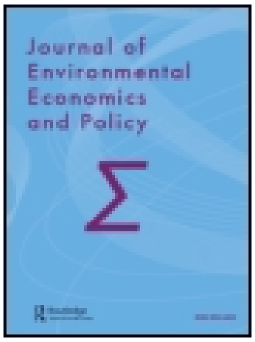

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Recreation demand and pricing policy for international tourists in developing countries: evidence from South Africa

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ABSTRACT

National park agencies in Africa often lack incentives to maximize revenue, despite the decline in conservation subsidies from the State. We explore the potential of pricing policy to generate funds for extensive conservation. We estimate recreation demand by international tourists for a popular South African park, calculate the consumer surplus and find the revenue-maximizing entrance fee. Our results suggest substantial underpricing and therefore significant forgone income. By charging low fees at popular parks despite increasing conservation mandates and declining conservation subsidies, national parks in developing countries are forgoing substantial revenue crucial for combating widespread biodiversity losses.

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1. Introduction

Despite the increase over time in tourism in Africa (UNWTO 2011, 2017), national parks and other protected areas have remained financially strained, and continue to rely on fiscal transfers from the State to fund conservation activities (Inamdar et al. 1999; McRae 1998; Whitelaw, King, and Tolkach 2014). There has been an increasing call for African governments to focus on people-oriented national objectives, such as access to education, energy, water and sanitation, and health, and to tackle the high levels of unemployment and poverty in their countries. The result has been a general decrease in funds apportioned for conservation. Several African governments, for example South Africa, Zimbabwe and Botswana, are reducing funding to national parks (see Child 2017; Hwari 2017; Nkala 2017). This threatens the existence of protected areas (see McRae 1998). Yet African tourism is based largely on wildlife and wilderness resources. The decline of protected areas also threatens associated opportunities for social progress through job creation, enterprise development, infrastructure development, and forex earnings.

Conservation requires significant funding. One important cost relates to local communities' conservation roles in and around protected areas. In many African contexts, these roles—whether direct or indirect—are critical for the effectiveness of protected areas. Authors such as Hansen

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and DeFries (2007) observe that many protected areas are not successfully conserving biodiversity, often despite adequate management within their borders, because of the expansion and intensification of land use in the adjoining areas. Land use at the periphery of protected areas can alter ecological functions inside protected areas and result in biodiversity loss, as a protected area is almost always part of a larger ecosystem (Muchapondwa et al. 2012). Given the competing land-use options at their disposal, local communities must be given incentives to be proactive about the integrity of protected areas. In the past, schemes to compensate local communities for their proactive role in conservation or their losses from conservation have been inadequate, leading increasingly to community apathy towards community-based conservation activities (Adams and Infield 2003; Fischer, Muchapondwa, and Sterner 2011). When local communities benefit from their conservation efforts, there is a double dividend: conservation wins, and so do sustainable rural livelihoods (Muchapondwa 2003). The call for sustainable financing for protected areas is in many ways a call for more action on the people-oriented national objectives to which African governments are increasingly paying more attention.[1]

In this paper, we explore the potential of pricing policy to generate funds for extensive conservation. Park pricing as a tool for natural resource management is still under-utilized, partly because revenue-maximizing behaviour is not the usual culture of park administrators, as most professional rewards are tied instead to program development (Laarman and Gregersen 1996). Yet international tourists are often willing to pay higher entrance fees (Naidoo and Adamowicz 2005; Pandit, Dhakal, and Polyakov 2015), provided these are earmarked for conservation and park management (Baral, Stern, and Bhattarai 2008; Buckley 2003; Dikgang, Muchapondwa, and Stage 2017). An appropriate pricing policy can help fulfill conservation objectives, incentivize local communities to take a proactive conservation role and support tourism-related activities in surrounding areas, free up public finances for important social programs, and subsidize land-dispossessed local communities. Although South African national parks already charge different entrance fees based on a tourist's country of origin, we focus on entrance fees for international tourists.[2,3] Charging lower entrance fees to locals in a developing-country context can be justified on the grounds that locals—especially those living in the vicinity of parks—already bear a substantial portion of the cost of the parks' existence in terms of forgone alternative productive uses, such as agriculture or logging (Lindberg and Lindberg 1991). Furthermore, many African national parks were created by the direct displacement of local communities. In addition, locals as a group pay domestic taxes.

The key ingredient in securing sustainable financing from the State, civil society organizations, and park users in developing countries is knowledge of the use and non-use values of protected areas (Voltaire 2017). However, use values are easier for public policymakers to accept. For this reason, special attention has been given to deriving use values from revealed preference valuation methods, such as travel-cost models, albeit with the primary aim of demonstrating the recreational value of these spaces (see for example Brown 1993; du Preez and Hosking 2011; Hatfield and Malleret-King 2007; Krug 2000; Navrud and Mungatana 1994). What is lacking in the literature are studies that go further and derive appropriate user fees associated with computed use values, as user fees should not necessarily deplete consumer surplus.[4] This paper closes that gap, using the case study of Kruger National Park (KNP) in South Africa. In this paper, we estimate the recreation-demand function for international tourists, derive the associated use values, and find the implied revenue-maximizing park-entrance fee.

Most travel-cost studies have had limited influence on pricing policy, as they are primarily concerned with estimating the consumer surplus in order to demonstrate the value of the resource. Some also infer the change in entrance fees that will be tolerated by visitors. However, consumer surplus is often related to several attributes and, as such, entrance fees inferred from the consumer surplus can be imprecise or too high for practical use. In this paper, we distribute the consumer surplus across several park attributes to derive the portion related to the entrance fee, a method that is appropriate for making policy decisions.

The treatment of multiple-site visitors in the literature has also varied. Some studies use the fraction of time spent at a site to apportion the total-trip consumer surplus across multiple sites (see

Navrud and Mungatana 1994), while others use the share of visitors with a high national park affinity (see Mayer and Woltering 2018). It is not always the case that time spent at any particular site correlates with visitors' preferences for that site, as logistics are also a factor in tourists' decisions. In this paper, we apportion total-trip consumer surplus across sites using the reported percentage of total-trip enjoyment derived from visiting a particular site. Our measure is much better than previous objective approaches as its subjectivity relates directly to the utility functions of visitors.

Lastly, the travel cost literature has tended to use the number of previous trips to the park as the dependent variable (see for example Englin and Shonkwiler 1995b; Hellerstein 1991; Shrestha, Seidl, and Moraes 2002). Despite its continued use in the literature, such an approach has long been recognized as only appropriate where visits to the site are of the same duration (Kealy and Bishop 1986; Smith and Kopp 1980). Trip length is nonhomogeneous in cases where visitors travel substantial distances, and thus spend more time on site compared to visitors coming from closer to the site (Smith and Kopp 1980). The days visitors have available for recreation will tend to be much more homogenous than the length of the trip would (Hof and King 1992). According to Font (2000, 98), ' … the paucity of multiple observations in the demand curve econometrically estimated from data on visitors, because individuals often visit the recreational area once … ' is a major deficiency of the individual travel cost method based on trips. In the current paper, we address this issue by using the number of days on site as the dependent variable. This approach has been applied occasionally in the literature (see Bell and Leeworthy 1990; Burt and Brewer 1971; Hof and King 1992; Kealy and Bishop 1986; Mendes and Proença 2011; Mulwa, Kabubo-Mariara, and Nyangena 2018). We argue that it has an advantage, since the number of recreational days at the site offers better information about recreational demand by international tourists than the number of previous trips.

2. Background

The South African national park system is one of the cornerstones of the country's tourism economy. The South African National Parks (SANParks), the national parks agency, manages 19 national parks (including KNP) with a total area of just over four million hectares (KNP covers nearly two million hectares), comprising 67% of the protected areas under state management (SANParks 2019). About 7 million tourists (domestic, regional and international) visit SANParks national parks each year. It costs about $180 million annually to run South African national parks and SANParks received transfers equivalent to about 28% of its total expenditure during the 2018/19 financial year. Government funding for SANParks has been greatly reduced and is increasingly project-based, meaning SANParks must foot the bill for its own operational costs (SANParks 2019). SANParks is the biggest tourism product owner in the country, and manages tourism and conservation infrastructure worth close to $726 million (SANParks 2016). The financial performance of the national parks under SANParks management is thus crucial, both to the sustainability of SANParks and to its ability to fulfill its conservation obligations.

However, only five of the 19 SANParks-managed national parks currently generate a surplus, of which KNP is one (SANParks 2014). KNP generated an annual surplus of over $14 million (about 50% of SANParks' entire surplus) during the 2018/19 financial year and contributed 39% of SANParks' total revenue (SANParks 2019). The park is therefore also important for its ability to cross-subsidize other national parks, which are not financially viable but contain important biodiversity. In terms of tourism, KNP has developed a significant profile over time, with more than 1.89 million tourists visiting in 2018/19; around 20% of these are classified as international tourists (SANParks 2019).[5] The park's existence is important for more than conservation, as it supports a variety of tourism-related economic activities in the surrounding areas (Saayman, Rossouw, and Saayman 2012; Saayman and Saayman 2006).

KNP is a world-renowned park, and was first established in 1898. The park is the SANParks' flagship and offers a unique wildlife experience; it is popular among tourists for its big game sightings and large expanses of wilderness. It offers game drives, bush walks (including tracking rhinoceros, elephant and lion on foot), foot safaris and wilderness trails. The park is home to the 'big five' game animals, namely lion, leopard, elephant, buffalo, and rhinoceros. It contains nearly 2 000 plant species, about 150 species of mammals (including many large predator and grazing species), 50 fish species, over 500 bird species, 34 amphibian species and 116 reptile species (SANParks 2008). KNP offers a rare opportunity for visitors to see animals in their natural habitat, given its isolation from major developments—a big pull factor for tourists. The park is significant for conservation, and is part of the Kruger to Canyons Biosphere Reserve, designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as part of the Man and the Biosphere Programme.[6]

However, wildlife crime continues to be SANParks' most serious problem. The increase in poaching activity in KNP and other parks managed by SANParks has further increased pressure on financial resources, including those required for law enforcement. KNP has been more affected by rhinoceros poaching than any other African park.[7] Tourism is therefore important for generating the financial resources needed for antipoaching enforcement. In addition, the size of the national park estate has been increasing over time, in line with the South African government's objective of increasing the total size of protected areas. While SANParks' land acquisition is funded through a land acquisition grant from the State, the resultant increased size of the park estate gives rise to higher operating expenses. Increases in the budget allocation from the State for operating expenses have not kept pace with the increase in the size of SANParks' estate. However, transfers from the State remain an important source of funding for SANParks' conservation activities.

Given the high levels of poverty, inequality and unemployment in South Africa (and in Africa in general), increasing national parks' reliance on user charges could free government resources for these urgent priorities. In some ways, this is already happening, as fiscal transfers for the environment have declined over time. In South Africa, increasing revenue from user charges—particularly since 2003, when SANParks adopted a new pricing policy—have helped fill the funding gap for conservation in the SANParks' estate, and have even subsidized local communities who had previously been moved to make room for the park (Dikgang and Muchapondwa 2017a).

3. Methodology

Since there is little variation in entrance fees over time, we use the individual travel cost method (ITCM) proposed by Brown and Nawas (1972) to derive a recreation-demand function from which to estimate the economic benefits received by site visitors. The ITCM makes use of variations in individual travel costs to the site and visitation rates to estimate the recreation demand curve.[8] As travel cost and other recreational costs increase, visitation rates are expected to decrease. The recreation-demand model is specified as follows:[9]

$$d_i = f(tc_i, \boldsymbol{x}_i, \epsilon_i) \tag{1}$$

where d_i is the number of recreation days on the current trip for the ith visitor, and tc_i is the cost of traveling to the park. $\boldsymbol{x}_i$ is a vector of visitor-specific factors that influence the number of days spent at the site, and ϵ_i is an independent random disturbance term. The set $\boldsymbol{x}_i$ captures various socio-economic and demographic variables of the participants, such as age, gender, education, and annual household income, and other variables, such as the quality of the recreational experience as perceived by the tourist.

The consumer surplus (cs) is found by integrating equation (1):

$$cs = \int_{tc^0}^{tc^1} f(tc_i, \boldsymbol{x}_i, \epsilon_i)\mathrm{d}tc \tag{2}$$

where tc^0 is the individual's trip cost and tc^1 is the choke price. The consumer surplus per day (cs_D) can be computed as $cs_D = -1/\hat{\beta}_{\mathrm{tc}}$, where $\hat{\beta}_{\mathrm{tc}}$ is the parameter estimate on the travel cost variable.

Following Bell and Leeworthy (1990), Burt and Brewer (1971), Hof and King (1992), Kealy and Bishop (1986), and Mendes and Proença (2011), we use the number of days on site as the dependent variable. Such a formulation has the advantage that it represents a homogeneous recreation-demand relationship, in that the dependent variable is a single recreation day rather than trips of different lengths (Mendes and Proença 2011). The use of recreation days as the dependent variable has long been shown to be consistent with utility maximization theory, if one estimates the relationship as a function of net variable costs per day, including the opportunity cost of on-site time (McConnell 1975).[10]

3.1. Valuing recreation time and multi-site visits

There is substantial literature on how to incorporate the opportunity cost of time spent traveling to a recreational site (see for example Cesario 1976; Feather and Shaw 1999; Fezzi, Bateman, and Ferrini 2014).[11] In order to arrive at an accurate measure of the recreation cost for each day of stay, we add the opportunity cost of travel time to the out-of-pocket travel cost. The opportunity cost is calculated as a fraction ($0 < \varphi \leq 1$) of the wage rate multiplied by the round-trip travel time (see Amoako-Tuffour and Martínez-Espiñeira 2012; Englin and Shonkwiler 1995b; Fezzi, Bateman, and Ferrini 2014).[12] When it comes to on-site time, we assume the opportunity cost of time spent on site is the same as that of time spent traveling, even though this may vary across individuals (Cesario 1976; Mendes and Proença 2011).

Multiple-site visitors create a difficulty in travel-cost models. Researchers have dealt with this issue differently. Our approach is related to that of Navrud and Mungatana (1994) who calculate the recreational value of flamingo viewing in Lake Nakuru National Park in Kenya based on the proportion of time spent viewing and photographing flamingos. They use a three-step procedure. First, they calculate recreational value per visitor and per visitor day for an entire trip in Kenya, using the estimated demand functions. Next, using the portion of time spent in the park under consideration, they derive the recreational value of the tourist's stay in that park. Following this, they calculate the recreational value of flamingo viewing in the park based on the portion of time spent viewing and photographing flamingos. In the current paper, we use the reported percentage of total trip enjoyment derived from visiting KNP to derive the recreational value associated with the park. Our measure is directly related to the utility function of the individual and is superior to approaches that try to impose some parameters on the individual's utility function.

3.2. Data description

We make use of data collected through on-site sampling of international tourists at KNP in July 2014. The questionnaire was piloted in March and April 2014, and subsequently modified. A team of interviewers randomly approached tourists at the different campsites in the park—usually after breakfast or lunch, to minimize disruption of participants' activities.[13] Tourists interviewed had spent at least a day in the park, and had actual experience of the recreational activities. Tourists were first briefly interviewed, mainly about their country of residence, and then asked to participate in the entire survey if they were overseas tourists.[14]

The data collected includes round-trip travel cost, other trip-related costs, total number of people from the same household traveling together, country of origin, and a number of demographic variables. The survey also included questions on the tourists' views about the protection of wildlife and wildlife habitat by public authorities around the world, the duration of the current visit, income, and other sites visited during the same trip, including the recreation days spent in each of these sites. Respondents were also asked specifically about the round-trip travel cost to KNP, and to state the percentage of total trip enjoyment or utility derived from visiting KNP, as well as from other sites visited on the current trip. We ascertain the proportion of the round-trip travel cost attributed to visiting KNP based on the self-reported percentage of total trip enjoyment derived from visiting KNP, as well as the number of days spent at KNP. On average, respondents attribute about 48% of total trip enjoyment to the KNP visit.

Table 1 presents the summary statistics of the variables used in the analysis. On average, international tourists spent 3.23 days at the park during the current trip. The sample includes tourists from 18 different countries, including the United States, Canada and Australia, with 35% coming from the Netherlands, 21% from the U.S., 9% from Germany, 8% from the United Kingdom (UK), 6% from Belgium, 5% from France, and 3% each from Australia and Spain. The other countries in the sample have fewer than 3% of respondents each. Our sample is in line with official tourist statistics for KNP available from the SANParks guest demographics gate access system (SANParks 2013). The average respondent age in the sample is 41 years with a standard deviation of 16 while the average size of each tourist group is 1.73 with a standard deviation of 1.67. The mean household income in the sample is \$96 917,[15] with a standard deviation of \$57 912. In terms of household income, 19% had an annual household income between zero and \$50 000, about 47% had an income between \$50 001 and \$100 000, 29% had an income between \$100 001 and \$200 000, and 6% had an income above \$200 000. Our sample is gender balanced, with 49% male respondents. In terms of education, 18% of the tourists reported having only a primary or high school education, 18% had a college certificate or diploma, 32% had an undergraduate degree and 32% had a postgraduate degree. The respondents report a high level of wildlife interest, with 22% reporting that they are 'interested' in wildlife while 66% reported they were 'greatly interested' and only 12% reported levels of interest below these two levels. The reported tour satisfaction was also high, with 38% reporting that the tour satisfaction was 'better than expected' while 37% reported a 'much better than expected' experience and 25% reported levels of tour satisfaction below these two levels. A majority of the tourists (67%) were on a tour package.

There are three interesting facts worth emphasizing. The great majority of recreationists (265 out of 300) had not been to KNP during the five years preceding the survey. The average number of days the typical visitor spends at the recreational site is 3.23, with a variance almost three times the mean. The majority of tourists stay at KNP between one and four days.

3.3. Model specification and variable definitions

In this subsection, we present the recreation-demand model to be estimated, and discuss in detail how each of the variables in our model is constructed. We assume that participation in recreation entails two distinct types of cost. The first component of cost is the travel cost (*travcost*), which is an upfront cost before the consumption of any recreation activity.[16] The second type of cost is the on-site cost per day (*expenses*) which can also be treated as the marginal cost of each recreation day.[17]

Table 1. Summary statistics of variables used in the econometric model ($n = 300$).

Variable Description	Mean	SD	Min	Max
Number of recreation days spent at KNP on current trip (*RDAYS*)	3.23	3.04	1	27
Total trip cost including travel in US\$	4 207	2 399	980	25 200
Round-trip travel cost in US\$	1 584	898	335	8 500
Round-trip travel cost per day in US\$ (*travcost*) ($\varphi = 1/3$)	430	431	38	2 988
On-site expenses per day in US\$ (*expenses*) ($\varphi = 1/3$)	705	505	179	3 305
Round-trip travel cost per day in US\$ (*travcost*) ($\varphi = 3/4$)	525	504	46	3 372
On-site expenses per day in US\$ (*expenses*) ($\varphi = 3/4$)	929	507	314	3 437
Age[a]	41	16	16	81
Mid-point of household income brackets in US\$ (*income*)	96 917	57 912	25 000	250 000
Accompanying household members (*party size*)	1.73	1.67	0	8

US\$ – United States Dollars.

[a]It can be argued that adults are more realistic in their personal valuations of their recreational experiences given their budget constraints, because only adults have income. However, we believe that children also have preferences for recreational value. Navrud and Mungatana (1994) argue that excluding children would result in underestimation of the recreational value of the park.

We therefore estimate the following recreation demand model:

$$RDAYS = f(travcost,\ expenses,\ age,\ age^2,\ gender,\ income,\ education,\ satisfaction,\ wildlife\ interest,\ package,\ party\ size) \quad (3)$$

where *RDAYS* is the number of recreation days spent at KNP on the current trip. The variable *travcost* in equation (3) represents explicit and implicit travel costs for each recreation day, while *expenses* represents explicit and implicit on-site costs for each recreation day. The total recreation cost per day for individual *i* ($TCOST_i$) is then given as the sum of *travcost* and *expenses*:

$$TCOST_i = \underbrace{\frac{RTC_i}{RDAYS_i}\gamma_{KNP_i} + \frac{TTC_i}{RDAYS_i}\gamma_{KNP_i}}_{\zeta} + \underbrace{\frac{OCS_i}{RDAYS_i}\gamma_{KNP_i} + STC_i}_{\xi} \quad (4)$$

The first term on the right-hand side (RHS) in equation (4) is the out-of-pocket round-trip travel cost per day for KNP. RTC_i is the out-of-pocket round-trip travel cost paid by the tourist to get to South Africa from wherever their vacation trip started. This is divided by $RDAYS_i$, and then scaled by γ_{KNP_i} (the self-reported subjective utility or enjoyment derived from visiting KNP–$0.05 < \gamma_{KNP_i} \leq 1$) to derive the proportion of the travel cost for KNP, since respondents report visiting other sites.[18] The self-reported subjective utility is constructed such that it sums up to 1 ($\gamma_{KNP_i} + \gamma_{SA_i} + \gamma_{Other_i} = 1$), where γ_{SA} is enjoyment from other sites within South Africa and γ_{Other} is enjoyment from sites outside South Africa.

The second RHS term in equation (4) is the opportunity cost of travel time per day (TTC_i), scaled by days at KNP and enjoyment at KNP. The term ζ therefore represents both explicit and implicit travel costs (*travcost*) for each recreation day. The third RHS term in equation (4) captures the explicit on-site cost per day for KNP. This includes lodging, food, meals and entrance fees, and OCS_i is taken as the total expenditure on the whole trip less the round-trip travel cost. The last RHS term captures the opportunity cost of on-site time per day (STC_i). The term ξ therefore represents both explicit and implicit on-site costs (*expenses*) for each recreation day.

The opportunity cost of travel time is calculated as:

$$TTC_i = \varphi w_j h_T$$

where w_j is the average hourly wage in country *j* (or state *j*, in the case of the US) and h_T is the round-trip travel time in hours. The value of travel time is taken as a fraction ($0 < \varphi \leq 1$) of the wage rate. The opportunity cost of on-site time (*STC*) is constructed similarly, with h_T denoting the recreation time spent on site. We derive the imputed hourly wage by dividing annual income by the number of hours worked in the year 2013. The annual hours worked and annual income data for Europe is obtained from the Organization for Economic Co-operation and Development (OECD), while the corresponding US data for each state is obtained from the US Bureau of Labor Statistics. We make a simplifying assumption that all the tourists from the same country (or state, for the US) work the same number of hours annually; and even if they are paid different amounts, we assume they are paid in the same manner.

In order to calculate the round-trip travel time h_T from the place of residence to KNP, we use the shortest flight path from the place of residence to KNP. This rules out any individual inclination for a specific itinerary, as in Mendes and Proença (2011). An obvious weakness with this approach is that the shortest flight path implies taking the most direct flight; in most cases, this tends to be more costly. The typical tourist would possibly consider the travel time as well as seeking to avoid costly direct flights, but there are limits to their ability to do so. In trying to get an accurate measure of travel time, we also approximate the distance traveled by the tourist from his place of residence to the nearest airport. This is then converted into time, at an assumed average driving speed of 80 km/hour. For time spent on site, we make use of the reported number of recreation days the tourist is staying at the park, after considering that, in a typical day at KNP, one is normally awake for about 16 km/hour (Mendes and Proença 2011).[19]

The income variable is taken as the mid-point of the annual household income bracket. In most travel cost studies, income often has a weak effect. Many studies find it negative and significant (Creel and Loomis 1990; Grogger and Carson 1991) or insignificant (Englin and Shonkwiler 1995b), while in other studies it is positive and significant (Amoako-Tuffour and Martínez-Espiñeira 2012; Egan and Herriges 2006; Englin and Shonkwiler 1995a; Martínez-Espiñeira and Hilbe 2008). In Sarker and Surry (2004), income has a positive sign but is insignificant. We expect income to have a positive effect on the number of recreation days spent at the site (see Simões, Barata, and Cruz 2013).[20]

The level of educational attainment (*education*) ranges from primary and high school to post-graduate degree. We expect the effect of the level of education to be positive *a priori*, even though Englin and Shonkwiler (1995b) and Shrestha, Seidl, and Moraes (2002) find a negative effect. We also make use of the information regarding the number of accompanying household members on the trip (*party size*). Additional variables are *package*, which is a dummy variable controlling for whether the trip is part of a tour package or self-organized, and *satisfaction*, which measures the tourist's tour experience on a scale from 1 (much worse than expected) to 7 (much better than expected).[21] The variable *wildlife interest* ranks the views of the respondents on wildlife protection on a scale from 1 (not at all interested) to 7 (greatly interested). The variable *age squared* is a quadratic term for age.

Equation (3) is estimated with both $\varphi = 1/3$ and $\varphi = 3/4$ where φ is the fraction of the wage rate used to value recreation time. We also estimate equation (3) using *TCOST* as the variable of interest in place of *travcost* and *expenses*.

4. Results and discussion

The recreation-demand model presented in equation (3) was estimated using negative binomial models. Table 2 presents estimates for the different models. Results in Table 2 (columns I and II) use 1/3 of the wage rate while those in columns III and IV use 3/4 of the wage rate to value recreation time. Judging by the signs and magnitudes of the coefficients presented in Table 2, the different models appear highly robust. There are no sign changes across the specifications, and only the statistical significance of some marginally significant variables change. The overdispersion test also supports our use of the negative binomial class of models. From Table 2, we also note that the model selection criteria and goodness of fit tests do not suggest large differences between the different specifications.

From the generalized negative binomial model controlling for truncation, overdispersion and endogenous stratification (GTSNB) in Table 2, we note that *travcost* has the expected negative sign and is significant at the 1% level. The variable *income* has a positive sign as expected and is statistically significant at the 5% level. The education variables are insignificant. Higher levels of reported satisfaction are associated with longer stays at the site, while the level of wildlife interest has no impact on the duration of the visit. In theory, we would expect tourists who care more about wildlife protection and habitats to engage in longer visits at the site.

The binary variable *package* has a negative sign and is significant at the 1% level. This indicates the restrictions imposed on tourists when they opt for a package, in which case they cannot alter the package offered by the tour operator. The variable *party size* has the expected negative sign, and is statistically significant at the 1% level. We interpret this as indicating that—since a large party size is likely to cost significantly more, and is also possibly more complicated to plan—a much larger party size will therefore tend to lower the duration of the visit. In Table 3, we re-estimate equation (3) using an alternative measure of travel cost (*TCOST*) which combines both explicit and implicit onsite and roundtrip travel costs. The major difference here is the magnitude of the coefficient on the travel cost variable.

Table 2. Negative Binomial Estimates.

	(I) TSNB	(II) GTSNB	(III) TSNB	(IV) GTSNB
Travcost	−2.181***	−2.221***	−2.037***	−2.079***
	(0.337)	(0.341)	(0.293)	(0.304)
Expenses	−0.328*	−0.301	−0.160	−0.126
	(0.199)	(0.197)	(0.171)	(0.173)
Age	−0.011	−0.012	−0.009	−0.010
	(0.017)	(0.017)	(0.016)	(0.016)
Age squared	0.0002	0.0002	0.0002	0.0002
	(0.000)	(0.000)	(0.000)	(0.000)
Gender (1 if male)	−0.198*	−0.143	−0.199*	−0.154
	(0.112)	(0.131)	(0.111)	(0.129)
Income	0.183**	0.236**	0.167**	0.216**
	(0.085)	(0.116)	(0.084)	(0.105)
College certificate/diploma	−0.051	−0.064	−0.048	−0.058
	(0.153)	(0.155)	(0.148)	(0.149)
Undergraduate degree	0.023	0.019	0.037	0.032
	(0.152)	(0.156)	(0.150)	(0.153)
Postgraduate degree	−0.038	−0.064	−0.026	−0.050
	(0.161)	(0.166)	(0.158)	(0.162)
Wildlife interest: interested	−0.029	−0.048	−0.034	−0.056
	(0.168)	(0.166)	(0.167)	(0.166)
Wildlife interest: greatly interested	0.205	0.189	0.196	0.179
	(0.155)	(0.157)	(0.153)	(0.156)
Satisfaction: better than expected	0.001	0.001	0.007	0.006
	(0.119)	(0.120)	(0.116)	(0.117)
Satisfaction: much better than expected	0.317**	0.319**	0.325**	0.325**
	(0.141)	(0.144)	(0.138)	(0.141)
Package (1 if on tour package)	−0.539***	−0.528***	−0.533***	−0.523***
	(0.111)	(0.109)	(0.107)	(0.106)
Party size	−0.071***	−0.075***	−0.069***	−0.073***
	(0.027)	(0.028)	(0.026)	(0.027)
Constant	1.662***	1.686***	1.684***	1.720***
	(0.409)	(0.454)	(0.405)	(0.443)
α	0.158***		0.150***	
	(0.057)		(0.054)	
Age		0.021		0.023
		(0.023)		(0.025)
Gender		−0.442		−0.400
		(0.876)		(0.882)
Income		−0.374		−0.358
		(0.746)		(0.680)
Constant		−2.248		−2.437
		(1.822)		(1.915)
AIC	1000	1005	995	1000
BIC	1063	1079	1058	1074
Chi-squared	189	168	191	178
Log lik.	−483	−483	−481	−480
Observations	300	300	300	300

Note: Dependent variable is *RDAYS*. TSNB – Truncated and endogenously stratified negative binomial, GTSNB –Generalized truncated and endogenously stratified negative binomial. The parameter α shows the presence of overdispersion. Columns I and II show results when the opportunity cost of recreation time is taken as 1/3 while columns III and IV use 3/4. Robust standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% level, respectively. The variable *income* is divided by 100 000 while the variables *travcost* and *expenses* are divided by 1000 to avoid too many zeros on the regression coefficients.

Table 4 presents the consumer surplus estimates along with the 95% confidence intervals. The individual consumer surplus per day is $450, and ranges from $346 to $644 for the preferred specification in Table 2, with travel time valued at 1/3 of the wage rate. When travel time is valued at 3/4 of the wage rate, the consumer surplus per day is $481. The total number of international tourists to KNP for 2014 was 368 399. The implied annual recreational value for international tourists to

Table 3. Negative Binomial Estimates.

	(I) TSNB	(II) GTSNB	(III) TSNB	(IV) GTSNB
TCOST	−1.02***	−1.01***	−0.92***	−0.92***
	(0.147)	(0.150)	(0.117)	(0.120)
Age	−0.010	−0.0094	−0.0058	−0.0039
	(0.017)	(0.017)	(0.017)	(0.018)
Age squared	0.00018	0.00017	0.00011	0.000099
	(0.000)	(0.000)	(0.000)	(0.000)
Gender (1 if male)	−0.16	−0.066	−0.15	−0.048
	(0.113)	(0.142)	(0.113)	(0.139)
Income	0.23**	0.29**	0.23**	0.27**
	(0.093)	(0.130)	(0.095)	(0.123)
College certificate/diploma	−0.075	−0.090	−0.085	−0.095
	(0.166)	(0.168)	(0.165)	(0.167)
Undergraduate degree	−0.055	−0.049	−0.066	−0.052
	(0.160)	(0.161)	(0.160)	(0.161)
Postgraduate degree	−0.11	−0.14	−0.13	−0.15
	(0.171)	(0.173)	(0.170)	(0.171)
Wildlife interest: interested	0.059	0.056	0.076	0.075
	(0.170)	(0.167)	(0.171)	(0.170)
Wildlife interest: greatly interested	0.31*	0.30*	0.33**	0.32**
	(0.161)	(0.161)	(0.161)	(0.161)
Satisfaction: better than expected	−0.0069	−0.0027	0.000085	0.0053
	(0.129)	(0.127)	(0.129)	(0.127)
Satisfaction: much better than expected	0.26*	0.27*	0.25*	0.27*
	(0.152)	(0.150)	(0.152)	(0.150)
Package (1 if on tour package)	−0.52***	−0.51***	−0.50***	−0.50***
	(0.115)	(0.113)	(0.115)	(0.112)
Party size	−0.064**	−0.065**	−0.063**	−0.062**
	(0.030)	(0.031)	(0.030)	(0.031)
Constant	1.57***	1.46***	1.69***	1.53***
	(0.426)	(0.493)	(0.431)	(0.503)
α	0.181***		0.192***	
	(0.059)		(0.060)	0.0021
Age		0.0044		
		(0.019)		(0.019)
Gender		−0.58		−0.59
		(0.823)		(0.783)
Income		−0.36		−0.23
		(0.763)		(0.707)
Constant		−1.27		−1.05
		(1.464)		(1.365)
AIC	1017.2	1022.3	1018.3	1023.5
BIC	1076.4	1092.7	1077.6	1093.8
Chi–squared	175.4	144.8	179.2	148.4
Log lik.	−492.6	−492.2	−493.2	−492.7
Observations	300	300	300	300

Note. Dependent variable is *RDAYS*. TSNB – Truncated and endogenously stratified negative binomial, GTSNB – Generalized truncated and endogenously stratified negative binomial. The parameter *α* shows the presence of overdispersion. Columns I and II show results when the opportunity cost of recreation time is taken as 1/3 while columns III and IV use 3/4. Robust standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% level, respectively. The variable *income* is divided by 100 000 while the variable TCOST are divided by 1 000 to avoid too many zeros on the regression coefficients.

KNP is thus $536 million, and ranges from $412-$767 million ($573 million and ranging from $445-$803 million when travel time is valued at 3/4).[22]

Our estimates of individual consumer surplus per recreation day compare well to the consumer surplus of other recreational activities in South Africa. du Preez and Hosking (2011), for example, report a consumer surplus per day of $334 for the Rhodes trout fishery in South Africa. However, their sample is made up largely of domestic tourists. The consumer surplus estimates are also in line with most of the literature for southern and eastern African national parks. Krug (2000) reviews empirical studies in eastern and southern Africa and finds large aggregate estimates of consumer

Table 4. Consumer surplus (US$) per day estimated from recreation-demand models.

	$\varphi = 1/3$			$\varphi = 3/4$		
Model	Mean CS	Lower 95% CI	Upper 95% CI	Mean CS	Lower 95% CI	Upper 95% CI
TSNB	459	352	658	491	383	684
GTNSB	450	346	644	481	374	674
Access value (Millions US$)	536	412	767	573	445	803

US$ – United States Dollars.

Note. This table presents the consumer surplus (CS) when the opportunity cost of recreation time is taken to be either 1/3 or 3/4. The 95% confidence intervals (CI) are also presented and are calculated as $1/[\hat{\beta}_{tc} \pm 1.96(se)]$. The table also presents the access value for the preferred generalized truncated and endogenously stratified negative binomial models. TSNB – Truncated and endogenously stratified negative binomial; GTSNB – Generalized truncated and endogenously stratified negative binomial.

surplus. The consumer surplus for unique recreational sites for which no close substitutes exist is shown to be even larger in the literature. For example, Hatfield and Malleret-King (2007) use the ITCM to derive the consumer surplus of Mountain Gorilla tourism in the Virunga Volcanoes Massif and Bwindi Impenetrable Forests in central Africa. They report a mean consumer surplus of $1 314.[23]

KNP is representative of a number of large national parks in Africa that are endowed with highly valuable wildlife and attract a large number of international and domestic tourists. Such parks have high scarcity value. The potential contribution from charging appropriate entrance fees is therefore considerable, as these parks are among the most visited parks in Africa. The high consumer surplus also reflects the presence of a variety of natural and man-made attractions that interact to determine the level of satisfaction derived by the recreationists. Because the use value is only part of the total economic value, the use values reported here provide rather a low, conservative estimate of the probable magnitude of the total economic value.

While consumer surplus represents benefits accruing to consumers, it is important to note that in our case, it also reveals the extent of the potential surplus that could be captured by the park agency. If the park agency does not capture much of this surplus, as in the current case, it unnecessarily sacrifices potential revenue crucial for funding conservation. However, some of the surplus not captured by the park agency may end up being extracted by the private-sector tourism players. For example, restaurants, hotels and tour operators may overprice the complementary services that help to enhance a tourist's experience. However, these actors do not have an incentive to use the captured surplus for conservation. Furthermore, since national parks are funded through the national treasury, charging entrance fees to foreign tourists that are significantly lower than their willingness to pay also implies that effectively, tourists from wealthy nations are being directly subsidized (Whitelaw, King, and Tolkach 2014).

5. Calculating the revenue-maximizing park-entrance fee

Conservation requires the support of financial resources, and protected areas often have to gain extra income beyond fiscal transfers. The major sources of non-fiscal income are concessions, entrance fees, accommodation, game drives, trails, and other tourism-related activities. Entrance fees have been an important income source of funding for conservation in developing countries. However, they are frequently set below the levels international tourists are willing and able to pay (see Naidoo and Adamowicz 2005; Pandit, Dhakal, and Polyakov 2015; Walpole, Goodwin, and Ward 2001). At the same time, parks continue to be underfunded, and are unable to cover their operational budgets fully (Inamdar et al. 1999; McRae 1998; Walpole, Goodwin, and Ward 2001).

When considering park pricing policy for international tourists to unique sites, the starting point should be a market-driven framework that pays attention to recreation demand and supply to arrive at revenue-maximizing park-entrance fees. A crucial consideration in deciding the appropriate entrance fee is the inter-relatedness of parks within the country and beyond.[24] Chase et al.

(1998) and Dikgang, Muchapondwa, and Stage (2017) recognize this aspect, and consider multiple national parks simultaneously in order to arrive at appropriate entrance fees.

There are three main ways to think about optimal entrance fees. The objective could be efficiency (Mendes 2003), revenue maximization (Alpízar 2006; Chase et al. 1998; Dikgang, Muchapondwa, and Stage 2017; Walpole, Goodwin, and Ward 2001) or equity where domestic tourists form the bulk of the tourists.[25] The main justifications for an entrance fee in many public national parks are rationing (given the uneven demand that characterizes recreation demand), equity (an application of the 'user pays' principle), and financial considerations. The last is especially important in many other developing countries, where international tourists constitute a substantial proportion of the total number of tourists. With sufficient revenue from international tourists, the park agency can invest more in protecting their natural resources, thus preserving the integrity of the stock; it can extend free or subsidized access to more marginalized local groups, which can help change attitudes towards conservation; and it can finance benefit-sharing schemes with local communities.

In order to determine the revenue-maximizing park-entrance fee for international tourists to KNP, we start by writing the demand function (d_i) as

$$d_i = \exp(\alpha + \psi \boldsymbol{x}_i + \beta tc_i) \tag{5}$$

where $\boldsymbol{x}_i$ is a vector of explanatory variables, tc_i is the travel cost to the site and β is the parameter attached to the travel cost variable. From equation (5), the total revenue (TR) function can be written as $TR = \frac{1}{\beta}(\log d_i - \rho) \cdot nd_i$ where $\rho = \alpha + \psi \boldsymbol{x}_i$ and n is the sample size (see Appendix for the derivation). Maximizing the total revenue function with respect to d_i yields $d_i^* = \exp(\rho - 1)$ and using this expression together with equation (5) yields $tc_i^* = -1/\beta$. The fee in this case is set so that travel cost is on average equal to the average consumer surplus per day (cs_D). While our model has no price discrimination among international tourists as a group, one can introduce this by calculating a separate entrance fee for categories of international tourists based on, for example, their region of origin.

From section 4, the estimated consumer surplus per day is \$450 and ranges from \$346 to \$644 per international visitor per day for the preferred model in Table 4.[26] This is the average amount that the park agency ought to capture from all the activities it provides for a day's worth of recreation in KNP to international tourists. The typical full schedule activities and costs for an overnight visitor at the Skukuza rest camp in KNP are entrance fee \$22, Accommodation \$94, Sunrise Drive \$23, Morning Walk \$40, Afternoon Walk \$32, River Walk \$23, Sunset Drive \$23, Night Drive \$18, Community Levy \$3 and Subsistence \$30 giving a total of \$308. Using the lower bound of the consumer surplus per day (\$346) so as to minimize the decline in international tourist arrivals, there are opportunities for KNP to capture at least an extra \$38 from each international visitor per recreation day. The easiest way to do so would be to increase the entrance fee from \$22 to at least \$60. The proposed new fee aligns well with fees charged at other equally popular African parks: Amboseli National Park (\$60); Maasai Mara National Park (\$70) and Serengeti National Park (\$60).

The impact of changes in entrance fees on revenue depends on the price elasticity of demand (e_p). Recreation demand tends to be price inelastic (see also Dikgang, Muchapondwa, and Stage 2017; Pandit, Dhakal, and Polyakov 2015; Simões, Barata, and Cruz 2013), with a semi-log demand function, $e_p = \beta_{tc} \cdot \overline{tc}$ where $\overline{tc}$ is the average round-trip travel cost per day (*travcost*). When the opportunity cost of recreation time is taken as 1/3, price elasticity of demand ranges from −0.94 to −0.95 indicating demand is inelastic (raising entrance fees will raise revenue). We therefore note that the decline in recreation days per visit is small relative to the price increase. As the number of international tourists arriving at KNP has been steadily increasing, we estimate the extra revenue implied by an entrance fee increase of \$38 per day at a conservative value of \$14 million (i.e. an extra \$38 for each of the 368 399 tourists in 2014). This would have an effect of doubling KNP's surplus income. While a higher entrance fee may result in fewer tourists, the park would also attract tourists with higher purchasing power and this may minimize the impact of reduced tourist numbers on nearby communities who rely on tourism for their local businesses. The increased revenues are also important for comprehensively covering the costs incurred by local communities through benefit-sharing schemes.

6. Conclusion

This paper sets out to conduct an economic valuation to accompany a holistic analysis of the prospects for generating sustainable financing for national parks in developing countries, from both institutional players and park users, to be used in financing conservation activities, both within and outside the estate of the park studied. We estimate the recreation-demand function for international tourists to a popular South African national park, KNP, and derive associated welfare measures. We find that there is a large consumer surplus ranging from $346 to $644 per international visitor per day. This surplus can potentially be captured through an increase in the entrance fee. We estimate the revenue-maximizing daily park entrance fee for KNP to be at least $38 above the current levels. Such a fee would generate an extra income of about $14 million annually.

Our results have important implications for protected areas in developing countries. Popular national parks that attract tourists from further afield may be able to charge more, thus providing a mechanism for sustainably funding conservation. For financial sustainability, it is important that park revenue cover the costs associated with conservation, including those costs associated with the participation of local communities. This could reduce reliance on State support in the face of increasing conservation mandates and declining fiscal transfers. The existence of good gate-access systems at many African parks means park agencies get access to important historical data to fine-tune prices in response to changes in tourist demand in the long run. This offers the potential to maximize revenue at any given time.

Notes

1. Sustainable conservation requires an adequate outlay of funds to share with local communities—some of which have formally reclaimed ownership of portions of protected areas, while agreeing to maintain conservation as the primary land use (e.g. contract parks, as discussed in Dikgang and Muchapondwa (2017b) and Reid et al. (2004)).
2. The South African National Parks agency uses two entrance fees – a usage fee and a conservation fee. The conservation fee varies for local, regional and international tourists. Regional tourists are classified as those coming from the 15 Southern African Development Community countries. In terms of entrance fees, they pay twice the R70 tariff levied on local residents as of July 2014 (US$1 = South African Rand (R) 10.66 at the time the survey was conducted in July 2014), while all other nationalities pay an entrance fee that is four times that charged to local residents. However, regional tourists constituted only 1.8% of tourists to the park in 2014. The use of the term entrance fee in the current paper refers to the conservation fee.
3. The term international tourists in this paper refers to overseas or intercontinental tourists.
4. The importance of appropriate user fees to support conservation is widely recognized in the literature (see Emerton, Bishop, and Thomas 2006; Inamdar et al. 1999; Spenceley, Rylance, and Laiser 2017; Whitelaw, King, and Tolkach 2014). A number of past studies, for example, Alpízar (2006), Chase et al. (1998), Dikgang and Muchapondwa (2017a) and Dikgang, Muchapondwa, and Stage (2017) have therefore tried to estimate appropriate user fees.
5. Despite the small size of the international tourist market relative to the domestic market, the international market is important, given its relative maturity, and it accounts for a disproportionate share of total revenue (Dikgang and Muchapondwa 2017a).
6. See https://en.unesco.org/biosphere/africa/kruger-to-canyon
7. While rhinoceros poaching has been a growing challenge for over a decade, a resurgence in elephant poaching has exacerbated the problem. Organized poachers often exploit the alienation of local communities who fail to access full conservation benefits. Poaching may therefore be disrupted by creating opportunities for local communities through more equitable benefit-sharing initiatives (SANParks 2016).
8. The ITCM is based on information regarding the individual visitor, and therefore derives the Marshallian consumer surplus for the individual visitor.

9. Equation (1) is derived from a utility-maximization problem in which individuals choose the total number of days at a recreation site. According to Larson and Shaikh (2004), the recreation choice is assumed to be made conditional on an individual's labor-supply decision. Recreation demand then arises from the allocation of earnings from the labor market across a range of consumption activities.
10. An important objective of the current paper is to derive a revenue-maximizing daily entrance fee for KNP to finance conservation and benefit-sharing with local communities. Since a daily entrance fee is standard practice in many African parks, the current formulation of the ITCM allows us to easily compute the revenue-maximizing daily entrance fee. A related aspect is that domestic tourists usually make repeat trips more frequently. Due to the distance involved in international tourism, the majority of tourists might only visit the site once within a period of, for example, five years. For a park manager studying recreation demand for the purposes of setting an appropriate entrance fee, repeat trips by international tourists within an economically meaningful time horizon are unlikely. In this case, an analysis based on recreation days is more informative for computing a revenue-maximizing daily entrance fee.
11. In recreation studies, it is crucial to note that time can be as important as monetary costs in the decision to engage in recreational activities (Feather and Shaw 1999). According to Cesario (1976), opportunity cost reflects the value placed on alternative uses of leisure time; therefore, it is appropriate to value travel time at only a fraction of the going wage rate.
12. While it can be argued that the last part of the trip from Johannesburg to KNP may yield some positive utility, we follow Fix and Loomis (1998) by assuming consumptive benefits from this part of the trip are zero on average; otherwise, the estimated benefits would be amplified. One must also consider that for international tourists, this last part of the journey to KNP is completed after a long intercontinental flight. Therefore, while most visitors are likely to engage in a few other activities on their way to KNP, we argue that these other activities are incidental.
13. While it is ideal to sample visitors when they depart the recreational site (Mendes and Proença 2011; Parsons 2003), this was not practical in this case because the majority of international visitors were on tours, leaving little time to interview them when they were leaving the park.
14. While the sampling of international visitors was random, those who stayed longer had a greater chance of being sampled.
15. Unless otherwise indicated, all '$' amounts are in United States Dollars. US$1 = South African Rand (R) 10.66 at the time the survey was conducted in July 2014.
16. The upfront cost can be treated as a kind of long-run capital cost. In the case of international tourists traveling long distances, it might be expected, as in Smith and Kopp (1980), that the length of the trip and travel cost will be positively related. However, this contradicts the traditional ITCM, which hypothesizes an inverse relationship between travel cost and participation in recreation.
17. This way of classifying the costs associated with participating in recreation goes back to Pearse (1968), who viewed recreation costs as composed of a fixed component and a variable component, which varies with respect to the number of days at the recreation site. There is also a transaction cost, associated with making a decision on which recreation site to visit. However, we ignore such costs, as they are most likely to be negligible, and also hard to quantify.
18. We note that trying to retrieve the KNP portion of the recreation cost through scaling *RCT* by γ_{KNP} can result in very low values for the first RHS term, in cases where a respondent reports a low value of subjective utility for the park. An alternative would be to consider scaling *RCT* by the fraction of days at KNP. However, many respondents who visit KNP plan the trip as part of an extended tour that usually includes other countries in southern Africa, as well as other sites within South Africa. The trip would therefore most often tend to be much longer than usual, resulting in very low values of travel cost. Another weakness is that the travel cost allocated this way assumes that a day in KNP is the same as a day at any other site, since all days are assigned similar weights.
19. There are also park-imposed constraints on movement outside the designated campsites between 6pm and 6am. However, tourists staying within the park can undertake tourist activities during these times by making use of the exclusive SANParks guided tours offered.
20. While an increase in income might have an indeterminate effect on demand for recreation as it also has the effect of increasing the opportunity cost of leisure, we expect its effect on the number of recreation days spent at a site to be positive at the margin because of the huge sunk cost associated with the trip that the visitor has already undertaken.
21. This variable captures a number of site-specific characteristics, such as wildlife diversity, tourism infrastructure, accessibility, and price. For the purposes of the analysis of this variable and also the variable *wildlife interest*, we combine the first five categories into a single category as they have fewer observations in them.
22. If we restrict the analysis to only the countries in our sample in 2014 (they provide 86% of total international tourists to KNP), the annual recreational value for international visitors is $460 million and ranges from $354–$658 million (or $492 million, ranging from $382–$689 million when travel time is valued at 3/4).

23. For comparison purposes, it is important to note that the consumer surplus estimate presented by Hatfield and Malleret-King (2007) is for a one-hour activity tracking Mountain Gorillas.
24. For example, a change in the entrance fee at KNP might induce substitution effects among other local or even regional parks, unless the park offers a unique tourist experience.
25. See Laarman and Gregersen (1996) for an overview of pricing policies in nature-based tourism.
26. The corresponding recreation days per tourist $d^* = 1.2$ (1.4 with time valued at 3/4 of the wage rate) with $\hat{\rho} = 1.19$ (and 1.32 with time valued at 3/4 of the wage rate) using the data in Table 1 and parameter values in columns II and IV of Table 2.

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Appendix

In this section, we provide the full derivation of the optimal price. We start from the demand function

$$d_i = \alpha + \psi \boldsymbol{x}_i + \beta tc_i \tag{A.1}$$

where $\boldsymbol{x}_i$ is a vector of explanatory variables, tc_i is the travel cost to the site and β is the parameter attached to the travel cost variable. Since we estimate a negative binomial model, the form of the model is similar to that of the Poisson model:

$$d_i = \exp(\rho + \beta tc_i)$$

where $\rho = \alpha + \psi \boldsymbol{x}_i$. Taking natural logs gives $\log d_i = \rho + \beta tc_i$ and further manipulation gives the following inverse demand function:

$$tc_i = \frac{1}{\beta}(\log d_i - \rho) \tag{A.2}$$

From the inverse demand function, we derive the total revenue (TR) function by using the fact that $TR = tc_i \cdot d = tc_i \cdot nd_i$ where n is the sample size

$$TR = \frac{1}{\beta}(\log d_i - \rho) \cdot nd_i$$

Differentiating with respect to d_i yields

$$\frac{\partial TR}{\partial d_i} = \frac{nd_i}{\beta d_i} + \frac{n\log d_i}{\beta} - \frac{\rho n}{\beta} = 0$$

$$\frac{\partial TR}{\partial d_i} = \frac{n\log d_i}{\beta} + \frac{n}{\beta} - \frac{n\rho}{\beta} = 0$$

$$\frac{\partial TR}{\partial d_i} = \frac{n}{\beta}(\log d_i + 1 - \rho) = 0$$

which simplifies to

$$d_i^* = \exp(\rho - 1) \tag{A.3}$$

Substituting (A.3) into (A.2) yields $tc_i^* = \frac{-1}{\beta}$.