Frequency and Time in Recreational Demand

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Abstract

In the standard single-site travel cost model, it is assumed that time spent on-site is exogenous. This assumption results in a willingness to pay (WTP) for time on-site of zero, which may be less realistic for many urban parks that are frequently visited by local residents. We develop a single-site travel cost model where a visitor simultaneously chooses the number of visits and how much time to spend on-site. In this model, the WTP estimate includes the price of the trip and the price of time spent on-site. Next, we develop a two-part hurdle model with non-zero correlation between the number of trips and time spent on-site. We use data gathered in an urban park in Iceland to estimate the model. The estimated WTP values are more than twice as high as the estimates of the standard single-site model.

JEL codes: C51, Q26, Q51

Key words: Count data, endogenous time on-site, hurdle model, travel cost model, urban parks, willingness to pay

1. Introduction

Urban parks are generally designed by landscape architects and maintained by local authorities to provide diverse recreational opportunities and to promote health and social well-being in urbanized areas for the local population. It is important that economic valuation methods accurately measure the total benefits of urban parks. Otherwise development pressure may lead to socially sub-optimal decisions about their long-run conservation (More, Stevens, and Allen 1988).

The travel cost recreational demand literature has focused on estimating demand for national parks (Trice and Wood 1958; Clawson 1959; Martínez-Espineira and Amoako-Tuffour 2008), hunting sites (Creel and Loomis 1990), beaches (Hynes and Greene 2013), and recreational fishing sites (Grogger and Carson 1991; Egan and Herriges 2006). These sites usually differ from urban parks regarding their size and travel costs for users. Endogeneity of time becomes increasingly more important for welfare estimates when the cost of a trip is negligible compared with the opportunity cost of time spent on-site. This is often the case for open access urban parks.[1] To evaluate the total welfare effects of such parks, time spent on-site and not only travel costs are important for welfare estimates.[2]

Time spent on-site is usually treated as exogenous and therefore not included as a component of the willingness to pay (WTP) for a visit in the travel cost literature (e.g., Creel and Loomis 1990; Egan and Herriges 2006; Hynes and Greene 2013). One exception is McConnell (1992) who modelled the demand for trips and the length of stay for each trip. He showed that the standard welfare estimates without any welfare effects from time-on-site are appropriate in his model. However, this is not a general result. For example, Landry and McConnell (2007) showed that endogeneity of time spent on-site sometimes will affect the welfare estimates. Larson (1993) accounted for time spent on-site by assuming recreationists jointly choose the number of trips and total duration of recreation, and his results demonstrated the importance of accounting for the endogeneity of time spent on-site in recreation. Hellström (2006) studied the joint choice of the number of leisure trips and nights spent on-site by Swedish households. He estimated a bivariate count data model and found

[1] There are few empirical applications of the single-site travel cost model to urban parks. Exceptions include Lockwood and Tracy's (1995) application of a zonal travel cost model to data on recreational use of Centennial Park in Sydney and Martinez-Cruz and Sainz-Santamaria's (2017) application of a latent class count data model to recreational use of two parks in Mexico City. However, these studies did not explore the effects of endogenous time spent on-site. Another issue related to urban parks is the limited variation in travel costs of the users. We also note that empirical estimation of welfare estimates is complicated when urban parks, such as Central Park, are tourist attractions. Not only is it difficult to allot travel cost for a multipurpose trip, but there are at least two latent demand functions behind the recreational demand, one for locals and another for out of town visitors. The locals' demand curve is likely to be relatively flat in travel cost while the visitors' demand curve will be much steeper and more in line with what is seen for national parks. However, these problems are beyond the scope of this article.

[2] The importance of time costs in welfare calculations are discussed in Goolsbee and Klenow (2006). They pointed out that for some goods, such as the Internet or watching television, the main cost is not buying the product but the opportunity cost of time spent using them. They also showed that the endogeneity of time is crucial for welfare estimates related to such goods.

positive cross-price elasticities between trips and nights spent on-site, which indicates substitution. However, neither Larson (1993) nor Hellström (2006) provided any welfare estimates.

This paper adds to the literature on single-site travel costs models in three ways. First, we define the recreational good as a function of the number of trips to the site and time spent on-site. Our model combines McConnell's (1992) single-site model with endogenous on-site time and a nonlinear budget constraint with Larson's (1993) duration specification where the individual simultaneously chooses the number of trips to a given site and the time spent on-site. As a result, the welfare estimate in our proposed model includes the effect of time on-site.

Second, we provide a theory-consistent method for simultaneously estimating the number of trips and time spent on-site by estimating a hurdle model. In this model, time on-site is only observed when there is a trip. The number of trips is modelled by a count data model as is customary in the single site recreational demand literature (e.g., Shaw 1988; Creel and Loomis 1990; Grogger and Carson 1991; Shonkwiler and Shaw 1996; Egan and Herriges 2006; Hynes and Greene 2013). Time spent on-site can only take positive non-zero values and although it is observed discretely, it is generated continuously and we model it using a gamma model.[3] Time on-site is likely to be right skewed due to heterogeneity among visitors with at least a few heavy users that spend significantly more time on-site than the average. To allow for non-independence of the two parts of the model, normally distributed random effects with a non-zero covariance are introduced to each part.[4] The solution of our

[3] Hellström (2006) used the number of nights spent at the location as a time unit, and assumed a discrete data generating process of time spent on-site. Our focus is on urban parks where time on-site is measured in hours and minutes, and we assume that time spent on-site is continuous.

[4] Due to computational challenges, few studies have applied hurdle models that account for non-zero correlation between stages in count data literature. Two examples of such studies are Winkelmann (2004) and Min and Agresti (2005).

model is approximated by Gauss-Hermite integration and estimated with a maximum-likelihood procedure by using a Dual Quasi-Newton (DQN) method for the optimization.

Third, to demonstrate the importance of including endogenous time on-site in welfare estimates, we apply the proposed model to data gathered on-site in an urban park in Iceland, Heiðmörk. We provide an estimate of WTP for access that accounts for the opportunity cost of time on-site and the number of trips to the park. This estimate is compared with the estimate of the standard model with exogenous time on-site. The WTP estimates of the proposed model is more than twice as large as in the standard model.[5]

The remainder of the paper is organized as follows. Section 2 presents our theoretical model and the associated WTP measure, Section 3 presents the econometric model, Section 4 describes the data and empirical specification, Section 5 provides the empirical results before Section 6 concludes.

2. Theoretical Model

Let an individual obtain utility by using a flow of recreational services x and a composite commodity bundle z with a normalized price $\bar{p}_z = 1$. To experience the recreational services, the individual needs to take a trip to the recreational site and spend time on-site. Let n be the number of trips and t be the time spent on-site. For simplicity, t is assumed to be constant for all trips of the individual.[6] The flow of recreational services is given by:

$$x = x(n, t). \tag{1}$$

Following Larson (1993), the utility function is specified as $u(x(n,t), n, z)$. It is assumed to be quasi-concave in its variables and exhibit joint weak complementarity between

[5] As mentioned in Martinez-Cruz and Sainz-Santamaria (2017), it is usually difficult to find close substitutes to urban ecosystems or urban parks. This is also the case for the Reykjavik area with no other urban parks, and substitute sites are not a part of the model. However, it is straightforward to extend the model to account for substitute sites.

[6] Constant time on-site on each trip for one individual is a simplification, however, it is consistent with our data. This consistency may suggest that most individuals have a quite habitual pattern in their visits to the park.

the number of trips and time spent on-site, i.e., without a trip there is no utility from time spent on-site and without time spent on-site there is no utility from a trip. The two can therefore be considered technical complements in a household production function. To produce utility from the experience of a recreational activity the following combination of inputs is always required: $(n = 1, t)$. How much utility is produced by each trip depends on the choice of t.

The opportunity cost of travel time and time spent on-site can be different and neither is necessarily equal to the wage rate as discussed in Bockstael, Strand, and Hanemann (1987). Assuming the opportunity costs of travel time and time spent on-site are exogenous shadow prices, the individual faces the nonlinear budget constraint:

$$Y = z + p_n n + p_t t n, \tag{2}$$

where Y is income, p_n is the price per trip and p_t is the price per unit of time spent on-site. The price p_n includes all out-of-pocket costs incurred by a trip, such as the marginal cost of driving or the cost of subway/bus fares as well as the opportunity cost of time spent travelling.[7] As in McConnell (1992), the travel time and prices in Equation (2) are assumed to be fixed for all trips for one individual but they may vary among individuals.

The individual's maximization problem is:

$$\max_{\{n,t,z\}} \quad u(x(n,t), n, z) \quad \text{s.t.} \quad Y = z + p_n n + p_t t n. \tag{3}$$

The problem is identical to the problem in McConnell (1992) and the solution is the indirect utility function $V(p_n, p_t, Y)$. We define recreation as a function of the number of trips and the time spent on-site and get identical results to McConnell (1992).[8] Roy's identity provides the Marshallian demand for the number of trips:

[7] Total travel cost per trip can be defined as: $p_n = p_c + p_\tau \tau$, where p_c is all out of-pocket costs incurred by a trip, τ is travel time and p_τ is the price per unit (hour) of travel time.

[8] For complete derivations of Equation (3), the dual optimization problem, and associated identities, we refer the reader to the online supplementary material.

$$n(p_n, p_t, Y) = -\frac{\partial V/\partial p_n}{\partial V/\partial Y} = n, \tag{4}$$

and the demand for total duration of recreation:

$$t(p_n, p_t, Y) \neq -\frac{\partial V/\partial p_t}{\partial V/\partial Y} = nt. \tag{5}$$

However, to derive the demand for time spent on-site, we use Larson's (1993) definition of recreation $x \equiv nt$. The demand for time spent on-site is given by:

$$t(p_n, p_t, Y) = \frac{\partial V/\partial p_n}{\partial V/\partial p_t} = \frac{\lambda nt}{\lambda n} = t. \tag{6}$$

Equation (6) is also derived in McConnell (1992). However, for two reasons, endogenous time on-site becomes important for the welfare estimates in our model but not in McConnell's (1992). First, as Larson (1993), we define utility as $u(x(n,t), n, z)$ rather than $u(n, t, z)$. Second, as Larson (1993), we define recreation as $x \equiv nt$ instead of defining *n* and *t* separately.

2.1 Willingness to Pay for Access

Consumer surplus approximates WTP as well as compensating and equivalent variations with known bounds, as shown by Willig (1976). Given one shadow price for the duration of recreation, p_x, the consumer surplus and WTP is given by the Marshallian demand integrated over a change from the current price level p_{x_0} to the choke price $\bar{p}_x$ at which there will be no demand for recreation, or:

$$WTP = \int_{p_{x_0}}^{\bar{p}_x} x dp_x. \tag{7}$$

Calculating the WTP for our demand specification; i.e. $x \equiv nt$, is more complicated. Our price of the duration of recreation depends on the price per trip, the price per unit of time spent on-site, the time spent on-site, and the number of trips, or:

$$p_x x = p_n n + p_t t n. \tag{8}$$

We can reformulate Equation (8) by using the identity $x \equiv nt$, take the total differential of the resulting function, and reformulate Equation (7) to:

$$WTP = \int x dp_x = \underset{\text{(i)}}{\int n dp_n} + \underset{\text{(ii)}}{\int x dp_t} - \underset{\text{(iii)}}{\int \frac{np_n}{t} dt}. \tag{9}$$

In Equation (9), p_x is a function and not a variable, and we have a Riemann-Stieltjes integral.[9] Thus, treating p_x as a variable and integrating over *x* will lead to incorrect WTP estimates. Equation (9) consists of three parts. Part (i) is the area under the Marshallian demand curve for the number of trips, which is the conventional measure of WTP for access in the single-site travel cost model. It represents the recreationists' consumer surplus from taking trips to a recreational area. Part (ii) is the area under the Marshallian demand curve for the duration of recreation with respect to the price of time spent on-site. It represents the recreationists' consumer surplus from spending time on-site for trips during the entire season. Part (iii) is the total travel cost per time unit (hour) integrated over a change in time spent on-site from the current price level to the choke price. Part (iii) is subtracted because the number of trips and time spent on-site are substitutes in the consumption of the recreational good.[10] Parts (ii) and (iii) are not included in the WTP estimate given that time on-site is treated as exogenous.

Equation (9) can be written as:

$$WTP = \int x dp_x = \underset{\text{(a)}}{\int n(1-\epsilon_{t,n}) dp_n} + \underset{\text{(b)}}{\int x\left(1-\frac{p_n}{tp_t}\epsilon_t\right) dp_t} - \underset{\text{(c)}}{\int \frac{np_n}{Y}\epsilon_{t,Y} dY}, \tag{10}$$

[9] For a general overview of the Riemann-Stieltjes integral see, for example, Widder (1989). See the online supplementary material for a complete derivation of the WTP estimates.
[10] The number of trips and time spent on-site are complements in the sense that one cannot consume the recreational good without taking a trip. However, the visitor is likely to make a trade-off between the number of visits and time spent on-site.

where $\epsilon_{t,n}$ is the cross-price elasticity between time spent on-site and the number of trips, ϵ_t is the own-price elasticity for time spent on-site, and $\epsilon_{t,Y}$ is the income elasticity of time spent on-site. The WTP measure in Equation (10) consists of three parts. Note that parts (a), (b), and (c) in Equation (10) do not directly correspond to parts (i), (ii), and (iii) in Equation (9). Table 1 gives the definitions of the elasticities used in Equation (10).[11]

Part (a) of Equation (10) measures the consumer surplus associated with taking trips to the site. It accounts for the relationship between the demand for time spent on-site and the demand for trips through the cross-price elasticity $\epsilon_{t,n}$.

Part (b) is a measure of the consumer surplus associated with spending time on-site for all the trips taken over the entire season. The duration of recreation x is scaled by the factor $\left(1 - \frac{p_n}{tp_t}\epsilon_t\right)$, which includes the effect of a change in the relative price of a trip $\frac{p_n}{p_t}$, the time on-site t, and the own-price elasticity of time on-site ϵ_t. The more elastic the demand for time on-site, the larger the scaling factor for the consumer surplus. However, if the demand is perfectly price-inelastic, i.e., $\epsilon_t = 0$, or the price of a trip is dwarfed by the opportunity cost of time on-site on a given trip, tp_t, then part (b) collapses into part (ii) of Equation (9), i.e., the consumer surplus with respect to time on-site that does not account for any relationship between the number of trips and time on-site.[12]

Part (c) of Equation (10) is a measure of the income effect. The share of income spent on trips $\frac{np_n}{Y}$ and the income elasticity of demand for time on-site $\epsilon_{t,Y}$ jointly shift the demand curves following price changes. If the demand for time on-site is unaffected by changes in

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[11] We assume that the decision-making process for the number of trips is continuous even though observed trips are discrete.

[12] This can occur for two reasons. First, for users who live near the area, the cost of travel is negligible. For example, the transportation costs are negligible for many local users of Central Park in New York, where a large share of Manhattan's residents live within a mile radius from the park. Second, the opportunity cost of total time on-site may be high. For the opportunity cost of total time on-site to be able to dwarf the price of the trip, the price of time on-site must be relatively high since the daily time on-site is bounded by the individual's available time. A relatively high price of time on-site is plausible in affluent metropolitan areas where individuals often need to work long hours to keep up with their employers' demands.

income, part (c) will be zero. In the case of urban parks, the share of income spent on trips is likely to be low for most individuals and therefore part (c) might be small.

Table 2 summarizes the qualitative relationships between the WTP estimates in Equations (9) and (10) and the signs of the demand elasticities. If the time on-site is constant, the own-price elasticity for time on-site ϵ_t, the income elasticity of time on-site $\epsilon_{t,Y}$, and the cross-price elasticity between time on-site and the number of trips $\epsilon_{t,n}$ all will be zero. Given exogenous time on-site, Equation (10) collapses into the WTP of the standard single site travel cost model in Equation (9). However, even in this case, Equation (9) will not provide the WTP estimate of the standard single-site model. This is only the case when the price of time on-site p_t is constant and parts (ii) and (iii) of Equation (9) disappear.[13]

(Table 1 about here)

(Table 2 about here)

3. Econometric Model

The number of trips *n* and the time spent on-site *t* were jointly estimated. The number of trips was assumed to be generated from a discrete distribution, $f_N(N = n|B)$ for $n = 0,1,2, \ldots$, and the probability of observing $n = 0$ was given by $\Pr(N = 0|B)$ where *B* is a vector of exogenous variables. Time spent on-site is only observed if the individual takes a trip to the site, i.e., when $n > 0$. Thus, the data generating process for $t|n > 0$ was assumed to follow a continuous distribution defined only over positive real values, $g_{T|n>0}(t|n > 0, B)$ for $t > 0$. Time on-site is defined as the following two-part model:

$$g_T(t|B) = \begin{pmatrix} \Pr(N = 0|B) & \text{if } t = 0 \\ \Pr(N > 0|B) g_{T|n>0}(t|n > 0, B) & \text{if } t > 0 \end{pmatrix}. \tag{11}$$

[13] This conclusion does not change even if the opportunity cost of time spent on-site, tp_t, is added to the travel cost variable in the standard single-site model.

Time on-site is only observed when a trip takes place, and $f_N(N = n|B)$ and $g_{T|n>0}(t|n > 0, B)$ are likely to be stochastically correlated. Introducing random effects, ε_i, $i = 1,2$ to each part of the model accommodates this stochastic correlation. The result is the two mixture distributions $f_N(N = n|B, \varepsilon_1)$ and $g_{T|n>0}(t|n > 0, B, \varepsilon_2)$. The conditional means of *n* and *t* are $\mathrm{E}(n|B, \varepsilon_1)$ and $\mathrm{E}(t|B, \varepsilon_2) = \Pr(N > 0|B)\mathrm{E}(t|n > 0, B, \varepsilon_2)$, and the marginal effects of $\mathrm{E}(t|B, \varepsilon_2)$ are $\partial\mathrm{E}(t|B, \varepsilon_2)/\partial B_i = \Pr(N > 0|B)\, \partial\mathrm{E}(t|n > 0, B, \varepsilon_2)/\partial B_i$. Now assuming the random effects are jointly normal, we have:

$$\varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \sim MVN\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{pmatrix}\right]. \tag{12}$$

The likelihood function associated with the joint density of the two mixture distributions is given by:

$$L = \int \left[\prod_{i=1}^{M} f_N(n_i|B, \varepsilon_1)\, g_{T|n>0}(t_i|n > 0, B, \varepsilon_2)\right] \vartheta(\varepsilon) d\varepsilon, \tag{13}$$

where $\vartheta(\varepsilon)$ is the normal density function of ε. The probabilities of interest were calculated from the maximum likelihood estimates.

In order to estimate Equation (13), the number of trips was assumed to be generated by a Poisson log-normal mixture distribution.[14] The conditional expectation and variance of *n* is given by $\mathrm{E}(n|B, \varepsilon_1) = r(B)\exp(\varepsilon_1) = \lambda$ and $\mathrm{var}(n|B, \varepsilon_1) = \lambda$. However, $\mathrm{E}(n|B) \neq \mathrm{var}(n|B)$ are not equal under the Poisson log-normal specification and therefore the distribution allows for overdispersion (Egan and Herriges, 2006). Furthermore, time on-site was assumed to be generated by a gamma log-normal mixture distribution, where the conditional expectation and variance is given by $\mathrm{E}(t|n > 0, B, \varepsilon_2) = k\phi = h(B, \varepsilon_2)$ and $\mathrm{var}(t|n > 0, B, \varepsilon_2) = k\phi^2$, respectively.

[14] Note that we do not need to assume a truncated distribution for trips since the data includes zeroes for those who did not take a trip in the previous calendar month. For more details on the econometric model, see the online supplementary material.

We do not adjust for endogenous stratification in our model, which is likely to exist in our data due to on-site sampling.[15] The decision not to account for this issue was based on the complexity of our model. Furthermore, our main objective is to compare the differences between WTP estimates from a standard single site travel cost model and a model, which allows for endogenous time on-site. Given that the bias is likely to be similar in both these models, our comparison still demonstrates the importance of accounting for endogenous time on-site.

4. Data and Empirical Specification

Data was gathered on-site in Heiðmörk, which is an open access urban park on the fringe of Reykjavik. The data were collected during the period July 2008 to September 2009. Heiðmörk is widely used among the population in the Reykjavik area, and the park provides a wide range of ecosystem services. It is by far the largest recreational area in the vicinity of the capital area covering around 3,000 hectares of vegetated areas, lava fields, two lakes, caves and a water basin as well as offering picnic areas, playgrounds and over 40 kilometers of trails for pedestrians and horseback riders. The park is used extensively all year round and its users are heterogeneous with respect to socio-demographic characteristics and recreational activities (Eiriksdottir et al. 2020).

The data was gathered on a per group basis. The sample consists of 2,392 observations with a 67% participation rate, thereof only 1,525 observations were complete without missing values. A comprehensive discussion on the sampling methodology and the survey design as well as the reasons for missing data and how missing data can be handled is provided in Eiriksdottir et al. (2020). The dataset contains variables for the number of trips

[15] We refer readers to McKean, Johnson, and Taylor (2003) for a method of adjusting overdispersion and endogenous stratification simultaneously.

taken in the previous calendar month, travel mode, group size, round trip distance, an allotted relative importance of the trip in cases of multipurpose trips, the recreational activity undertaken on the sampled occasion, and socio-economic variables. It was also recorded how much time was spent on-site on the sampled occasion. To account for our simplifying assumption that the respondent spent the same amount of time on each visit, we used average time spent on-site for each group. The socio-economic variables included gender, age, size of household, the number of children in the household, marital status, education, job market participation, and annual disposable household income. The questionnaire did not include any suggestions of substitute sites or allowed for the possibility that the respondents came up with substitute sites. Substitute sites were excluded because there is no single area in this part of Iceland that provides the full range of recreational possibilities that Heiðmörk does, i.e., there are no good substitute sites. Typically predetermined substitute sites are included in questionnaires used in the travel cost literature and these substitute sites are included in the models (e.g., Hanauer and Reid 2017) to the effect of lowering the welfare estimate.

Given that our main objective is to demonstrate the effect on WTP values of including endogenous time spent on-site, we estimated models without socio-economic variables. The Marshallian demand functions, $n(p_n, p_t, Y)$ and $t(p_n, p_t, Y)$, were assumed to take the semi-log functional form as is standard in the single-site count data recreational demand literature. The price of time spent travelling and time spent on-site were measured as a scaling of income, and income is perfectly collinear with this price; see Equation (17) below. Consequently, income was not included as a variable.[16] The demand equations for the

[16] However, given an income variable that is independent of the prices, it is straightforward to include income in the empirical specification. Furthermore, the direct effect of income on WTP is limited to part (c) of Equation (10), which again is scaled by the income share spent on travel to recreational site. The effects of not using income as a separate variable in the empirical estimation are therefore likely to be small. A discussion about the theoretical issues related to how the opportunity cost of time should be estimated is beyond the scope of this paper. We refer readers to McKean, Johnson, and Walsh (1995), McKean, Johnson, and Taylor (2003), Amoako-Tuffour and Martinez-Espineira (2012), and references therein for developments in estimating the opportunity cost of time.

number of trips and the time spent on-site were specified as:

$$n = \exp(\alpha_0 + \alpha_1 p_n + \alpha_2 p_t + \varepsilon_1) \tag{14}$$

and

$$t = \exp(\beta_0 + \beta_1 p_n + \beta_2 p_t + \varepsilon_2). \tag{15}$$

The demand for duration of recreation was specified as:

$$x \equiv nt = \exp\big((\alpha_0 + \beta_0) + (\alpha_1 + \beta_1)p_n + (\alpha_2 + \beta_2)p_t + (\varepsilon_1 + \varepsilon_2)\big). \tag{16}$$

Following Eiriksdottir et al. (2020), the price of time, p_t, was based on one third of the hourly wage rate given 1,800 working hours per year independently of whether time was spent travelling or on-site.[17] On a per group basis, it was computed as:

$$p_{t_i} = (1/3 \cdot (income_i/1800) \cdot adults_i), \tag{17}$$

where $income_i$ was estimated with an interval regression method based on the respondent's reported yearly income category, and $adults_i$ was the number of adults in the group travelling together. In Equation (17) we assumed that all the adults in the group have the same income as the respondent. This can be a quite strong assumption, especially in the case of families with young adults. The price of travel, p_n, on a group basis was calculated as:

$$p_{n_i} = \big(dist_i \cdot (cost/km) + ttime_i \cdot p_{t_i}\big) \cdot \%ofpurpose_i, \tag{18}$$

where $dist_i$ is the roundtrip distance from the respondent's home, $cost/km$ is the marginal cost of travel based on travel mode[18], $ttime_i$ is the roundtrip travel time based on travel mode and $\%ofpurpose_i$ is the relative importance of the trip in the case of a multipurpose trip and 1 otherwise.[19]

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[17] A 1/3 of the hourly wage rate is widely accepted as a lower bound of the opportunity cost of time (Parsons 2003; Hagerty and Moeltner 2005; Voltaire, et al. 2016).

[18] The marginal cost of driving was assumed to be the price of petrol. Following Victoria Transport Policy Institute (2015), the average fuel consumption was assumed 5l/100km for motorcycles, 9.5l/100km for mid-sized sedans, and 13.5l/100 for SUVs. The cost of petrol was based on monthly prices of petrol from June of 2008 to September of 2009. The price of petrol, 95 Octane, on January 1st 2008 was 139.5 ISK/l. Monthly changes in the price were obtained from Statistics Iceland (2015). The marginal cost of other travel modes than driving, i.e., walking, running, cycling, or horseback riding was assumed to be zero.

[19] Although the self-reported percentage of a multipurpose trip is an imperfect measure, it is better to use this measure than dropping observations that report a multipurpose trip, which would lead to a bias in the WTP

The summary statistics of the variables are provided in Table 3. Based on the 1,525 complete observations, 77% of respondents took 5 trips or less in the last calendar month and less than 2.5% took 20 trips or more, with the average being 4.20 trips. This indicates the presence of heavy users that visit the park substantially more often than the average. The average time spent on-site was about 80 minutes, ranging from about 3 minutes to 7.5 hours. On average, there were 1.56 adults per group, the average travel cost per group was 620 ISK, and the average time cost per group was 880 ISK. The sample is discussed in more detail in Eiriksdottir et al. (2020).

(Table 3 about here)

Equations (14) and (15), the WTP estimate in Equation (10) will only have a closed form solution when $\alpha_1 < 0$, $(\alpha_2 + \beta_2) < 0$, $\alpha_2 < 0$, and $\beta_1 > 0$.[20] Under these conditions, the WTP estimate in Equation (10) takes the closed form:[21]

$$WTP = \int_{p_{x_0}}^{\infty} x dp_x = -\frac{1}{\alpha_1} n - \frac{1}{\alpha_2 + \beta_2} x + \frac{\beta_1}{\alpha_1} n p_n \left(1 - \frac{1}{\alpha_1 p_n}\right) + \frac{\beta_2}{\alpha_2} n p_n, \tag{19}$$

where α_1 is the half-price elasticity of the demand for trips, $(\alpha_2 + \beta_2)$ is the half-price elasticity of the demand for the duration of recreation with respect to the price of time spent on-site, $p_n\left(1 - \frac{1}{\alpha_1 p_n}\right) = p_n\left(1 + \frac{1}{|\epsilon_n|}\right)$ corresponds to the measure for marginal revenue in profit maximization, $\frac{\beta_1}{\alpha_1}$ is the share of marginal consumption diverted to time spent on-site when the price of trips increases and $\frac{\beta_2}{\alpha_2}$ is the lost demand for time spent on-site as a share of marginal consumption resulting from an increase in the price of time on-site.[22]

measure. It can also be argued that this measure is no more flawed than the acceped way to measure the opportunity cost of travel time. We refer readers to Martinez-Espineira and Aoako-Tuffour (2009) for a discussion on how to handle the issue of multipurpose trips.

[20] See the online supplementary material for the derivation of the WTP estimates based on the empirical specifications of *n* and *t*.

[21] Otherwise there does not exist a closed form for the WTP for access given by Equation (19).

[22] The half-price elasticity shows the percentages change in the quantity demanded for the variable for a unit change in its price.

Homogeneity of degree zero in prices and income was imposed by dividing both prices with the Icelandic price index. There are no symmetry conditions on price effects between n and t.[23]

5. Empirical Results

We estimated both the standard single-site travel cost and the proposed model and compared the WTP estimates of the two models. The parameter estimates of the standard model with fixed time on-site are shown in Table 4, and they are highly significant. The associated WTP estimates calculated by Equation (7) are shown in Table 5. The estimated average monthly WTP is around ISK 6,300 per group and ISK 4,100 per person. The average WTP per person per hour and per trip is almost ISK 1,000.[24]

(Table 4 about here)

(Table 5 about here)

Next, we estimated the proposed model with endogenous time on-site. Table 6 shows the parameter estimates and associated t-values from the Poisson gamma log-normal mixture model given by Equation (13), and the demand specifications in Equations (14) and (15). There is a significant and negative relationship between the price and number of trips, i.e., when the price of a trip increases, the user takes fewer trips. Furthermore, there is a negative relationship between the price of time on-site and the number of trips, i.e., with increasing shadow price of time, the user takes fewer trips. There is also a significant and positive relationship between the price of trips and the average time on-site. Thus, as the price of travel increases, an individual will take fewer trips, but spend more time on-site during each trip. Finally, as the price of time on-site increases, the time on-site decreases.

[23] See the online supplementary material for proofs of homogeneity and a proof of the no symmetry condition between n and t.

[24] The average exchange rate for the year 2015 was ISK 130 = US$ 1.

(Table 6 about here)

Table 7 shows the estimates of the Cholesky matrix and the covariance between the number of trips and time on-site. All estimates are statistically significant, which demonstrates the importance of allowing for non-zero covariance between the two stages of the model.

(Table 7 about here)

Table 8 shows the estimated uncompensated price elasticities and the associated *t*-values for the number of trips, time spent on-site, and total duration of recreation. The elasticities, except for the cross-price elasticity between total duration of recreation and the price of a trip, are significant at the 5% level of significance.

A 1% increase in the price of a trip reduces the frequency of trips by 0.31% and increases the average time on-site by 0.26%. The cross-price elasticity between price of time on-site and the number of trips indicates that a 1% increase in the price of time on-site reduces the number of trips by about 0.14%, i.e., time on-site is a gross complement to the number of trips. The cross-price elasticity between time on-site and the price of a trip is positive, i.e., the number of trips and time on-site are gross substitutes.

(Table 8 about here)

Table 9 shows the WTP for the model with endogenous time on-site as calculated by Equation (19). The estimated average monthly WTP per group is more than ISK 15,200 (or US$ 117), the average monthly WTP per person is almost ISK 9,800 (or US$ 70), and the average WTP per person per hour per trip is more than ISK 3,100 (or US$ 24). These WTP estimates are more than twice as high as the estimates of the model with exogenous time on-site, and they show that the standard single-site travel cost model, anyway in our case, underestimates the welfare effects substantially.

(Table 9 about here)

6. Conclusions

The travel cost method has some limitations for estimating the demand and WTP for access to centrally located urban parks where a large part of the benefits are related to time on-site. In the standard single-site travel cost model, it is assumed that all users spend the same time on-site. This is less plausible for local urban parks than for large national parks, where there is much less variation in time spent on-site among individuals. We add to the travel cost literature by allowing time on-site to be endogenously determined and reflected in the welfare estimates. A WTP measure that accounts for time on-site have been developed. Our measure differs from the measure of the standard single-site model where time on-site is treated as an exogenous variable. Our WTP measure depends on the substitution pattern between the number of trips and time on-site as well as their relative income effects. Our measure collapses into the measure of the standard model when time spent on-site is treated as a constant. Therefore, when it comes to the issue of time endogeneity, the WTP estimates from the standard single site travel cost model provide perfectly good approximations in cases where there is little variation in time spent on-site among individuals.

We estimated the demand for duration of recreation as a two-part model that allows for correlation between the decisions of how many trips to take and how much time to spend on-site. The frequency was modeled with a Poisson log-normal count model, and the length of stay was modeled with a gamma log-normal model that only allows non-negative values. The likelihood function does not have a closed form solution. Therefore, it was approximated by using Gauss-Hermite integration, and it was optimized with the numerical DQN method.

The proposed model results in substantially higher WTP estimates than the standard single-site model. In the standard model, the estimated average monthly WTP per group was approximately ISK 6,300 as compared with ISK 15,200 in our model. This difference indicates the importance of allowing for endogenous time on-site to capture the full social value of urban parks. We also found substantial trade-offs between the number of visits and time on-site. The magnitudes of these trade-offs depend on the price of a trip and the price of spending time on-site. The high WTP values suggest that Heiðmörk provides large benefits for the population in Iceland's capital area.

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Table 1. Definitions of Uncompensated Demand Elasticities

Variable	Own-Price Elasticity	Cross-Price Elasticity	Income Elasticity
Trips: n	$\epsilon_n = \frac{\partial n}{\partial p_n}\frac{p_n}{n}$	$\epsilon_{n,t} = \frac{\partial n}{\partial p_t}\frac{p_t}{n}$	$\epsilon_{n,Y} = \frac{\partial n}{\partial Y}\frac{Y}{n}$
Time spent on-site: t	$\epsilon_t = \frac{\partial t}{\partial p_t}\frac{p_t}{t}$	$\epsilon_{t,n} = \frac{\partial t}{\partial p_n}\frac{p_n}{t}$	$\epsilon_{t,Y} = \frac{\partial t}{\partial Y}\frac{Y}{t}$
	Trip-Price Elasticity	Time-Price Elasticity	Income Elasticity
Recreation: x	$\epsilon_{x,n} = \epsilon_n + \epsilon_{t,n}$	$\epsilon_{x,t} = \epsilon_{n,t} + \epsilon_t$	$\epsilon_{x,Y} = \epsilon_{n,Y} + \epsilon_{t,Y}$

Table 2. The Qualitative Effects of Uncompensated Demand Elasticities on WTP

Equation (10)	Demand Elasticity	Effect on WTP
Part (a)	$\epsilon_{t,n} = 0$	$\int n(1-\epsilon_{t,n})dp_n = \int ndp_n$
	$\epsilon_{t,n} > 0$	$\int n(1-\epsilon_{t,n})dp_n < \int ndp_n$
	$\epsilon_{t,n} < 0$	$\int n(1-\epsilon_{t,n})dp_n > \int ndp_n$
Part (b)	$\epsilon_t = 0$ or $\frac{p_n}{tp_t} \to 0$	$\int x\left(1-\frac{p_n}{tp_t}\epsilon_t\right)dp_t = \int xdp_t$
Part (c)	$\epsilon_{t,Y} = 0$	$\int \frac{np_n}{Y}\epsilon_{t,Y}dY = 0$

Table 3. Summary Statistics of Variables

Variable	Description	Mean	Std. Dev.	Min	Max
Trips, n	Number of trips taken last calendar month	4.20	5.95	0.00	31.00
Hours, t	Time spent on-site	1.30	0.90	0.05	7.50
Travel cost, p_n	Travel cost per group (scaled by a factor 1/1000 in ISK)	0.62	0.42	0.00	6.38
Time cost, p_t	Time cost per group (scaled by a factor of 1/1000 in ISK)	0.88	0.59	0.15	6.15
Adults	Number of adult visitors per group	1.56	0.65	1.00	6.00

Table 4. Estimation Results, Poisson Model

	Estimate	t-ratio
Constant	1.75***	73.16
Travel cost, p_n	-231.46***	-14.72
Log likelihood	-6669.00	

Note: Significance code: *** denotes significance at the 1% level.

Table 5. WTP Estimates in ISK, Poisson Model

	Estimate	95% Confidence Interval	
Per group	6,339***	6,271	6,407
Per person	4,063***	4,019	4,107
Per person per hour per trip	968***	958	978

Notes: The first row shows the average monthly WTP per group. The second row shows the average monthly WTP per person and the third row shows the average WTP per person per hour per trip. The confidence intervals are calculated using the delta method. Significance code: *** denotes significance at the 1% level.

Table 6. Estimation Results, Poisson Gamma Log-Normal Mixture Model

	No of Trips		Time on Site	
	Estimate	t-ratio	Estimate	t-ratio
Constant	1.09***	12.06	0.07*	1.79
Travel cost, p_n	-211.18***	-5.36	172.57***	6.36
Time cost, p_t	-65.47**	-2.30	-51.69***	-3.82
Log likelihood	-5456.50			

Notes: The standard deviations are estimated using a sandwich estimator. The travel cost and time cost parameters are scaled by 421.1. Significance codes: *** denotes significance at the 1% level, ** significance at the 5% level, and * significance at the 10% level.

Table 7. Cholesky Factors and Covariance Estimates

	Estimate	t-ratio
L1	-1.27***	-44.69
L12	0.20***	6.91
L2	-0.18***	-6.23
cov(*n,t*)	-0.26***	-6.83

Notes: L1, L2, and L12 are the Cholesky factors from the lower triangular Cholesky matrix. Standard deviations are estimated using a sandwich estimator. The *t*-value of cov(*n,t*) is calculated using the delta method. Significance code: *** denotes significance at the 1% level.

Table 8. Estimated Price Elasticities, Poisson Gamma Log-Normal Mixture Model

	No of Trips		Time on Site		Duration	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Travel cost, p_n	-0.31***	-5.36	0.26***	6.36	-0.06	-0.81
Time cost, p_t	-0.14**	-2.30	-0.11***	-3.82	-0.25***	-4.21

Notes: The *t*-values are calculated using the delta method. Significance codes:
*** denotes significance at the 1% level and ** significance at the 5% level.

Table 9. WTP Estimates in ISK, Poisson Gamma Log-Normal Mixture Model

	Estimate	95% Confidence Interval	
Per group	15,243***	13,618	16,868
Per person	9,771***	8,729	10,813
Per person per hour per trip	3,128***	2,794	3,461

Notes: The first row shows the average monthly WTP per group. The second row shows the average monthly WTP per person and the third row shows the average WTP per person per hour per trip. The confidence intervals are calculated using the delta method. Significance code: *** denotes significance at the 1% level.