The Effect of Water Quality Characterization on Recreation Demand Model Results

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Purpose

- Representations of water quality in economic literature:
  - Direct measurements of water quality constituents
    - Egan et al. (2009), Moore et al. (2015)
  - Water quality index score
    - Carson and Mitchell (1993), Johnston et al. (1999)
  - Designated uses & achievement
    - Viscusi, Huber, and Bell (2008)

- How do these different representations of water quality affect estimated results and willingness-to-pay?
  - Which of these measures best captures how people think about and make decisions regarding WQ?

Data

- Trip Data:
  - 2002 Iowa Lakes Survey administered by Iowa State University:
  - Collected information on 2001 visitation to 129 lakes by 3,859 respondents in Iowa
    - Currently running specifications using 1,286 respondents

- Water Quality Data:
  - 2001 Water quality data also collected by Iowa State, supplemented by additional parameters from Iowa Lakes Information System
  - Over 23 different annual WQ parameters available
  - Water quality index values based US EPA's Construction & Development Rulemaking
    - Parameters include TN, TP, DO, Turbidity, PH, TSS, BOD, and Temperature

$$\mathrm{WQI} = \prod_{i=1}^{n} Q_i^{w_i}$$

  - Assigned designated uses (DUs) for each lake were collected from the Iowa DNR and violations of individual lake DUs were compiled from Iowa's 2002 305(b) report submitted to EPA.

Mixed Logit Random Utility Model

$$U_{njt} = \begin{cases} X_{jt}\beta_n + \varepsilon_{njt} & j = 1\text{to}129 \\ \alpha_{0,n} + \alpha_{0,n} * Z_n + \varepsilon_{njt} & j = 0 \end{cases} \qquad (1)$$

$$L_n(\beta_n) = \prod_{t=1}^{T} \left[\frac{e^{Vnjt}}{\sum_j e^{Vnjt}} \right] \qquad (2)$$

$$P_n = \int L_n(\beta_n) f(\beta) d\beta \qquad (3)$$

$$WTP = -\frac{\beta_X * \Delta X}{\beta_{\text{cost}}} \qquad (4)$$

Preliminary Results

	Mean		St. Dev	
Characteristics	Estimate	T-stat	Estimate	T-stat
RESPONDENT CHARACTERISTICS				
MALE	-0.0309	-0.466	---	---
AGE	-0.3971	-3.298	---	---
AGESQ	0.3990	3.579	---	---
SCHOOL	0.3836	4.394	---	---
HOUSEHOLD	-0.2112	-9.362	---	---
TC	-4.8851	-111.914	---	---
STAY HOME CONST	-8.6141	-23.800	-2.2692	-55.597
SITE CHARACTERISTICS				
LOG_ACRES	0.4225	34.242	-0.2171	-40.184
RAMP	0.6380	7.456	-1.0409	-25.641
FACILITIES	0.0040	0.118	-0.7568	-19.041
STATE PARK	0.2826	6.972	-0.8814	-27.382
WAKE	0.2516	6.562	-0.7377	-21.386
TOTALFISH	0.0163	1.020	-0.2680	-16.663

Preliminary Results

	EGAN et al		Disaggregated WQI		WQI		Designated Uses	
VARIABLE	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
SECCHI	0.1326	6.829						
LOG_CHLORO	0.2625	9.285						
ISS	-0.0675	-4.755						
VSS	-0.0286	-0.924						
LOG_CYNOBACT	-0.2689	-15.557						
LOG_TOTPHYTO	0.3051	13.551						
LOG_TN	-0.0507	-2.858	-0.0265	-1.517				
LOG_TP	-0.3020	-10.139	-0.1145	-4.205				
DO			0.1021	8.596				
TURBIDITY			-0.0237	-5.577				
PH			-0.0530	-0.843				
TSS			0.0230	1.403				
BOD			0.0784	2.812				
TEMP			-1.6921	-19.097				
WQI					0.0900	9.157		
DU_A (CONTACT)							0.0676	1.549
DU_B (AQUATIC LIFE)							0.5702	3.223
DU_HQ							1.0956	24.146
DU_HQR							0.3952	9.244

Preliminary Willingness-to-Pay

One unit Change	Egan et al	Disaggregate WQI	WQI
TN	$0.01	$0.01	$0.06
TP	$0.06	$0.06	$0.01

- The two direct WQ measure models produce similar results
- The WQI results are the average value of a one unit change across all lakes.
  - The shape of sub-index curves and critical levels in different lakes can lead to larger or smaller results than the direct WQ parameter models

Next Steps/Extending the Analysis

- Look further into the Designated Use data
- Finalize all models and estimate using full trip dataset
- Welfare analysis of more realistic nutrient reduction scenario

Appendix – Water Quality Index

Parameter	Concentration	Subindex	Weight
Total Nitrogen	≤ 3 Mg/L > 3 Mg/L	100*exp(TN * -0.4605) 10	0.18
Total Phosphorous	≤ 0.25 Mg/L > 0.25 Mg/L	100 – 299.5 * TP – 0.1384 * TP^2 10	0.18
Total Suspended Solids	≤ TSS_{10} Mg/L TSS_{10} < TSS ≤ TSS_{100} >TSS_{100}	10 a * exp(TSS * b) 100	0.14
Biochemical Oxygen Demand, 5-day	≤ 8 Mg/L > 8 Mg/L	100 * exp(BOD * -0.1993) 10	0.19
DO DO sat≤100%	DO ≤ 3.3 Mg/L 3.3 < DO < 10.5 Mg/L DO ≥ 10.5 Mg/L	10 -80.29+31.88 * DO-1.401*DO^2 100	0.31