The Travel Cost Model for Lake Recreation: A Comparison of Two Methods for Incorporating Site Quality and Substitution Effects

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This paper empirically illustrates how different assumptions regarding recreationists' decision-making behavior affect the predicted changes in recreational activity given a water quality improvement. A multinomial logit model, which reallocates visits away from other sites to the improved site, predicts a smaller outward shift of the recreationist's demand curve than the more traditional travel cost model, which does not assume any reallocation of visits among sites.

Key words: substitution effects, travel cost models, water quality improvements.

As discussed in Bockstael, Hanemann, and Strand, the basic tenet of the travel cost model is that valuation can be revealed through behavior. Therefore, criteria for evaluating the reliability of competing travel cost specifications should include how adequately the individual's decision-making behavior is modeled. Of central importance in recreational demand models are the different methods in which substitute sites and site quality characteristics are introduced into the model and how the resulting model structures impose different behavioral assumptions about recreationists' decision making.

Recently, discrete/continuous choice, recreational demand models have been developed that explicitly incorporate both the relevant substitution and site quality effects that influence recreationists' choices regarding where and how often to recreate (Feenberg and Mills; Hanemann 1982; Bockstael, Hanemann, and Strand; Morey; Morey and Rowe). Implicit in the structure of such multisite demand models is an assumption regarding how recreationists reallocate visits when faced with quality changes at a given site.

The objective of this paper is to illustrate empirically how the assumption regarding the recreationists' decision-making behavior in response to a water quality change in a discrete choice model differs from that in a more traditionally specified travel cost model and the extent to which these different behavioral assumptions affect the predicted changes in recreational activity at the site.

Multinomial Logit Model

The choice model developed here is a two-equation multinomial logit (MNL) specification that estimates site and frequency of lake recreation choices for individual recreationists. In this model utility is derived directly from the consumption of activities undertaken by the individual and indirectly from the characteristics of those activities. Lake recreation is considered an activity where the recreationist combines the characteristics of the lake, the socioeconomic characteristics of

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the household decision maker, and time to produce a lake-specific recreational activity. For a more detailed development of this model, the interested reader is referred to an additional paper by Caulkins, Bishop, and Bouwes.

The decision structure that is assumed to lead to a visit to a lake results from two separate choices. One choice involves determining whether or not the individual will undertake lake recreational activity on that day given that s/he is among the lake recreation user population, and the other decision involves determining which lake to visit given that the decision has been made in favor of lake recreation. By the laws of conditional probability, these two decisions can be incorporated in the following manner:

$$P_{g\cap i} = P_{i|g} * P_{g|r} \tag{1}$$

where $P_{g\cap i}$ is the joint probability of choosing to take a trip to a lake and choosing lake i from their choice set; $P_{i|g}$ is the conditional probability of choosing lake i from their choice set given that one has decided to take a day trip to a lake, and $P_{g|r}$ is the probability of choosing lake recreation on that day given that one participates in lake recreation.

In this model a separate equation is estimated for each of the two RHS probabilities. The product of the estimates for these two probabilities produces the LHS, joint probability, which when multiplied by 365 yields the conditional demand for lake i in terms of the number of day trips taken to the lake during the year by the recreationist.

Lake Choice Equation

On a given day a recreationist with tastes and preferences, $\bar{S}$, will choose to visit the site that provides the greatest amount of utility. That utility can be specified as

$$U(\bar{X}^B, \bar{S}) = V(\bar{X}^B, \bar{S}) + u(\bar{X}^B, \bar{S}) \tag{2}$$

where $V(\bar{X}^B, \bar{S})$ is the deterministic portion of utility and is assumed to represent average, i.e., mean behavior; and $u(\bar{X}^B, \bar{S})$ is the nondeterministic portion of utility, with mean independent of $\bar{X}^B$, and is assumed to represent unobserved characteristics of the day trip, $\bar{X}$, or unobserved characteristics of the decision maker, $\bar{S}$.

By assuming that the stochastic u's have a Weibull distribution and are independently and identically distributed, Domencich and McFadden have shown that the conditional probability of choosing lake i from a choice set of B sites can be expressed as

$$P_{i|g} = e^{V(\bar{X}^i,\bar{S})} \Big/ \sum_{j=1}^{B} e^{V(\bar{X}^j,\bar{S})}. \tag{3}$$

It is assumed that $V(\bar{X}, \bar{S})$ has the linear-in-parameters form:

$$V(\bar{X}, \bar{S}) = B_0 + (\bar{X}, \bar{S})B_1 + \cdots + (\bar{X}, \bar{S})B_k. \tag{4}$$

McFadden has shown that the maximum likelihood estimates for equation (3) are consistent and asymptotically efficient under very general conditions. A Newton-Raphson iterative routine was used, and B_0 was set equal to zero to insure that the maximum likelihood estimates were uniquely identified (Hanemann 1978, Morey).

To estimate $P_{i|g}$ it is assumed that each recreationist's choice set depends on the geographical location of his/her residence. The number of options varies from recreationist to recreationist, and the alternatives are unranked since there is no obvious pairing of one household's lake choice set with another's.

Probability of Lake Recreation Equation

On any given day the recreationist is assumed to make the decision of whether or not to visit a lake. The probability of choosing lake recreation for that day can be expressed as

$$P_{g|r} = \frac{e^{Z(\bar{X},\bar{S})}}{e^{Z(\bar{X},\bar{S})} + e^{Z(\bar{W},\bar{S})}} \tag{5}$$

where $P_{g|r}$ is the probability of taking a day trip; $Z(\bar{X}, \bar{S})$ is the average utility of lake recreation; $Z(\bar{W}, \bar{S})$ is the utility of not taking a day trip, and $\bar{W}$ is the vector of characteristics of not going.

The probability of choosing lake recreation depends, in part, on how accessible and desirable the lakes are to the recreationist. The natural measure for the desirability or accessibility of visiting any and all of the different lakes in the recreationist's choice set is the average accessibility and desirability of traveling to each of the alternative sites. The indices of accessibility and desirability are composed of the average values for each lake characteristic:

$$\left(\sum_{j=1}^{B_n} X_{jk}\right) \Big/ B_n \quad \text{for } k = 1, \ldots, K. \tag{6}$$

The indices of desirability and accessibility, which represent the average utility of lake recreation, are assumed to have the linear-in-parameters form:

$$(7)\quad Z(\bar{x}, \bar{s}) = \sum_{m=1}^{M} \left\{ \left[\left(\sum_{j=1}^{B_n} X_{jm} \right) \Big/ B_n \right] \gamma m \right\} + \sum_{1=m+1}^{Q} (\bar{X}, \bar{S}) \gamma_1$$

where $(\bar{x}, \bar{s})$ incorporate interactions between the socioeconomic characteristics of the decision maker and the attributes of lake recreation. Estimates of the parameters that maximized the log-likelihood function were obtained using the same Newton-Raphson iterative routine.

Data

The source for the cross-sectional survey data on Wisconsin lake recreationists was the Statewide Water Quality Survey (SWQS) done by the Wisconsin Survey Research Laboratory.

The following information was taken from the survey: (*a*) how many annual visits to what lakes, (*b*) residential location of respondent, (*c*) number of household members that accompany respondent to lakes, (*d*) number of nonhousehold members that accompany respondent to lakes, (*e*) entrance fees, (*f*) MPG for car used to transport respondent to lake, (*g*) average speed individual drives to lakes, (*h*) age, (*i*) years of education, (*j*) number of children under eighteen in household, (*k*) size of household, (*l*) years lived in Wisconsin, (*m*) total family income, (*n*) occupation of respondent, and (*o*) occupation of spouse.

The lack of specific information in the SWQS on activities at all of the lakes visited did not allow for the formal hypothesis testing of different demand equations for different lake activities. While it is commonly believed that responses to water quality improvements vary for different recreational activities, Schneider and Bouwes found that different lake activities did not significantly affect either Wisconsin recreationist's opinions of the important components of water quality or their perception of its level. These findings suggest that assuming uniformity of response to water quality improvements across activities may not be an unreasonable assumption. Other deficiencies in the SWQS (Caulkins, Bishop, and Bouwes) limited estimation to a subset of the sample consisting of forty-five lake users who reside in northern Wisconsin.

Lake specific information was provided from two sources. The Wisconsin Department of Natural Resources *Basin, County and Township Report* microfilms provided shoreline use information on the lakes. Water quality, lake size, and lake depth data were taken from a classification of Wisconsin lakes study (Uttormark and Wall).

Travel Cost Variable

The round-trip travel costs are defined by equation (8):

$$(8)\quad \text{Travel costs} = \frac{\text{round-trip transportation costs} + \text{round-trip opportunity cost of travel time} + \text{entrance fee}}{\text{opportunity cost of time}}$$

where the opportunity cost of time is equal to one-fourth the hourly wage rate (Cesario). The travel costs are deflated by the opportunity cost of time to assure that the equation is homogenous of degree zero in prices (Morey).

Water Quality Variable

Uttormark and Wall's 1975 Lake Classification Index (LCI) was chosen as an objective measure of water quality at lakes in northern Wisconsin. The existence of benefits from a water quality change are determined by the lake user's subjective perception of the improvement in water quality. A subjective-objective water quality linkage is necessary if policy-induced changes in water quality are to be explicitly translated into changes in lake visitation behavior (Freeman). Bouwes and Klessing were unsuccessful in establishing such a link; consequently, the objective LCI measure of water quality was used in the demand equations. Because it is unlikely that all objective water quality improvements would be perceived by the recreationists, any predicted changes in recreation resulting from a water quality improvement in this study should be considered an upper bound.

Other Lake Attributes

Schneider and Bouwes found that aesthetics-related characteristics of lakes were considered important determinants in choosing a site. To determine to what extent scenic preferences influence site choice, four categories of shoreline use were used—urban, low intensity development, agricultural, and undeveloped (Wisconsin Department of Natural Resources). The percentage of shoreline for each category was used in this study. Lake size (acres) and lake depth (feet) were two other lake attributes included to determine their influence on site choices.

Empirical Results for the MNL Model

The maximum likelihood estimates with the approximations for their corresponding asymptotic *t*-statistics are reported in table 1 for the site choice equation. On the basis of a likelihood ratio test, the null hypothesis (specification 3) that the coefficients on the percentage of shoreline in low intensity development, agricultural use, and lake size are not statistically different from zero cannot be rejected at the .10 level. The results confirm that recreationists prefer the sites in their choice sets that are closer to home and have better water quality.

Since the socioeconomic variables can only enter equation (3) interactively with lake-specific variables, plots of residuals on socioeconomic variables (age, education, number of children under the age of eighteen in the family, number of family members eighteen years or older, and type of employment) were examined to determine if any systematic relationship existed. None were detected.

The maximum likelihood estimates with the approximation to their corresponding asymptotic *t*-statistic are reported in table 2 for the frequency of lake recreation choice equation. On the basis of a likelihood ratio test, the null hypothesis (specification 3) that the coefficients on average lake size and education are not statistically different from zero cannot be rejected at .005 level.

Each lake recreation characteristic variable represents a utility comparison between taking a day trip versus not taking a day trip (Domencich and McFadden). For example, the average water quality variable, *LCI*, represents a utility comparison between taking a day trip and enjoying on average *LCI* water quality services, as defined in equation (6), versus not taking a day trip and not enjoying any of the services. A socioeconomic variable represents an interaction term between the socioeconomic characteristic of the decision maker and a dummy variable that equals one if the recreationist takes a day trip and zero otherwise.

The results indicate that the average accessibility of the lakes in the recreationist's choice set as well as the desirability of those lakes in terms of water quality and shoreline use are important determinants of the probability of choosing lake recreation. Caution must be used in interpreting the empirical results for both equations since it is unknown what specific lake activity was undertaken on each visit to a lake.

Both water quality and travel costs are the only policy variables necessary to evaluate the recreational benefits which would be generated by a lake rehabilitation project that would result in an improvement in that lake's water quality. Equation (3) can be manipulated to estimate to what extent an (increase/improvement) in (price/water quality) at lake *i* will cause the recreationist to substitute day

Table 1. Maximum Likelihood Estimates, Site Choice Equation

*L**	Percent Correct	*TC*	*LCI*	*SHLUNP*	*LDPTH*	*SHLID*	*SHAG*	*LSIZE*
1. −1309								
2. −1009		−.3235	−.1686	−1.694	−.0089	−.1595	+.492	−.00002
		(−17.34)	(−11.40)	(−7.28)	(−4.52)	(−.50)	(0.97)	(−2.70)
3. −984.1	59.1	−.4353	−.3143	−2.386	−.0154			
		(−15.34)	(−12.41)	(−9.49)	(−6.54)			

Notes: Numbers in parentheses are asymptotic *t*-statistics. Estimates are based on 944 site choices made. *TC* is travel costs as specified in equation (8); *LCI*, lake classification index for water quality measured in units of penalty points; *SHLUNP*, the percentage of shoreline that is undeveloped; *SHLID*, the percentage of shoreline in "low intensity development"; *SHAG*, the percentage of shoreline in agricultural use; *LDPTH*, lake depth in feet; *LSIZE*, lake size in acres; and *L**, log of the likelihood function.

Table 2. Maximum Likelihood Estimates, Probability of Lake Recreation

L^*	Percent Correct	$\overline{TC}$	$\overline{LCI}$	$\overline{SHLUNP}$	$\overline{SHLID}$	$\overline{SHAG}$	$\overline{LDPTH}$	$\overline{LSIZE}$	*AGE*	*RECY*	*EDUC*	*NUMPL*
1. −11,380												
2. −3,424		−.2376	−.1017	−1.552	−2.022	−4.299	.0218	−.00003	−.0063	0.0003	.0230	−.3343
		(−11.43)	(−5.75)	(−8.53)	(−5.45)	(−6.51)	(7.00)	(−1.87)	(−2.05)	(3.18)	(1.50)	(−7.90)
3. −3,428	94.0	−.2564	−.0997	−1.365	−1.643	−4.495	.0220		−.0075	.0004		−.3252
		(−13.46)	(−6.15)	(−8.92)	(−4.99)	(−6.87)	(7.65)		(−2.45)	(5.23)		(−7.88)

Notes. Numbers in parentheses are asymptotic *t*-statistics; estimates are based on 16,425 lake recreation or no lake recreation decisions made; $\overline{TC}$ is average travel costs to lakes in recreationist's choice set; $\overline{LCI}$, average lake classification index for water quality for lakes in recreationist's choice set; $\overline{SHLUNP}$, average percentage of shoreline that is undeveloped for lakes in recreationist's choice set; $\overline{SHLID}$, average percentage of shoreline in low intensity development for lakes in recreationist's choice set, $\overline{SHAG}$, average percentage of shoreline in agricultural use for lakes in recreationist's choice set; $\overline{LDPTH}$, average lake depth for lakes in recreationist's choice set; $\overline{LSIZE}$, average lake size for lakes in recreationist's choice set, *AGE*, age of household decision maker; *RECY*, recreational income of household; *EDUC*, number of years of education of household decision maker; *NUMPL*, number of people that usually accompany household decision maker on his/her lake visits; and L^*, log of the likelihood function.

trips (away from/to) lake i (to/away from) other lakes in his/her choice set. Equation (5) can be manipulated to estimate to what extent an (increase/improvement) in (price/water quality) at lake i affects the overall (accessibility/desirability) indices which cause the recreationist to substitute (away from/to) lake recreation.

Alternative Travel Cost (ATC) Model

Sutherland developed a regional gravity model that addresses both the substitution and site-quality effects. His model consists of four components: (*a*) a trip production component provides estimates of the number of recreation days by activity (swimming, boating, fishing, and camping) emanating from 132 population centroids; (*b*) a site attractiveness component estimates the relative attractiveness of each of 179 recreational centroids; (*c*) a gravity model uses the estimated results of (*a*) and (*b*) to produce a trip interchange matrix, and (*d*) the elements within the estimated trip interchange matrix are then used to estimate typical Clawson-Knetsch travel cost demand curves for each recreational site and activity. Such a model does not appear to be empirically reliable since the error associated with the predicted number of recreation days (unadjusted R^2s ranging from .03 to .09) in the first component cascades through and is compounded by the errors associated with each subsequent component. Sutherland's approach was rejected for this reason.

Another multisite approach is Desvousges, Smith, and McGivney's two-stage varying parameters model, where visits are first regressed on travel costs and other socioeconomic variables for each site; then the estimated own-price coefficients are regressed on the site attributes. Such a model requires a substantial number of observations at each site and a substantial number of sites. Our limited data set precluded such estimation.

The alternative travel cost (ATC) model estimated here is one where the data on visits to different sites is pooled to estimate a single, visitation equation of the form

$$(9)\quad DT_{ij} = F(TC_{ij}, \bar{X}_j, f_{ki} * TC_{ki}, \; \ldots f_{Ki} * X_{Ki}, \bar{S}_i)$$

where DT_{ij} is the number of day trips by recreationist i to site j, which is the site he/she most often visited during the year. TC_{ij} is the round-trip, deflated travel costs by i to j, and $\bar{X}_j$ is a vector of site quality characteristics that includes the LCI measure of water quality. The impact that alternative sites have on the demand for day trips to site j is captured by K weighted-average variables of the characteristics of day trips to those sites. For example, the weighted-average travel cost variable is defined as

$$(10)\qquad \sum_{b=1}^{B_i} f_{bi} * TC_{bi}$$

where $b = 1, \ldots, B_i$ represents the alternative sites visited during the year by individual i; f_{bi} is the relative frequency of visiting site b.

Empirical Results for the ATC Model

The double log specification provided the best fit both in terms of the highest adjusted R^2 and the expected signs on statistically significant variables. After having corrected for heteroscedasticity using the Glejser procedure, the weighted least squares estimates are reported in table 3. On the basis of an F-test, the null hypothesis (specification 2) that the coef-

Table 3. Weighted Least Squares Estimates, Alternative Travel Cost Model

DEP VAR	*C*	ln*TCj*	*LCIj*	*LSIZEj*	*LDPTHj*	*SHLIDj*	*SHAGj*	*SHLUNPj*	ln*AGE*	ln*NMPL*	*EDUC*	*RECY*
1. ln(*TRIPS*$_j$)	1.8352	−.5823	−.1461	−.00004	−.0001	−.4834	1.5982	−.0961	.6522	−.6166	.0452	.0004
	(0.69)	(−3.83)	(−1.97)	(−0 48)	(−0.01)	(−0.41)	(0.85)	(−0 10)	(1.29)	(−1.37)	(0.63)	(1.06)
2. ”	2.8865	−.6112	−.1457				1.3518			−.7185		.0006
	(4.71)	(−5.74)	(−3.12)				(1.02)			(−2.12)		(1.89)

DEP VAR	*WC*	$\ln[\Sigma f_b{*}TC_b]$	$\Sigma f_b{*}LCI_b$	$\Sigma f_b{*}LSIZES_b$	$\Sigma f_b{*}LDPTHS_b$	$\Sigma f_b{*}SHLIDS_b$	$\Sigma f_b{*}SHAGS_b$	$\Sigma f_b{*}SHLUNPS_b$
1.	.1324	.4095	−.0103	−.00001	.00027	−2.5420	5.3711	−1.1348
	(0.34)	(1.57)	(−0.07)	(−0.70)	(0.16)	(−1.54)	(1.32)	(−0.84)
2.		.3743					5.6678	
		(1.98)					(2.21)	

Notes Sum of squared residuals for equation 1 (SSR_1) = 35 94, SSR_2 = 45.77, numbers in parentheses are *t*-statistics; number of observations, 44, ln*TC* is natural log of travel costs to lake most often visited (*j*); *LCI*, lake classification index for water quality for lake *j*; *LSIZE*, lake size in acres for lake *j*; *LDPTH*, lake depth in feet for lake *j*, *SHLID*, percentage of shoreline in low intensity development for lake *j*; *SHAG*, percentage of shoreline in agricultural use for lake *j*, *SHLUNP*, percentage of shoreline that is undeveloped for lake *j*, ln*AGE*, natural log of age of household decision maker, ln*NMPL*, natural log of the number of people that accompany the household decision maker on his/her lake visit; *EDUC*, number of years of education of household decision maker, *RECY*, recreational income of household, *WC*, 1 = white collar employment for household decision maker; 0 otherwise; $\ln[\Sigma f_b{*}TC_b]$, weighted average travel costs to alternative lakes in recreationist's choice set, $\Sigma f_b{*}LCI_b]$, weighted average water quality lake classification index for alternative lakes, $\Sigma f_b{*}LSIZES^b$, weighted average lake size in acres for alternative lakes, $\Sigma f_b{*}LDPTHS_b$, weighted average lake depth in feet for alternative lakes, $\Sigma f_b{*}SHLIPS_b$, weighted average percentage of shoreline in low intensity development for alternative lakes, $\Sigma f_b{*}SHAGS_b$, weighted average percentage of shoreline in agricultural use for alternative lakes; $\Sigma f_b{*}SHLUNPS_b$, weighted average percentage of shoreline that is undeveloped for alternative lakes.

ficients on the excluded variables are not statistically different from zero could not be rejected at the .01 level.

Comparison of the MNL and ATC Models

In order to compare the performance of the MNL model with that of the ATC model, estimates of the predicted change in visits were calculated for a one (LCI) unit improvement in water quality at Shadow Lake in northern Wisconsin for both models. A sample of sixty recreationists interviewed at the site was used.

These sixty recreationists originally made 1,305 visits to Shadow Lake. The ATC model predicts that an additional 208 trips (a 16% increase) would be made in response to a one-unit water quality improvement. The MNL model predicted a smaller increase, an additional 154 trips (a 12% increase). While a 4% difference between the predictions for the two models may not appear to be large, it translates into a difference of 3,000–4,000 additional summer visits when total summer attendance (80,000–90,000) is taken into consideration. This difference was predicted by Freeman:

> Suppose that there are two sites *j* and *k*, which are identical in all respects except for their water quality. Let WQ_j be less than WQ_k. Assume that equation [9, the ATC model] has been estimated for the region. Then postulate an improvement in *WQ* at WQ_j such that $WQ_j = WQ_k$. The model of equation [9, the ATC model] would predict an increase in V_j [visits to site *J*] such that $V_j = V_k$, with no changes in visitation at *k* or any other site in the region. However, the more likely outcome is a diversion of activity from *k* to *j*, with only a small increase in the total activity at the two sites. Sites *j* and *k* would have the same activity levels, but they would be equalized at a level somewhat below the original level of *k*. Thus equation [9, the ATC model] would tend to overestimate the actual increase in visits to *j* and total visits to the two sites combined. (The insertion of the words in brackets is mine.) Freeman, p. 213

By overestimating the increase in the number of day trips to Shadow Lake, the ATC model shifts the demand curve associated with the improved water quality too far out, and consequently the area between the initial demand curve and the shifted one overestimates the actual change in consumer surplus. The ATC model overestimates the increase in the number of visits to the improved water quality site primarily on account of its inability to adequately portray how recreationists would reallocate their visits amongst the lakes in their choice sets.

The MNL model, on the other hand, behaves according to Freeman's "more likely outcome." For the described change in WQ_j, the site choice equation would predict an increase in site *j*'s probability and a corresponding decrease in site *k*'s probability, and the frequency of lake recreation choice equation would predict a slight increase in the overall probability of lake recreation.

Conclusion

The principal finding of this study illustrates how different assumptions regarding recreationists' decision-making behavior may affect the predicted changes in recreational activity given a change in water quality. The MNL model specification portrays recreationists' decision-making behavior according to Freeman's "more likely outcome," and this leads to smaller increases in the additional number of day trips made to Shadow Lake as a result of a water quality improvement. The use of the more conventional model in estimating the recreational benefits for a proposed lake rehabilitation project could overestimate actual benefits. In some cases this could lead decision makers mistakenly to undertake projects that they believe are economically justified.

Some caution seems appropriate in interpreting these results. It is important to note that it is not possible to attribute definitively the differences in predicted changes in recreation activity solely to the different behavioral assumptions implicit in the two models. Numerous issues were confronted in the empirical estimation of the two models, and the manner in which we have addressed them may influence the empirical results. First, whether different demand equations are needed for different lake recreational activities (e.g., swimming, boating, fishing) could not be addressed in this study because of a lack of data. If the set of decision rules that govern the choices made by fishermen are not based on the same characteristics as that for swimmers, then separate demand functions should be estimated for each activity. Second, the specification of the relevant choice sets presented problems for both models. Third, for the MNL model, the assumption that each day trip represents a decision that is independent of past or planned future visits to sites is not that plausible. The development of a Markov chain model would be preferable. Fourth, issues concerning the opportunity cost of time spent at the site and traveling to and from the site and their impacts on recreational decision making could not be addressed in this study. Finally, the subjective-objective water quality linkage could not be established empirically and was assumed. For these reasons the empirical results obtained here should be considered suggestive.

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