Spatial Limits of the TCM revisited: Island Effects

John B. Loomis[*], Juan Marcos González[*‡],
Armando González-Cabán[†]
[*]Department of Agricultural and Resource Economics, Colorado State University
[†]USDA Forest Service, Forest Fire Laboratory, Riverside, California
‡Corresponding Author
Phone: +1-970-491-6325
Fax: +1-970-491-2067
Email: jmarcos@colostate.edu

Selected Paper prepared for presentation at the Western Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007

Abstract

The purpose of this paper is to address a problem that may arise with the assumption of a continuous spatial market in the TCM model. We find that this assumption can be challenged by geographical limitations that an area of study might have. Particularly for islands (or isolated island-like areas) that have a valuable non-market resource or good, the spatial market characteristic of the TCM model might be limited or truncated. The geographical truncation limits the observed maximum travel cost of the demand curve falsely implying a lower WTP than otherwise. The study uses a dichotomous choice CVM to confirm that the resulting demand schedules from the TCM underestimates WTP for day trips to the Caribbean National Forest in Puerto Rico. This results in a considerably smaller TCM WTP for the value of recreation sites at $17 to $29 versus $109 per day trip from the dichotomous choice CVM. .

JEL Classifications: Q0 Agricultural and Natural Resource Economics

Key Words: Contingent Valuation, count data, consumer surplus, Puerto Rico river recreation, travel cost models.

Introduction

The ideas behind the Travel Cost Model (TCM) were first suggested by Harold Hotelling in 1949 and later on extended to recreation by Marion Clawson. The model recognizes that recreation sites, even when people did not pay entrance fees, have an implicit price that stems from the costs involved with visiting the site. This *travel cost* includes both travel cost and travel time to get to the site. The idea of using an implicit price served to develop a demand-based model (analog to those commonly used in regular goods' demand) that could be used to value recreational uses of the environment (Parsons, 2003). Implicitly then, the TCM also relies upon the notion of a spatial market where visitors' willingness to trade travel costs for site visits reveals their willingness to pay (WTP) for the site and its characteristics. By looking across people who live at different distance from the recreation site hence face different travel costs, the model allows researchers to estimate a "revealed" demand curve for a site and its components.

Determining the travel cost incurred by each visitor has been one of the most researched aspects in the TCM literature. These efforts include studies that look at the opportunity cost of time (Larson and Shaikh, 2001), latent separability of costs (Blundell and Robin, 2000) and how to separate on-site time from travel time (Shaw, 1992; McConnell, 1992). In addition, past research has focused on the assumptions of the TCM that distant visitors actually incur the travel cost exclusively to visit the site of interest (the so-called multiple destination trip bias problem)(Haspel and Johnson, 1982; Mendelsohn et al., 1992), but very little research has focused on physical or natural spatial limits to the travel cost model. The closest concern in using TCM is in urban recreation settings where there may be insufficient variation in travel costs to fully reflect a visitor's WTP (Loomis and Walsh, 1997).

A similar, but somewhat different problem arises in the case of recreation that take place on small islands such as Hawaii, Puerto Rico, Jamaica etc., i.e., islands with significant resident populations that visit local sites. The difficulty on these islands is the maximum travel cost that a visitor can incur is limited or truncated by the physical size of the island. If the site is of high value to the locals, such that their maximum WTP exceeds the maximum cost associated to the distance necessary to drive, this will not be reflected in a typically estimated trip frequency model (e.g., count data model of recreation). That is, the choke price may be constrained below the maximum WTP by the physical distance of the island. In this case, TCM will under-estimate visitors maximum WTP because it appears to the model that visitation stops at this physically imposed choke price, and there is no consumer surplus, i.e., WTP beyond this level. This is particularly a problem with on-site sampling in which we only observe visitors, that is people who even at the highest observed travel cost still take one or more single destination trips. With on-site sampling we cannot observe the zeros.

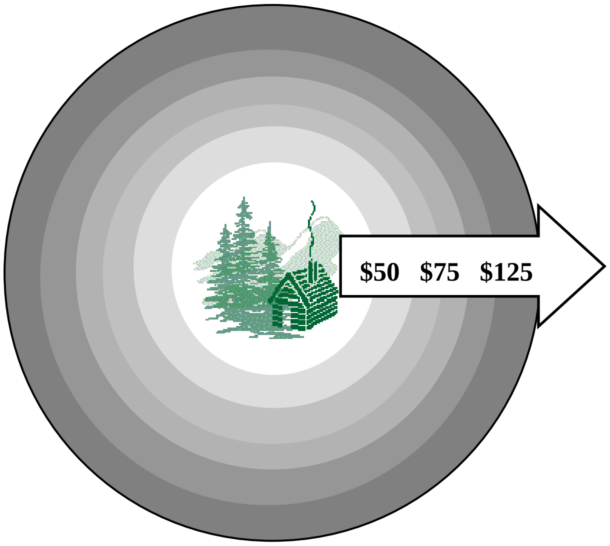
In our data from Puerto Rican residents visiting streams on the Caribbean National Forest, the maximum observed travel cost was approximately \$60 (strongly influenced by the 100 mile width of the island). To allow respondents WTP to not be constrained by this physical limit on the choke price, we asked them if they would still take their most recent trip at a random **increase** in the bid amount that was upwards of \$200. This additional question allowed us to look at the same valuation problem from a CVM perspective and proves useful as it shows how much the TCM under estimates people's WTP.

In the next sections we elaborate on the idea of truncated spatial markets and how this can affect the WTP measures that researchers obtain when using TCM. Then, we discuss the empirical application in which this truncation is seemingly observed, explain the methodology followed to determine individual's WTP under each type of model and present the results obtained from them. Finally, we look at future areas of research in this area.

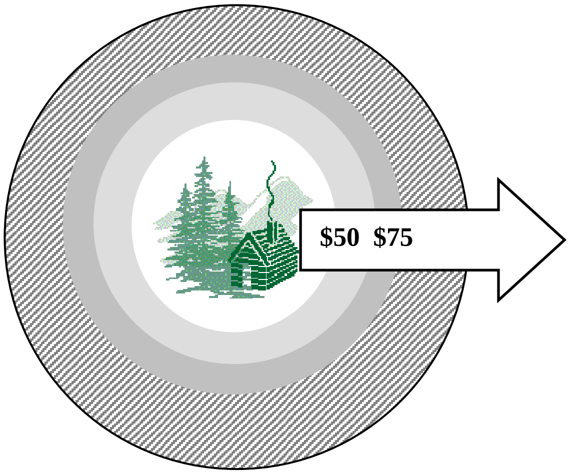
A Truncated Spatial Market

The TCM assumes that people from different points can travel to a given site. Because a main component of the implicit price in the model has to do with time traveled, travel cost is understood to increase in a continuous fashion as one gets further away from the site of interest. Figure 1.A. shows a representation of this spatial property of the travel cost. In the representation one can see that the cost of visiting a site increases as we move to the outer rings of the diagram. On the other hand, figure 1.B. shows what would happen if the spatial market was truncated and the geographical area around the site was limited. In this case, the maximum amount observed is lower than the one we see in diagram A. Even if the site was worth more to the average person in the inner rings, they would not have the chance to reveal it because they have no need to do so. In essence, the demand curve is truncated at the maximum amount of money needed to visit the site from any particular point of the island.

Figure 1. A) Continuous Spatial Market Assumed by TCM and

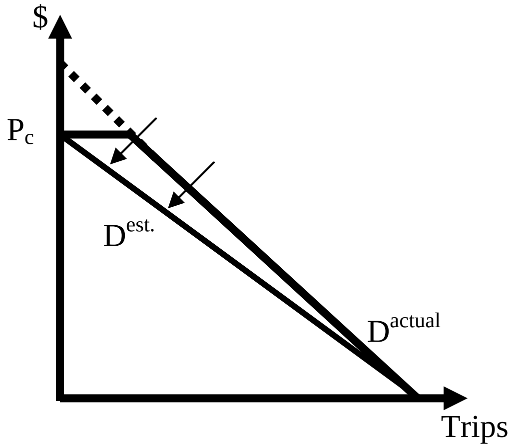


B) Example of Truncated Spatial Market



As presented in figure 2, the reduction in WTP (hence consumer surplus) caused by spatial truncation can come from two different sources. First, when calculating consumer surplus from visitors' revealed preferences, the researcher does not observe any portion of the demand curve that is above the choke price P_c. The area above this price is not revealed to the researcher, thus it cannot be accounted for despite being a real gain for consumers. Furthermore, because TCM valuation studies make use of fully parametric regressions (count data models), the demand curve estimated by them adjusts itself to the information it has, tilting the schedule down towards the choke price.

Figure 2. Truncated Demand Schedule



As a result of this the estimated demand curve ($D^{est.}$) appears flatter than the actual demand schedule (D^{actual}). Not only would the researcher miss the portion of the demand that is above the truncated price level, but it would also force the estimated demand to adjust to this lack of information beyond P_c and cause a further “loss” in consumer surplus.

Methodology

To measure the degree of under-estimation in visitors WTP from the TCM in a constrained island environment, we compare our TCM estimates to those estimated from a dichotomous choice Contingent Valuation Method (CVM). CVM does not suffer from the physical limits as it increases the travel cost by a random amount so a difference between the two WTP measures **could be** attributed to the situation explained above.

Likely, any difference between TCM and CVM estimations is not due to hypothetical bias or other biases associated with CVM. In 1996 Carson et al. used over 600 different CVM and TCM estimates and concluded that differences between CVM and TCM

WTP were not statistically significant. If any, CVM WTP measures are generally below TCM WTP estimates (roughly .9 of TCM estimates).

In the TCM case, we use a traditional count data model. To account for possible overdispersion a negative binomial distribution was chosen and robust standard errors were obtained for each coefficient in the specified model. Two set of parameters were estimated under the TCM. The first one uses the on-site correction described by Englin and Shonkwiler (1995). However, on-site WTP values are smaller than the uncorrected WTP values because they are meant to obtain the surplus of the general population not just the visiting portion. With this in mind, the study also looks at the uncorrected TCM equivalent so both visitor groups can be compared. For the dichotomous choice CVM a probit distribution was chosen. In both models (CVM and TCM) the observations considered were limited to those where individuals who indicated that visiting the site was the main purpose of their visit. This was done to control for the possible multiple destination problem mentioned before and found sometimes in on-site samples.

Once the coefficients for the models are obtained mean WTP measures are calculated following TCM and CVM theory and considering the distributional assumptions made. An empirical convolution process follows in order to statistically determine whether differences in WTP measures are significant. The method proposed by Poe et al. in 2005 is intended to find all possible differences between two sets of values. By exploiting the distributional assumptions about the model parameters we generate a random vector of WTP values within the coefficients' confidence. The convolutions method then looks at these vectors and determines the probability that one WTP distribution lies on top of the other. The resulting p-values are then used as statistical ground to test that CVM and TCM WTP measures are indeed different.

Empirical Application

The study uses data set from a survey administered in the Caribbean National Forest in Puerto Rico. The on-site surveys contain information on trip demand for the 2005 season and a CVM question that was meant to complement the trip assessment. Data were collected at 11 different sites within the forest and contained demographic information of the users, distance and time traveled, and characteristics of the visited sites.

Over 700 observations were obtained and coded, of which 430 observations were used in this analysis. The reason for the reduction in observations is because only trips where visiting the site were the main reason for traveling are considered valid for the TCM. This is done to deal with multiple destination problems (274 trips were not single destination trips). As mentioned before, these observations are typically pointed out as a source of distortion in travel cost models. Also, because of the complicated form of the corrected negative binomial distribution, we eliminated visitors who took more than 100 trips because they appear to be from visitors that are somehow quite different than the vast majority who take a small fraction of these trips.

Variables in the models include an **intercept**, **travel cost (**in the TCM case) and a **bid** amount visitors were asked to pay (in the CVM case). The model also includes **road** (as a measure of accessibility), **mean annual stream discharge** (as a measure of average seasonal flow)**, distance of pool to bridge, pool volume, streamflow day** (as a measure of flow during visit), the number of **picnic tables** at the site and **median grain size (**measure of substrate sand size). A dummy was also included to indicate whether the site had a

waterfall, and whether there were **formal trails** and **restaurants** in the area of interest. Finally a dummy variable was also used to define whether the visitor was male or female. Separate regressions indicate these variables have the greatest explanatory power under each model. The following is a table that presents the summary statistics for the variables used.

Table1. Summary Statistics

	Mean	Minimum	Maximum
Bid	64.02196	1	200
Travel Cost (TC)	7.942791	0.259804	68.72794
Road	3.607921	2	5
Mean Annual Discharge	0.82763	0.106	1.667
Dist. Pool to Bridge	23.84158	0	145
Median Grain Size	462.5208	102	2337
Pool Volume	460.2487	42	1868.4
Gender	0.524851	0	1
Waterfall	0.479125	0	1
Streamflow Day	39.37861	9.2	108
Picnic Tables	0.544304	0	3
Trash Cans	4.784	0	13
Formal Trails	0.489109	0	1
Restaurants	0.135354	0	1

Results

Three models were used for the purpose of this study. The results of these models are summarized in Table 2. In all cases, the values obtained in the regression follows what theory suggests with a negative and significant bid and travel cost coefficient. These yielded a $17 WTP for the corrected TCM, $29 for the uncorrected version of it and $109 for the CVM. It should be mentioned that the highly significant value for alpha in the TCM results suggests we correctly chose a negative binomial distribution. As expected, the WTP measures for the corrected negative binomial distribution are lower than the uncorrected version and both TCM WTP values are well below the CVM analog.

Table 2. Results from parametric regressions using CVM and TCM models.

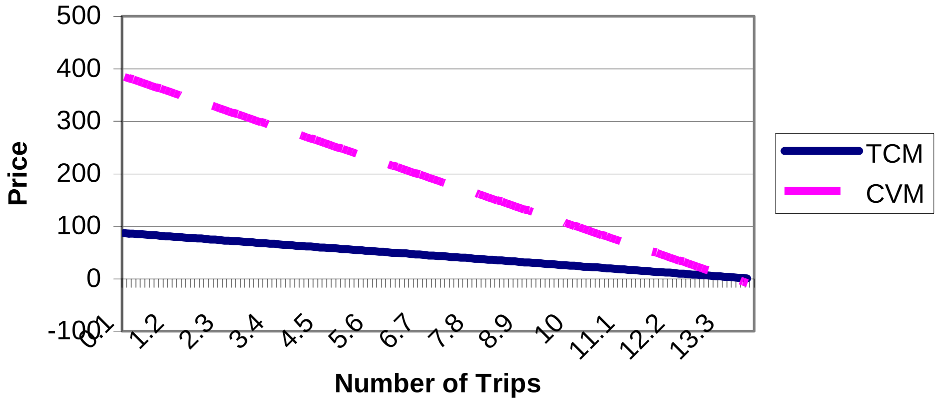
Variable	CVM Coef. (Std. Error)	TCM (Corrected) Coef. (Std. Error)	TCM Coef. (Std. Error)
Bid/TC	-0.0104 ***	-0.0576 ***	-0.0343 ***
	(0.001149)	(0.0175525)	(0.008647)
Road	-0.2485 **	0.1508 *	0.1323 **
	(0.10296)	(0.0825145)	(0.063739)
Mean Annual Discharge	-0.5113 *		
	(0.304429)		
Dist. Pool to Bridge	0.0012		
	(0.002557)		
Median Grain Size	-0.0003 **		
	(0.000169)		
Pool Volume	0.0004 *		
	(0.000249)		
Gender	0.1846		
	(0.128021)		
Waterfall		0.3394	0.2455
		(0.2473462)	(0.202802)
Streamflow Day		-0.0042	-0.0033
		(0.0052275)	(0.004084)
Picnic Tables		-0.6497 ***	-0.3489 ***
		(0.1769431)	(0.118958)
Trash Cans		0.0563	0.0303
		(0.0591204)	(0.042084)
Formal Trails		-0.4654 *	-0.3876 *
		(0.256722)	(0.203329)
Restaurants		0.6965 *	0.5263 *
		(0.3606127)	(0.297835)
	2.2962 ***	-15.5405 ***	1.4616 ***
	(0.584221)	(0.4559102)	(0.36982)
/LN(alpha)		16.7613 ***	
		(0.146858)	
alpha			1.0105 ***
			(0.073504)
Pseudo Log Likelihood	**-260.3699**	**-1013.9264**	**-1139.0408**
Mean WTP	**$ 109.48**	**$ 17.37**	**$ 29.16**

Significant at the 90% confidence level, ** significant at the 95% confidence level, *** significant at the 99% confidence level.

Results from the empirical convolutions show that in both cases (corrected and uncorrected) the CVM WTP is statistically different from the TCM WTP measures. A two tail p-value of 0.0053 and 0.0019 for the comparison between CVM WTP and the uncorrected and corrected TCM respectively showed that neither TCM WTP distributions overlaps the CVM WTP. This is not surprising considering the WTP obtained for the dichotomous choice CVM is 3.6 times greater than the uncorrected TCM WTP and more than 6 times greater the WTP obtained from the corrected TCM.

Figure 3. shows that the effect of the island's physical size limit determining the choke price in the "continuous" count data model also biases the slope coefficient. So the reduced WTP with the TCM is a combination of the censored choke price and its effect on the price coefficient. Figure 3 also illustrates what the implied demand curve from the CVM looks like.

Figure 3. Implied Demand Curves for Recreational Trips Under CVM and TCM



Conclusions

The count data TCM corrected for on-site sampling bias had a negative and statistically significant travel cost coefficient. This yielded an average net WTP $17 per trip. The dichotomous choice CVM had a negative statistically significant bid coefficient. The CVM yielded an average net WTP of $109 per trip. As can be seen this is a sizeable difference given that both are modeling the exactly the same people at the same sites. Our interpretation is that the higher WTP estimate from the dichotomous choice CVM is more reflective of the high quality visitor experience and the visitors' net WTP than would be the TCM.

Our very large difference in net WTP per trip is due to the physical size limit of the island of Puerto Rico. It would be interesting to repeat this type of TCM and CVM analysis at similar quality recreation sites on islands of different sizes to see what the relationship is. As an island grows in size relative to the quality of the recreation site, the difference in the WTP estimates should be less pronounced. Alternatively, on islands smaller than Puerto Rico the bias could even be much larger. Researchers need to be aware of this concern when doing local recreation site valuation on islands where most of the visitor use is by island residents.

Future research could also focus on using simulations to look at what happens to the estimated demand schedule in the TCM as truncation is eliminated by gradually expanding the population to a complete and continuous spatial market. This should provide relevant evidence to further identify the limits of the TCM and this particular geographical assumption.

References

Blundell, R. and J.M. Robin, 2000. Latent Separability: Grouping Goods Without Weak Separability. Econometrica, 168 (Jan), 53-84.

Carson, Richard T., N. Flores, K.M. Martin and J.L. Wright 1996. Contingent Valuation and Revealed Preference Methodologies: Comparing the Estimates for Quasi-Public Goods. Land Economics, February v. 72, iss. 1, pp. 80-99

Englin, J., Shonkwiler, J. S., 1995. Estimating Social Welfare Using Count Data Models: An Application to Long-Run Recreation Demand Under Conditions of Endogenous Stratification and Truncation. Review of Economics and Statistics. 77, 104-112.

Haspel, A.E. and F.R. Johnson, 1982. Multiple Destination Trip Bias in Recreation Benefit Estimation. Land Economics 58 (Aug), 364-372.

Larson, D. and S. Shikh, 2001. Empirical Specification Considerations for Two-Constraint Models of Recreation Demand. American Journal of Agricultural Economics 83 (May): 428-440.

Loomis, John B., and Richard Walsh. 1997. Recreation Economic Decisions: Comparing Benefits and Costs. State College, Pennsylvania: Venture Publishing, Inc.

McConnell, K., 1992, On-Site Time in the Demand for Recreation. American Journal of Agricultural Economics 74 (4): 918-924.

Mendelsohn, R.J. Hof, G. Peterson and R. Johnson, 1992. Measuring Receation Values with Multiple-Destination Trips. American Journal of Agricultural Economics 74, 926-933

Parsons, G.R., 2003. The Travel Cost Model, in: Champ, P., Boyle, K.J., Brown, T.C. (Eds.), A primer on Nonmarket Valuation**,** Vol. 3. Kluwer Academic Publishers, Netherlands, pp. 269-329.

Poe, G.L., Giraud, K.L. and J.B. Loomis. 2005. "Computational Methods for Measuring the Difference of Empirical Distributions." American Journal of Agricultural Economics, 87(2): 353-65.

Shaw, W.D., 1988. On-Site Samples Regression: Problems of Non negative Integers, Truncation and Endogenous Stratification. Journal of Econometrics 37, 211-223.

Shaw, W.D. 1992. Opportunity Cost of Time. Land Economics 68 (1), 107-115