that there are no differences in preferences, β, jointly between the two cities.

If we reject H_{1A}, then the primary hypothesis $H_1$is also rejected. However, if we fail to reject H_{1A} then we move onto our second hypothesis H_{1B}, testing for differences in the scale parameter between the two cities. This is done by estimating the pooled model without rescaling the covariates (i.e. $\sigma = 1$) and testing $\hat{\chi}_{H_{1B}} = 2[LL^*_\sigma - LL_{\sigma=1}]$, distributed $\chi^2_{1,\alpha=0.05} = 3.84$. The constrained number of parameters to be considered in the chi-square distribution is simply 1 for the scale parameter. If we reject H_{1B} we take the model with the rescaled data as the correct model. However, if we fail to reject both H_{1A} and H_{1B} then we assume preferences and scale are uniform (not statistically different) across cities such that $\beta_C = \beta_P = \beta$ and $\sigma_C = \sigma_P = \sigma$. We would then take the unscaled model (i.e. $\sigma = 1$) to be the best fitting model.

In our main analysis, we also explore the possibility of pooling cost treatments, money and time. This relates to Table 5 in the main text. In one model (Table 5 column 4) we monetize the cost of time using 1/3 the wage rate. If we believe that 1/3 the wage rate is equivalent to the shadow value of time, then we might also believe that pooling the money treatment with the monetized time treatment would result in similar joint preferences. We test this hypothesis in the same manner discussed above except now our separate models are money and monetized time, pooled money and monetized time, and pooled but rescaled money and monetized time.

A3.2. Results

The Chicago and Portland samples were run individually for money and time (separately). The log-likelihood values for these, LL_C and LL_P, are reported in Table A3-1. We then concatenate the money sample of Chicago and the money sample of Portland to perform the grid search optimization on the pooled money sample. These log-likelihood values, LL_{σ}^{*}, are also reported in Table A3-1 and Figure A3-1. We test H_{1A}: $\chi^2_{46,\alpha=0.05} < \hat{\chi}_{H_{1A}} = 2[(LL_C + LL_P) - LL_{\sigma}^{*}]$ for both the money and time samples. We fail to reject all H_{1A}, favoring the null that preferences are jointly stable across cities. The log-likelihoods, test statistics, critical values, and conclusions are all reported in Table A3-1.

Having failed to reject the null H_{1A}, we then test H_{1B}: $\chi^2_{1,\alpha=0.05} < \hat{\chi}_{H_{1B}} = 2[LL_{\sigma}^{*} - LL_{\sigma=1}]$. Again, we fail to reject the null that scale is stable across cities. These results favor estimating the pooled data without adjusting for potential differences in scale. This is also the result of a conventional likelihood ratio test, as presented at the bottom of Table 2.

For our alternative exploration into constraining preferences across cost treatments, we reject the null H_{1A} that preferences are equal across samples. By rejecting this null, we also reject H_{1B} in the process. However, for completeness, we carry out the rest of the procedure to its entirety providing test statistics and p-values for both H_{1A} and H_{1B}. This finding suggests that pooling samples without rescaling would not be appropriate if we were interested in joint preferences. However, we allow for a more flexible model for this analysis by simply including interactions between the cost treatment and each of the attributes. This allows scale (and all forms of correlation) to be represented in the covariance matrix of the model. The results of this procedure, along with summary values, can be found in Table A3, and Figure A3-2.

Table A3: Tests of Parameter Stability, Preference and Scale

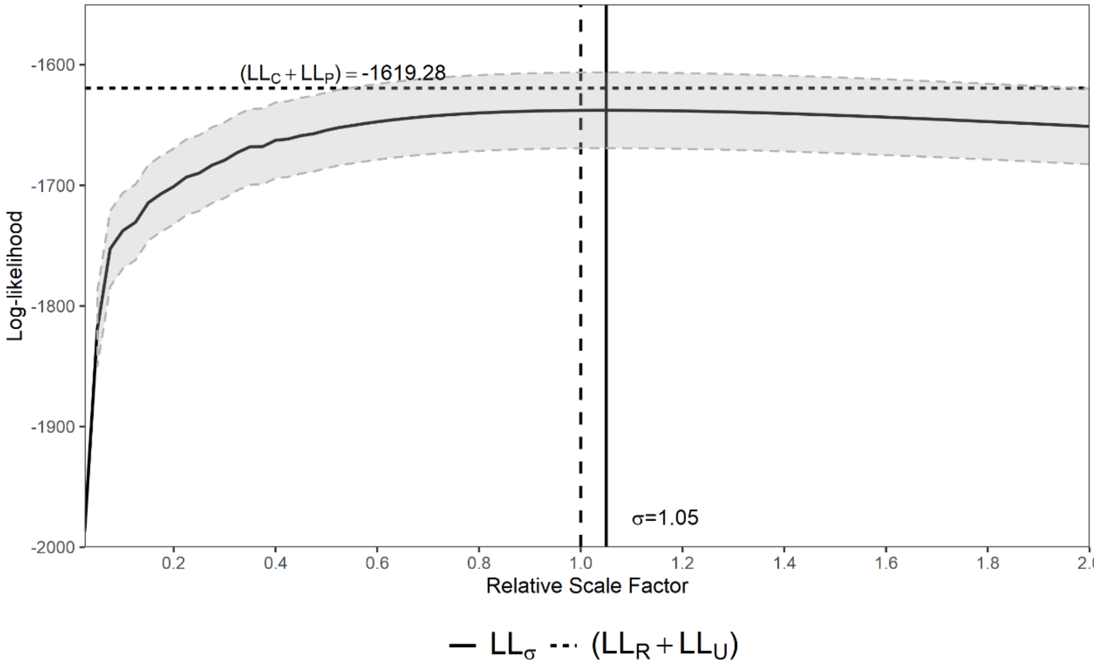
	LL_C	LL_P	$LL_{\sigma=1}$	LL_{σ}^{*}	σ^{*}	$\chi^2_{(K+1),\alpha=0.05}$	$\widehat{\chi^2}$	Conclusion
Panel A								
Money								
H_{1A}	-815.46	-803.82	-1637.79	-1637.71	1.05	62.83	36.86	Fail $p = 0.83$
H_{1B}						3.84	0.14	Fail $p = 0.71$
Time								
H_{1A}	-845.60	-770.10	-1635.17	-1633.40	1.30	62.83	35.39	Fail $p = 0.87$
H_{1B}						3.84	3.55	Fail $p = 0.06$

Panel B

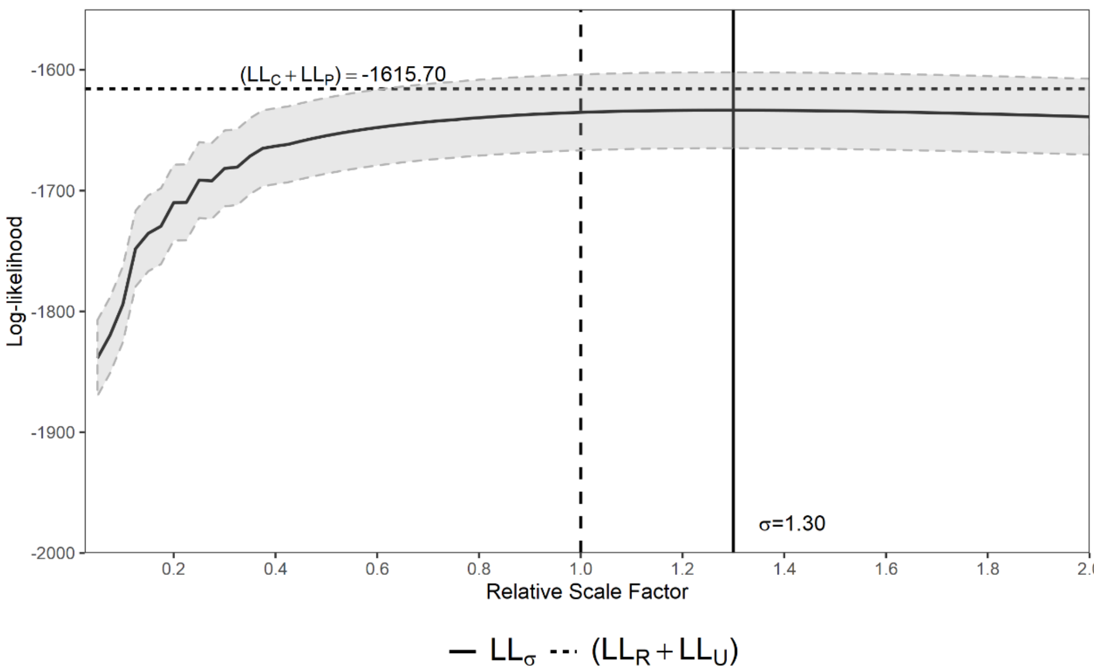
Cost Treatment	LL_M	LL_T	$LL_{\sigma=1}$	LL_{σ}^{*}	σ^{*}	$\chi^2_{(K+1),\alpha=0.05}$	$\widehat{\chi^2}$	Conclusion
Treat								
H_{1A}	-1034.66	-1045.16	-2123.80	-2121.54	1.275	62.83	83.44	Reject $p = 0.0006$
H_{1B}						3.84	4.53	Reject $p = 0.033$

Note: Table A3 summarizes the results of the hypothesis tests discussed in Appendix 3. Panel A provides log-likelihoods, critical values, test statistics, p-scores, and conclusions for testing preference and scale stability across cities for money cost treatments and time cost treatments separately. Panel B provides the same values and conclusions for testing stability of preferences jointly between the two cost treatments themselves. We fail to reject the null that preferences and scale are the same across cities. However, in panel B we reject the null for the pooled cost treatments for both preference and scale stability across these two samples.

Figure A3-1: Optimal Scale Ratio for Money and Time Treatments



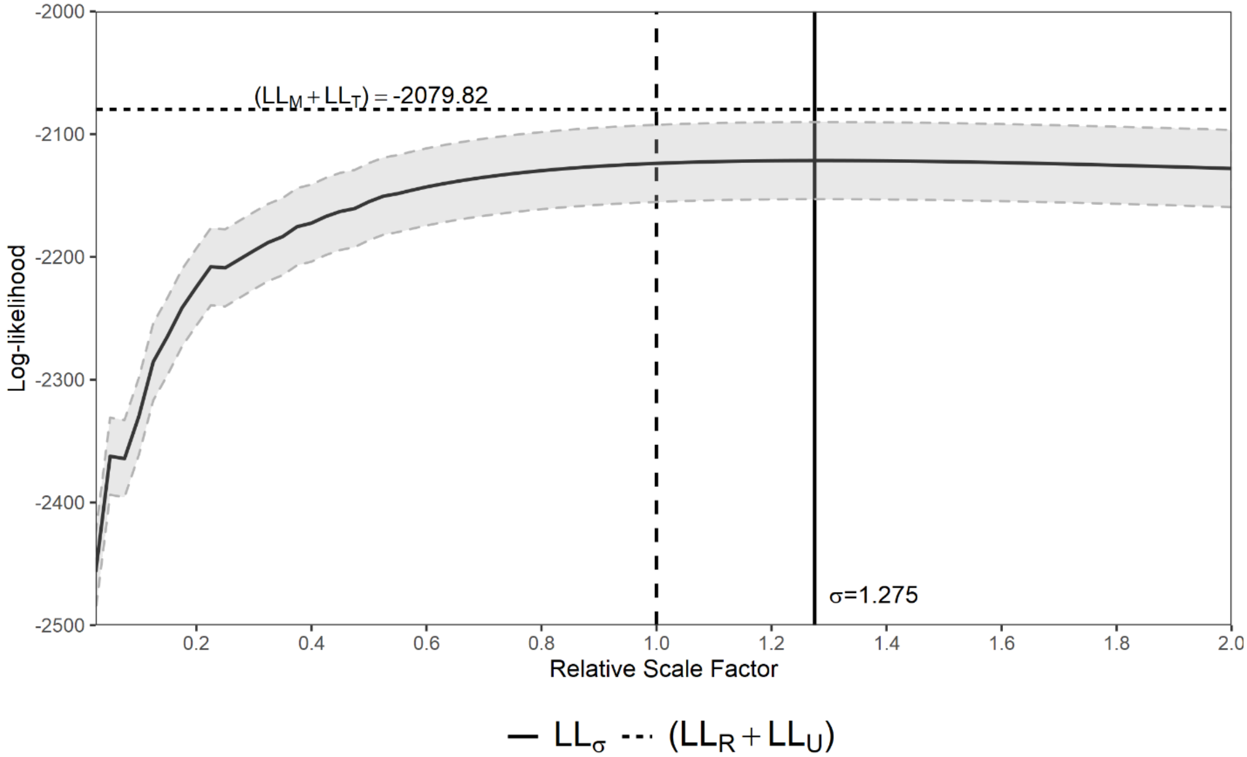
Panel A: Optimal Scale Ratio for Money Treatment



Panel B: Optimal Scale Ratio for Time Treatment

Note: Panel A and Panel B present the results of the scale ratio procedure as outlined by Swait and Louviere (1993). The confidence band around the (solid) log-likelihood function underlying the procedure highlights the region where we fail to reject H_{1A}. In both treatments, we fail to reject that preferences are jointly the same between cities.

Figure A3-2: Optimal Scale Ratio for Pooled Money and Time Costs



Note: Figure A3-2 presents the results of the scale ratio procedure as outlined by Swait and Louviere (1993). This examines the feasibility of pooling money cost treatments and (monetized) time cost treatments. The confidence band around the (solid) log-likelihood function underlying the procedure highlights the region where we fail to reject H_{1A}. The sum of the two log-likelihoods from the samples run independently ($LL_M + LL_T$) falls outside (above) the test region, and we reject the null that preferences are jointly the same between money and time cost samples.

A4. References

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