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An examination of sources of sensitivity of consumer surplus estimates in travel cost models

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ABSTRACT

We examine sensitivity of estimates of recreation demand using the Travel Cost Method (TCM) to four factors. Three of the four have been routinely and widely discussed in the TCM literature: a) Poisson verses negative binomial regression; b) application of Englin correction to account for endogenous stratification; c) truncation of the data set to eliminate outliers. A fourth issue we address has not been widely modeled: the potential effect on recreation demand of the interaction between income and travel cost. We provide a straightforward comparison of all four factors, analyzing the impact of each on regression parameters and consumer surplus estimates. Truncation has a modest effect on estimates obtained from the Poisson models but a radical effect on the estimates obtained by way of the negative binomial. Inclusion of an income-travel cost interaction term generally produces a more conservative but not a statistically significantly different estimate of consumer surplus in both Poisson and negative binomial models. It also generates broader confidence intervals. Application of truncation, the Englin correction and the income-travel cost interaction produced the most conservative estimates of consumer surplus and eliminated the statistical difference between the Poisson and the negative binomial. Use of the income-travel cost interaction term reveals that for visitors who face relatively low travel costs, the relationship between income and travel demand is negative, while it is positive for those who face high travel costs. This provides an explanation of the ambiguities on the findings regarding the role of income widely observed in the TCM literature. Our results suggest that policies that reduce access to publicly owned resources inordinately impact local low income recreationists and are contrary to environmental justice.

1. Introduction

The travel cost method (TCM) has emerged as one of the most powerful techniques used by applied scholars to measure non-market values of environmental amenities. A form of revealed preference analysis, TCM has gained a great deal of visibility internationally. In the past five years alone, studies on TCM have been published in the *Journal of Environmental Management* to measure values of protected areas in Spain (Martín-López et al., 2009), an ice-climbing destination in the northwestern United States (Anderson, 2010), whitewater kayaking sites in Ireland (Hynes et al., 2009) and a World Heritage Area in Australia (Fleming and Bowden, 2009). These and other articles on TCM have not only focused on estimating the values of the resources at hand, but also numerous broader issues facing researchers, including the value of travel time, the importance of considering substitutes, and a host of sampling and statistical issues and problems potentially facing the TCM researcher. These investigations have contributed greatly to a

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better understanding of sources of variability in results, even if a number of issues remain unresolved.

In this paper we explore four issues in using TCM to estimate consumer surplus associated with the recreational use of an environmental amenity. We examine how endogenous stratification; data set truncation; count data regression; and income-travel cost interaction impact the estimates of regression parameters and consumer surplus in both Poisson and negative binomial TCM models.

1.1. Endogenous stratification

On-site surveys are more likely to include a higher response from avid resource users than from those who seldom visit a site. This is a form of sample bias called endogenous stratification. Shaw (1988) developed a model that corrected for problems associated with Poisson samples drawn from on-site recreational surveys, including endogenous stratification. Englin and Shonkwiler (1995a) extended the analysis to the negative binomial model. In order to account for this form of sample bias, researchers routinely now apply the "Englin correction" to data sets obtained from on-site interviews by subtracting one visit from the number of visits a respondent has made to the site.

1.2. Data set truncation

Truncation in TCM data sets is an issue at both ends of the continuum. At the lower end, visitation is automatically truncated at zero, since visits cannot be negative. This form of *de facto* truncation has been the focus of considerable literature, and is not the focus of this study. At the upper end, truncation of data sets to disallow for (a) visits that originate relatively far from the destination and (b) observations with "excessive" visits has become common as well. Researchers have adopted a number of *ad hoc* measures to eliminate observations with extremely large travel costs and/or very high reported visits, believing that inclusion of these observations will produce biased parameter estimates and inflated consumer surplus values (Bin et al., 2005; Heberling and Templeton, 2009; McKean et al., 2012). However there is little in the way of systematic analysis to measure the effects that exclusion of these observations has on parameter and consumer surplus estimates.

1.3. Count data regression and overdispersion

Since the dependent variable in travel cost models, number of visits to a site, includes only integers (count data), researchers have adopted integer only (count data) regression procedures to estimate travel demand (Cameron and Trivedi, 2013; Creel and Loomis, 1990; Hellerstein, 1991; Hellerstein and Mendelsohn, 1993). Foremost among these has been the Poisson regression procedure. One problem with the Poisson is with its assumed distribution, where the mean is set equal to the variance. In many data sets however, the variance exceeds the mean. This violation of the assumed distribution is called overdispersion. Its presence causes the standard errors on regression parameters to be reduced, increasing the likelihood of Type I error – finding that a variable is statistically associated with number of visits when it really is not (Dean and Lawless, 1989; Palmer et al., 2007). A more recent study by Nakatani and Sato (2010) found an association between overdispersion and inflated consumer surplus estimates. Correction procedures exist for taking overdispersion into account in order to re-calculate standard errors. A second option in the case of an overdispersed TCM data set is to choose another count data regression procedure, the negative binomial (Berk and MacDonald, 2008; Heberling and Templeton, 2009). Straightforward comparisons of parameter and consumer surplus estimates obtained via Poisson or negative binomial regressions are lacking.

1.4. The role of income in TCM

One enigma that has faced TCM researchers over the years has received little scrutiny. It centers on the role of income in travel demand. Recreation or travel demand models are based on the more general neoclassical theory of consumer demand, which is in turn based on constrained utility maximization. The "law of demand," the inverse relationship between the price of a good or service and the quantity demanded, is one of the most widely supported relationships in the social sciences. It eventually serves as the basis for estimating the value of a non-market good or service by allowing integration of the area under the demand curve (Fig. 1). However, if the price/quantity relationship is the most well attested item to emerge from neoclassical theory, a close second is a positive relationship between consumer income and quantity demanded (Mas-Colell et al., 1995; Nicholson and Snyder, 2012). While the theory technically allows for a relationship that is zero or even negative, an enormous body of empirical work shows that virtually all goods and services display a positive relationship – so much so that items that possess this characteristic are dubbed "normal." But the travel cost literature has produced a body of evidence on travel demand and income that is quite unlike the results seen in ordinary consumer demand studies. A large percentage of TCM studies shows zero or negative signs on the relationship (Brox and Kumar, 1997; Englin and Shonkwiler, 1995a; Larson et al., 1997; Loomis et al., 2000; McConnell and Strand, 1983; McKean et al., 2010, 2012; Ralston and Park, 1989; Taylor et al., 2010; Weiler, 2006), implying that income has no impact on travel demand or that higher income reduces the demand to the site, making the site what economists call an "inferior good." While economists report these results in their studies, they rarely comment on the implications, or the fact that these results, at least in the context of the larger body of consumer demand theory, are anomalous.

Rather than ignoring the anamolous role of income in TCM, we examine how income may influence visitation by way of an interaction with travel cost. We hope to better identify the way income influences visitation and thus improve the TCM methodology. This

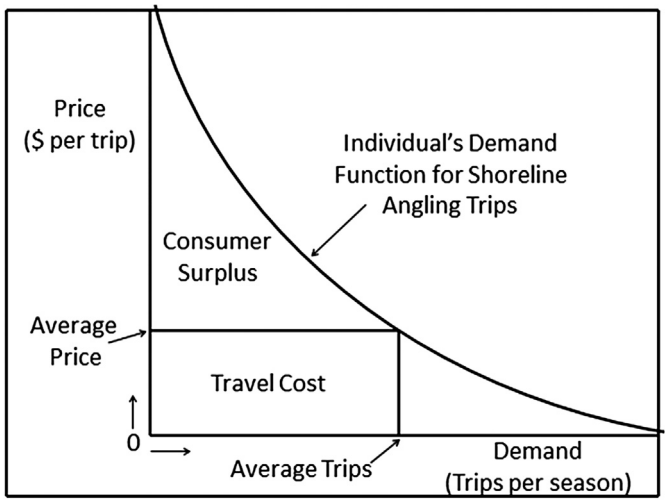

Fig. 1. Generalized demand function showing Consumer Surplus and Travel Costs (from Sohngen et al., 1999).