THE COST OF ALGAE CONTAMINATION IN FRESH WATER LAKES: IDENTIFICATION OF DEMAND FUNCTIONS FOR ENVIRONMENTAL QUALITY

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SEEDS

Motivation

When, where and to extent should we react to environmental changes?

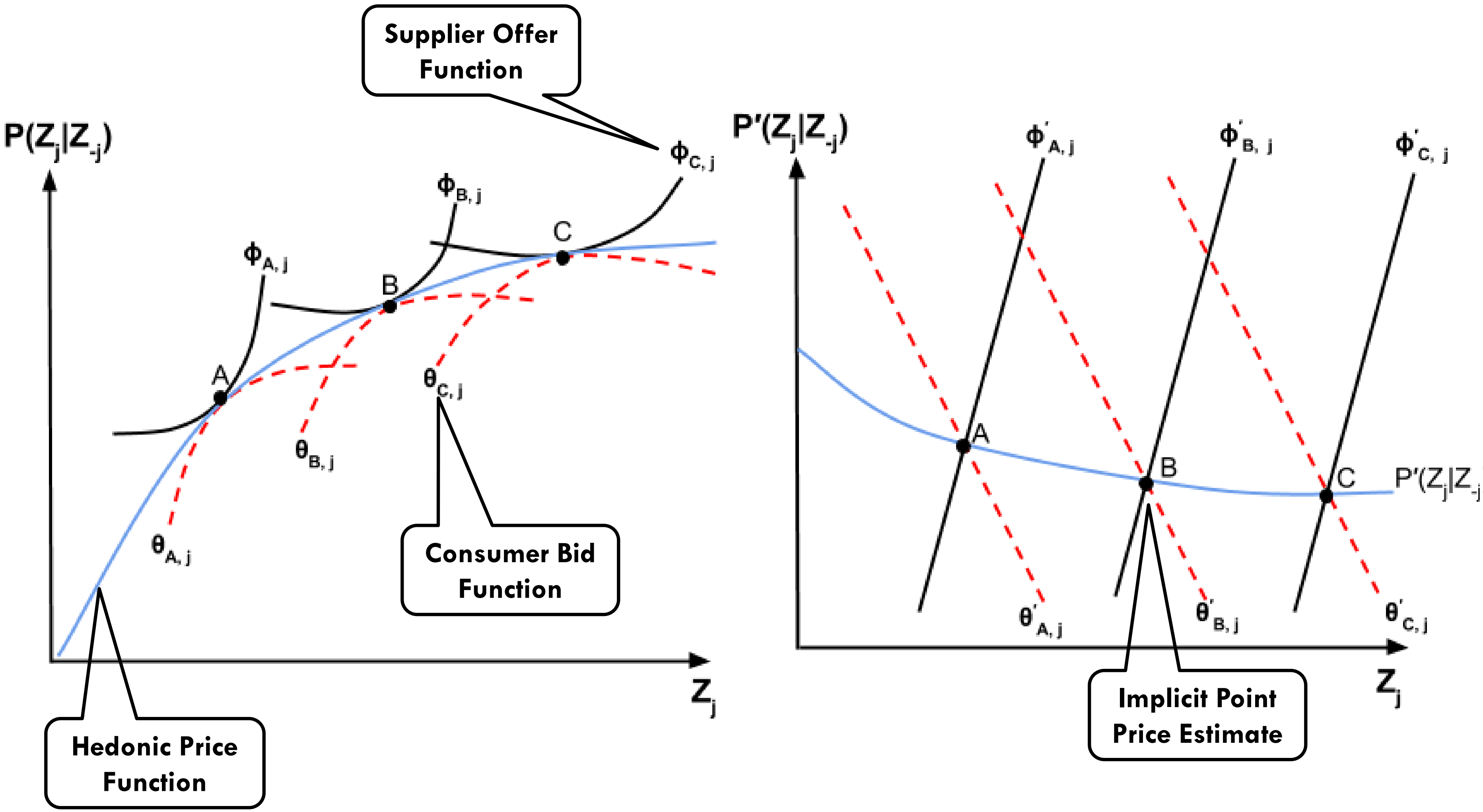
How does the value for environmental quality improvements change with initial conditions?

Recovery of consumer preferences for environmental quality

Key Findings

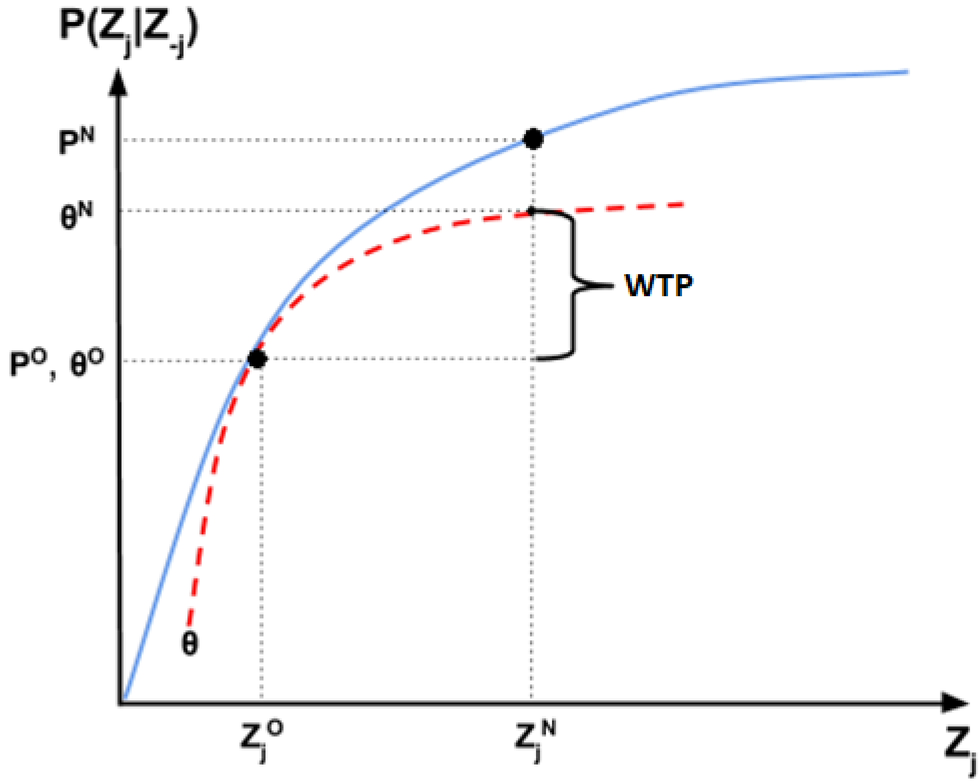
- 1.) Improve 2nd stage hedonics by recovering unbiased demand function estimate using exogenous IV
- 2.) Use heterogeneity in household characteristics to obtain inverse, compensated demand curves following Hausman (1981) and Palmquist (2005)
- 3.) Application to Harmful Algal Blooms (HABs) on Lake Erie reveals 1st stage MWTP estimates undervalue homeowner benefits by more than 50%

Rosen (1974)



Supplier Offer Function
Consumer Bid Function
Hedonic Price Function
Implicit Point Price Estimate
$P(Z_j|Z_{-j})$
$P'(Z_j|Z_{-j})$
Z_j
$\phi_{A,j}$
$\phi_{B,j}$
$\phi_{C,j}$
$\theta_{A,j}$
$\theta_{B,j}$
$\theta_{C,j}$
$\phi'_{A,j}$
$\phi'_{B,j}$
$\phi'_{C,j}$
$\theta'_{A,j}$
$\theta'_{B,j}$
$\theta'_{C,j}$
A
B
C

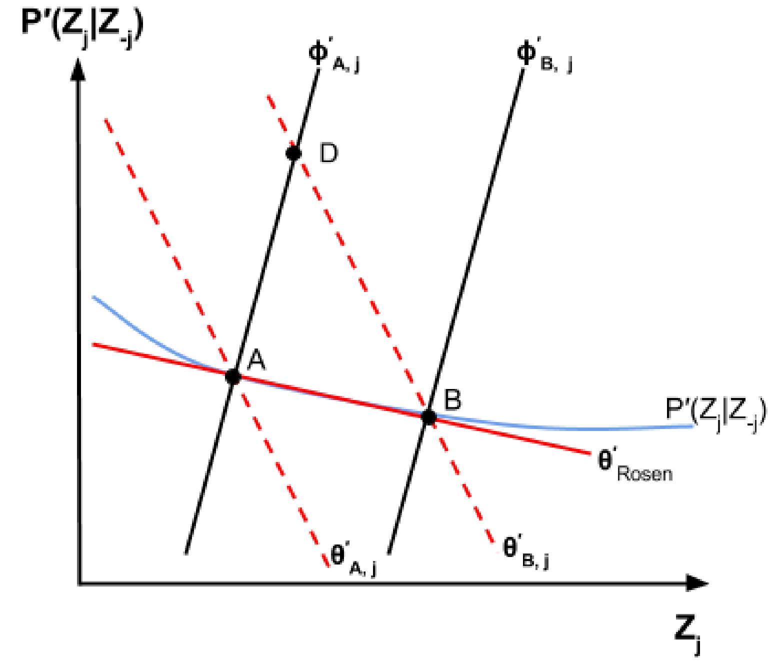
First Stage Welfare Bias



Solution 1: Rosen (1974)

- System of simultaneous equations:

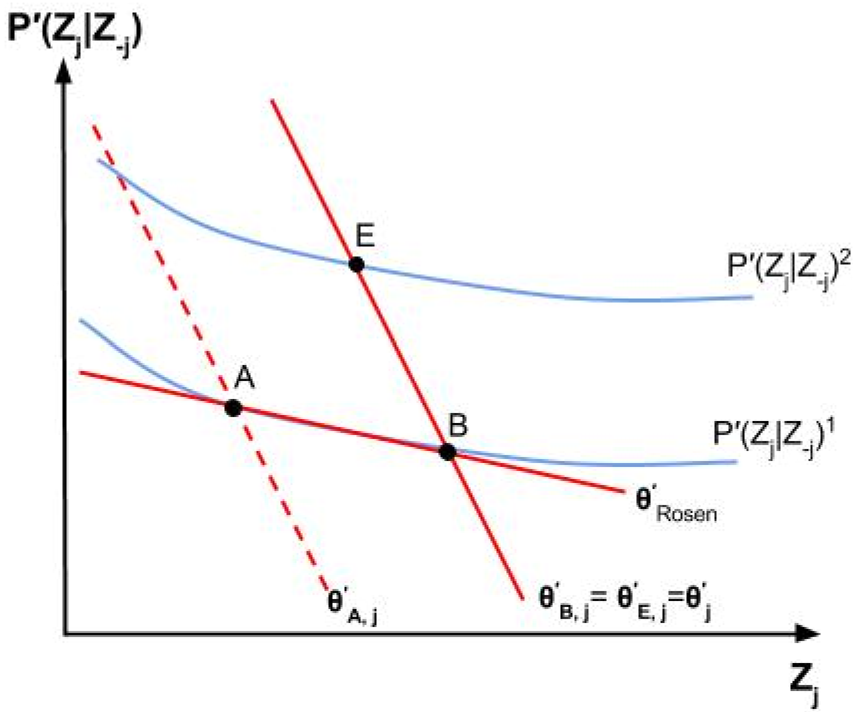
  - $\frac{\partial P(Z)}{\partial Z_j} = \theta'_j(Z_j, Z_{-j}, X^O, X^U)$
  - $\frac{\partial P(Z)}{\partial Z_j} = \phi'_j(Z_j, Z_{-j}, S^O, S^U)$



Problem: Endogeneity ($Corr(S^O, X^U) \neq 0$)

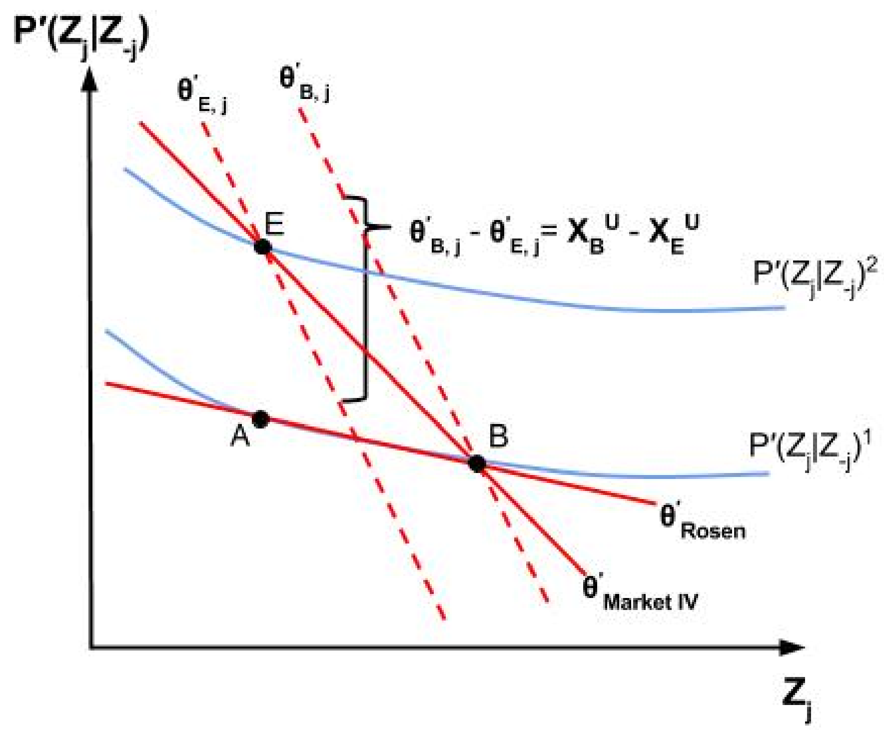
Solution 2: Bartik (1987)

- Add more information from separate hedonic markets:



Bartik (1987) Continued…

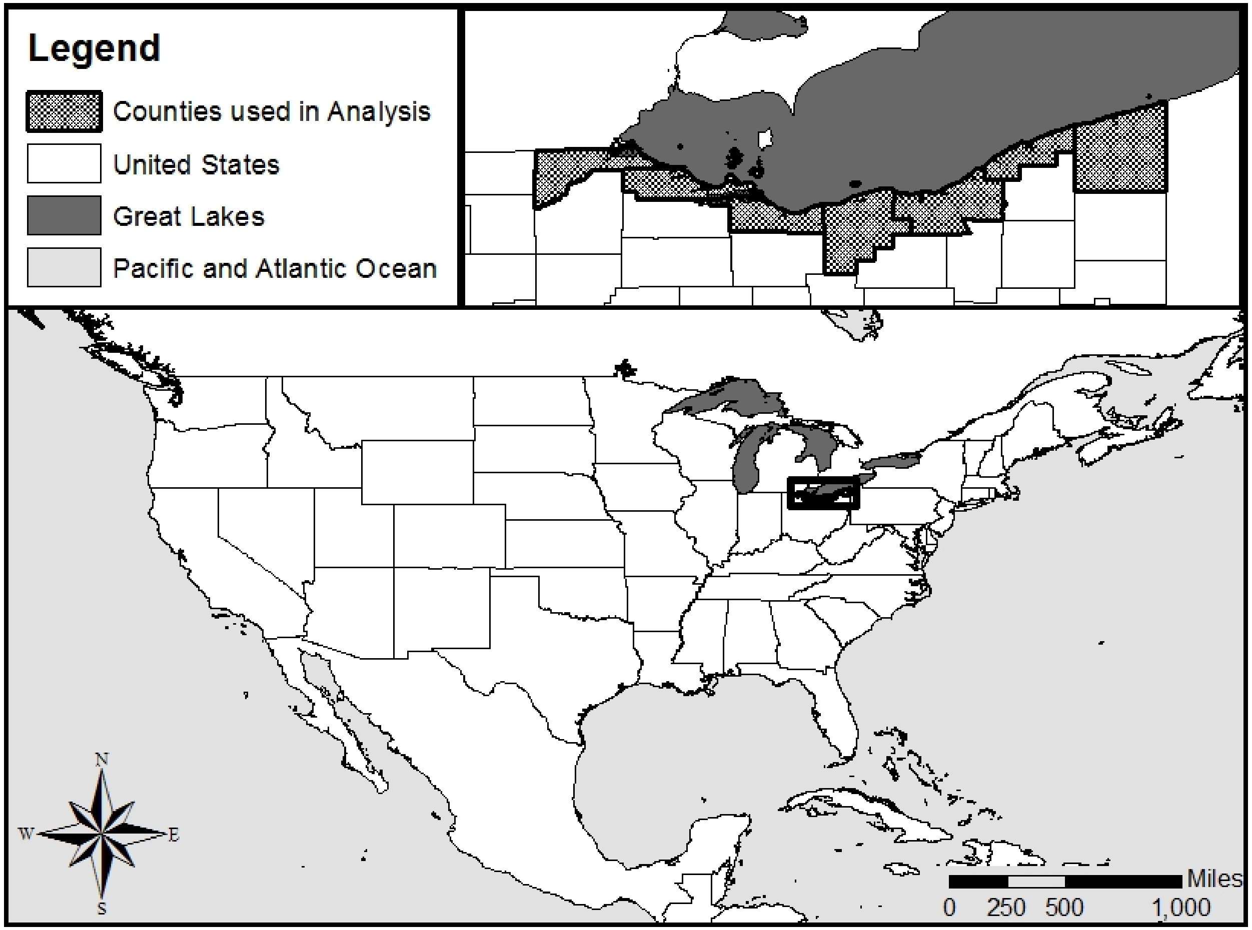
- Problem: preference-based sorting



Avoid Sorting Bias

- Avoid sorting bias in multi-market approach by introducing new exogenous IV
- Apply methodology to value non-marginal changes in HAB on Lake Erie
- Exogenous variation in hydrological characteristics to instrument for algae production

Study Setting



Highly Data Intensive

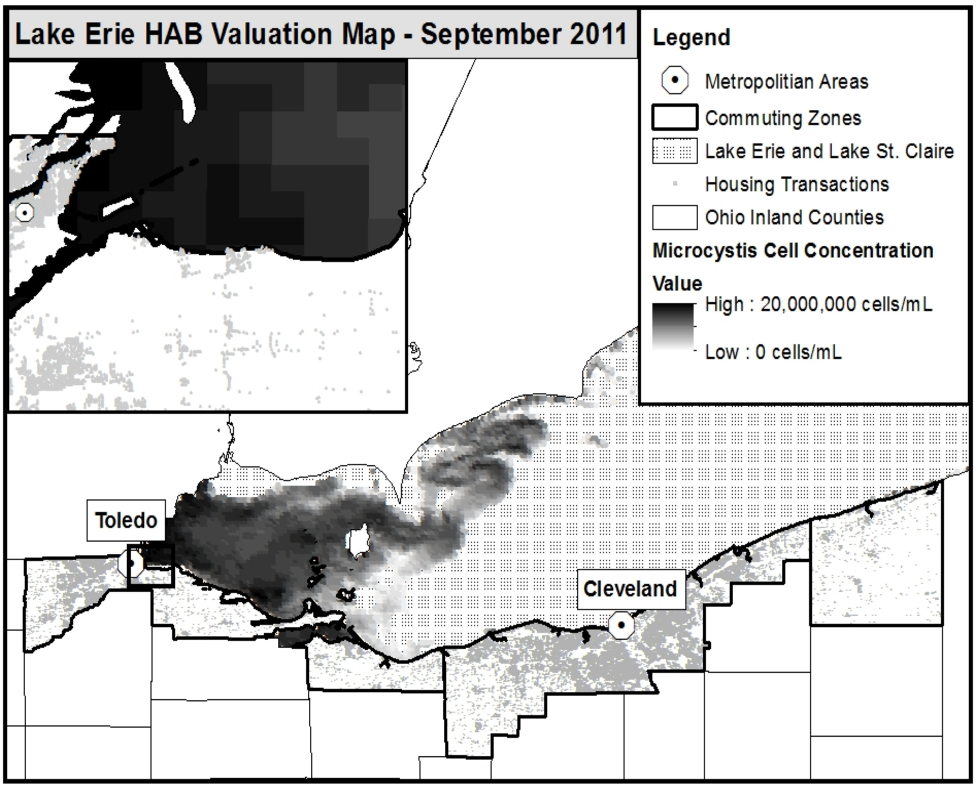
- Housing transactions from CoreLogic and county auditor websites
  - 7 counties bordering Lake Erie
  - 2002 – 2015
  - N=140,708

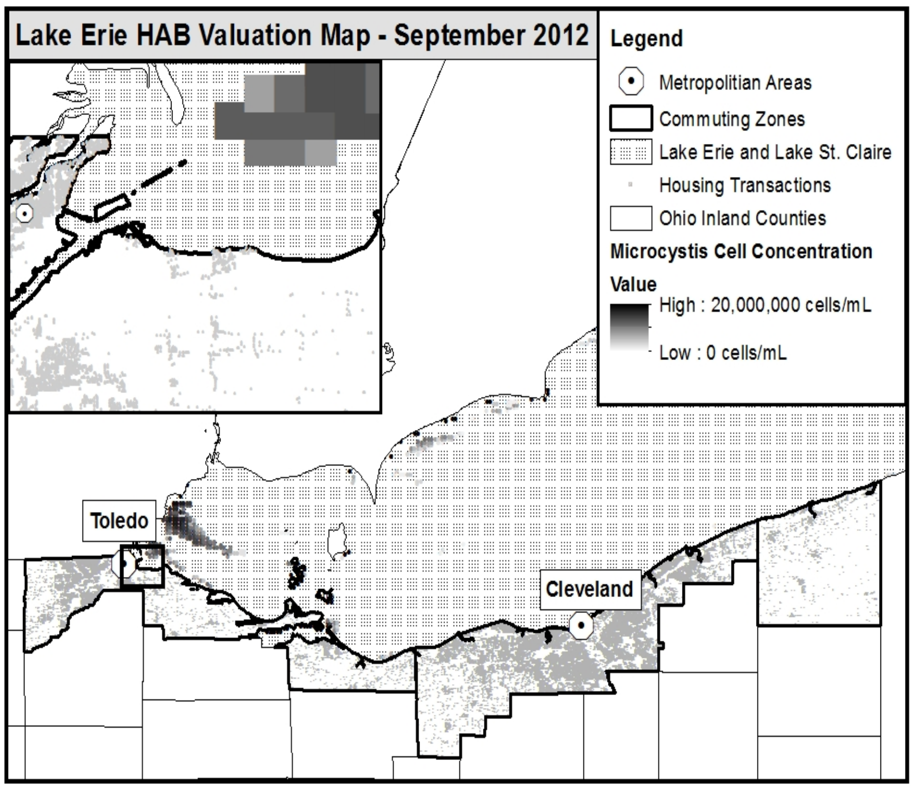
- Household-varying demographics information
  - HMDA (Home Mortgage Disclosure Act)
  - Nationwide database released annually

- Remote-sensing algae data from NOAA (2015) and Wynne and Stumpf (2014)
  - 10-day composites between June - October
  - 2002 - 2014

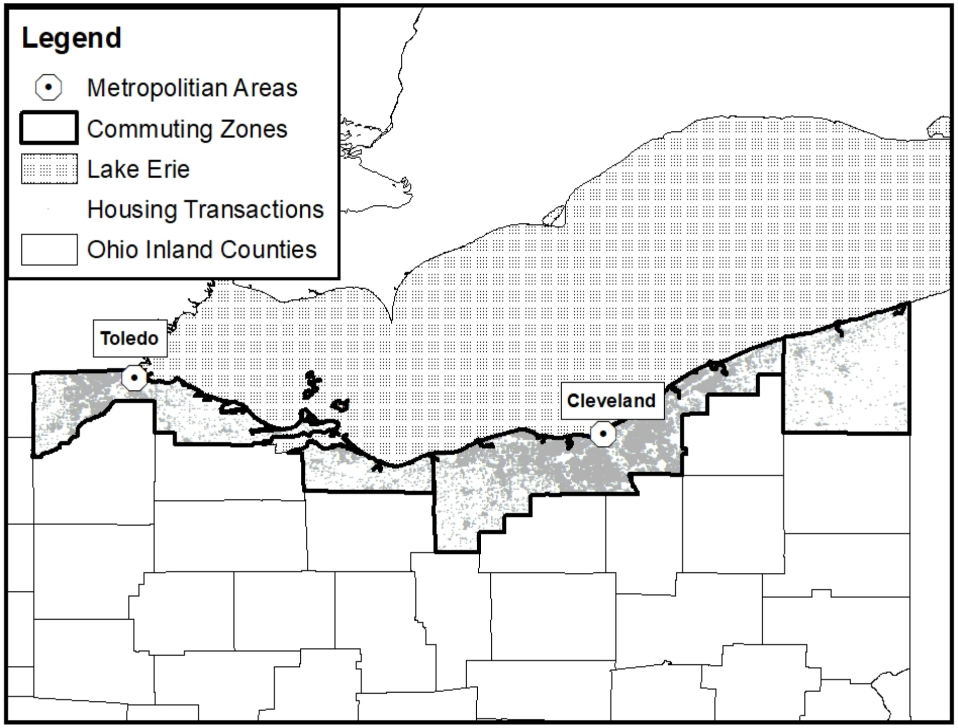
- Boating and Fishing License Data from Ohio Department of Natural Resources
  - 2009-2015
  - Geocoded to housing transactions

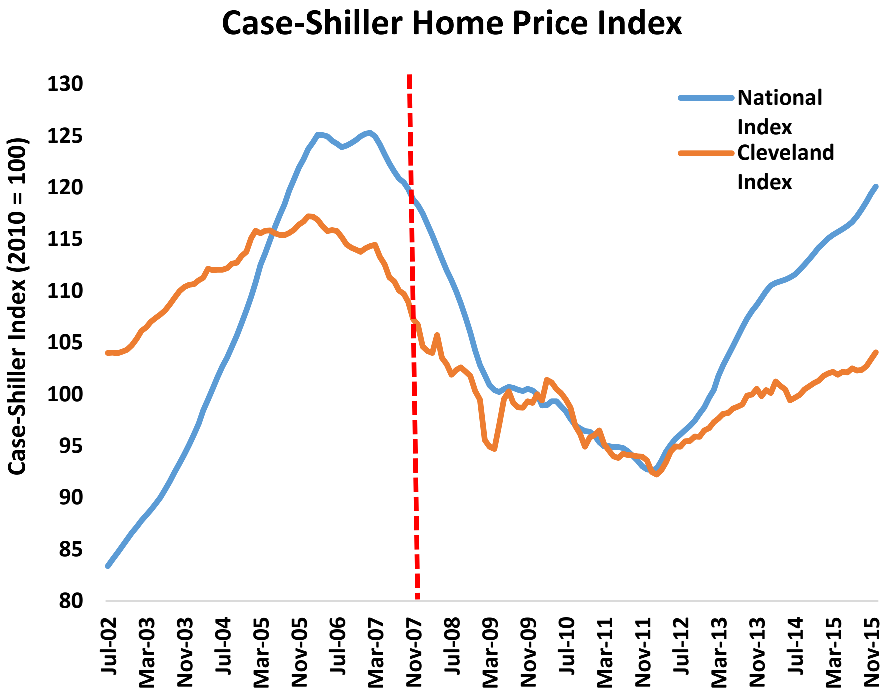
Remote Sensing and Housing Data



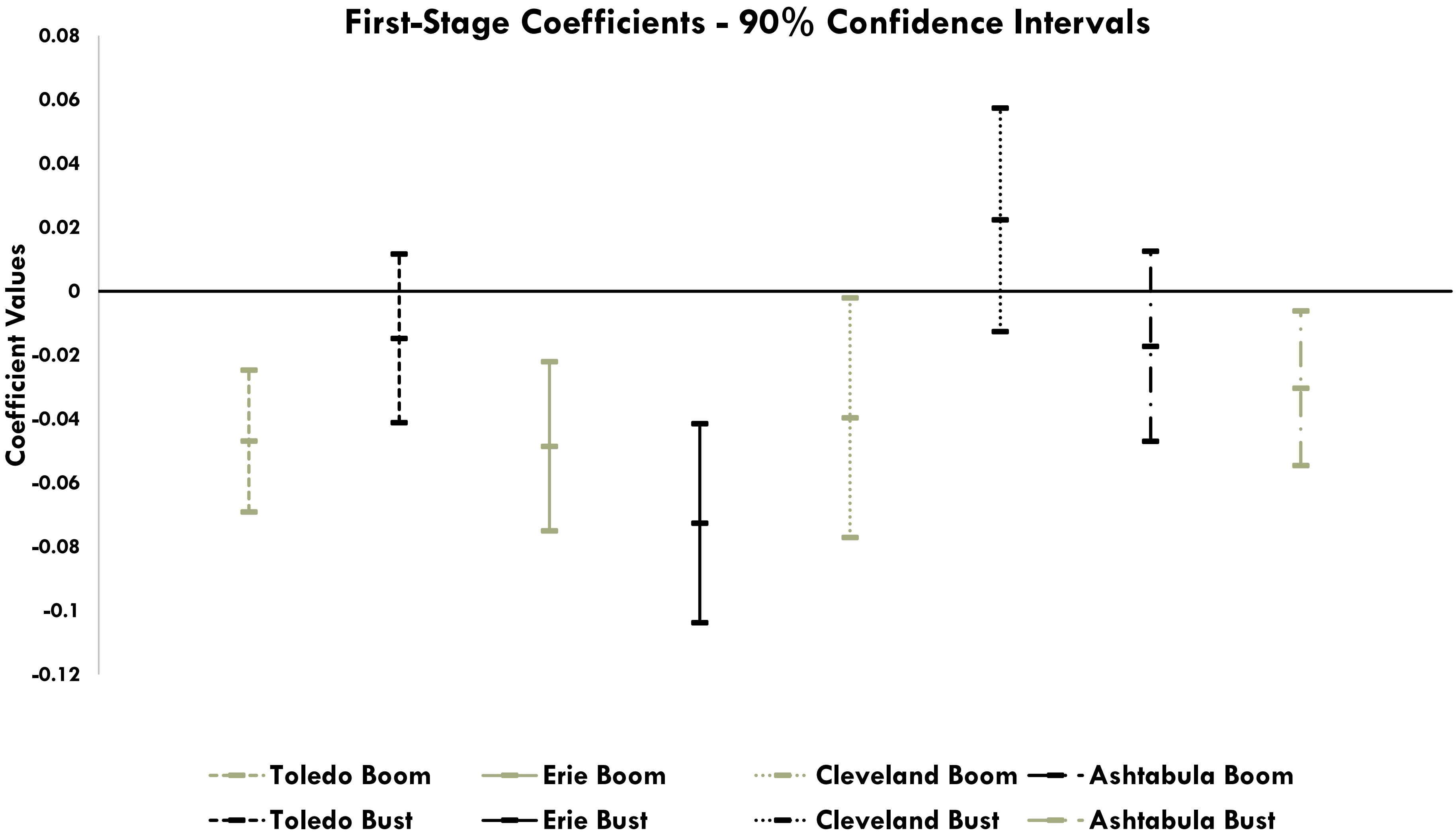


Spatial and Temporal Housing Markets

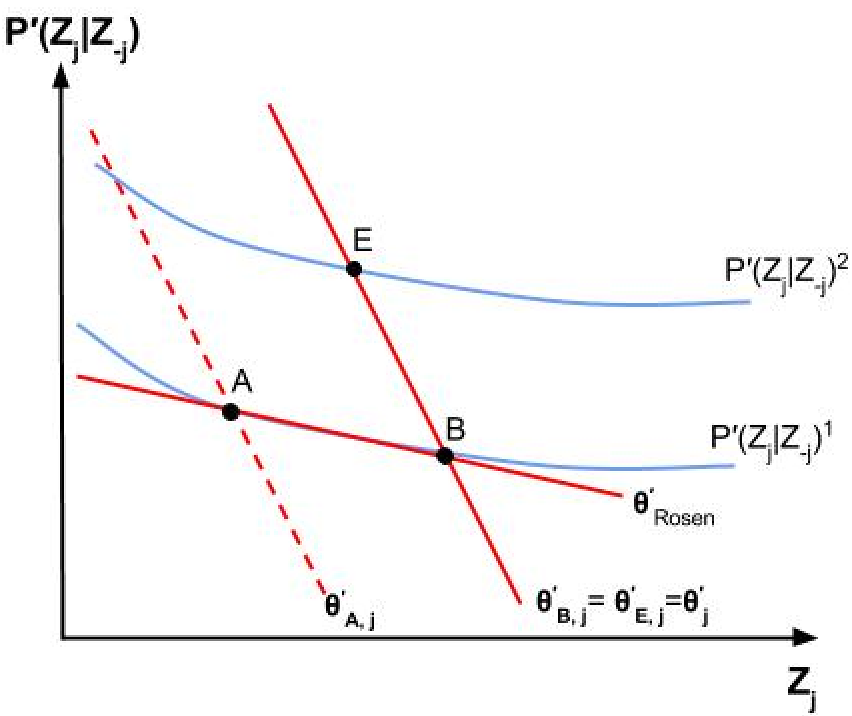




First-Stage Coefficient Estimates



Second-Stage Identification Strategy

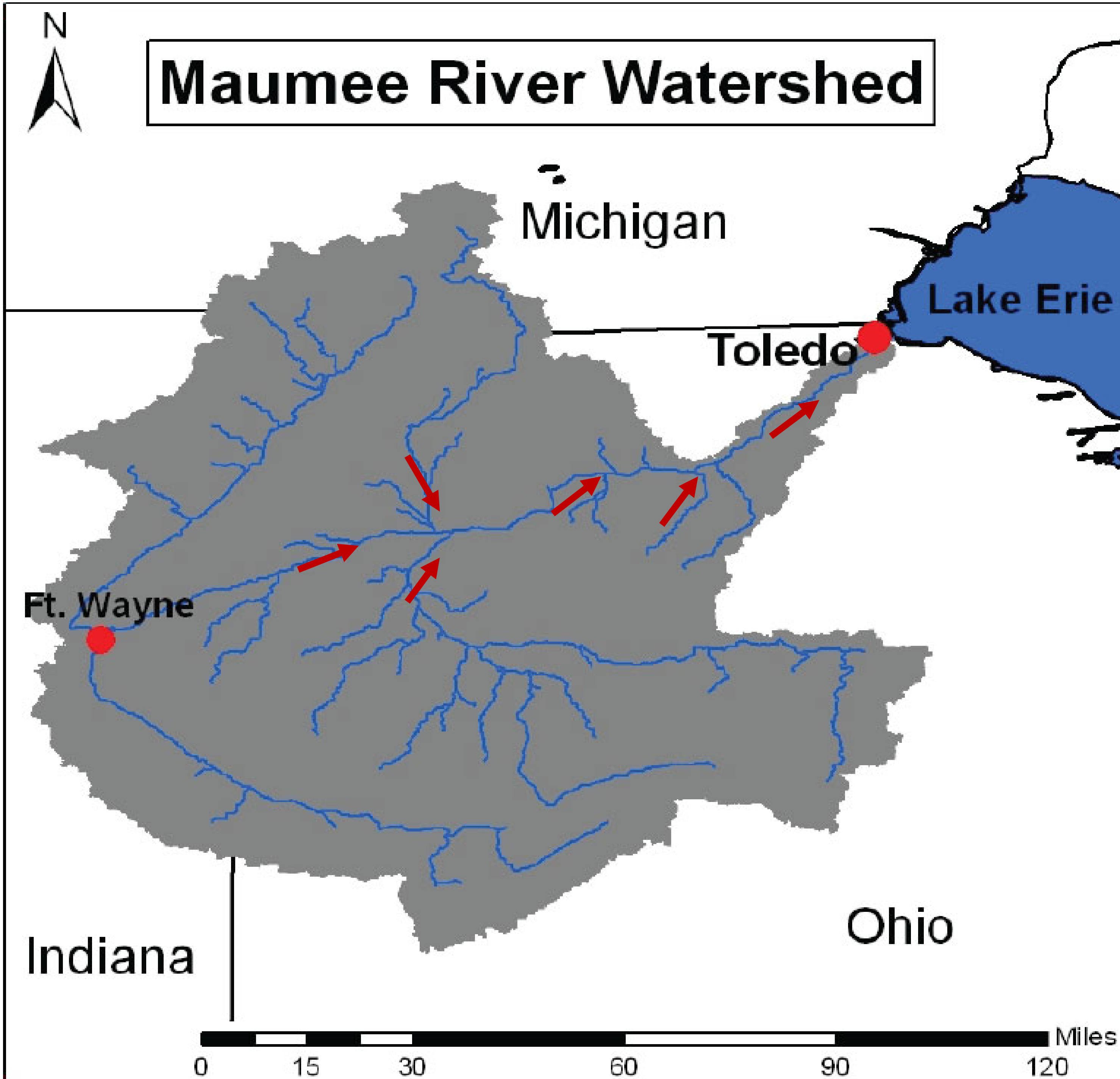


- 3 sets of results:
  - OLS – Does not correct for simultaneity bias
  - Multi-market IV – Uses shifts in hedonic price equilibrium to correct simultaneity bias; does not correct for taste-based sorting
  - Exogenous IV – Corrects for both simultaneity bias and taste-based sorting

Proposed Second-Stage IV

- Maximum, Spring (March – June) water discharge from the Maumee watershed.

- Heavier Maumee outflow increases nutrients in Lake Erie (Michalak et al. 2013; Zhou et al. 2013; Stumpf et al. 2012).



N
Maumee River Watershed
Michigan
Lake Erie
Toledo
Ft. Wayne
Indiana
Ohio
Miles
0
15
30
60
90
120

Second-Stage Results

Cobb-Douglas Specification (Log-Log)			
Variable	OLS	Market IV	Discharge
LogAlgae	-1.032***	-1.028***	-1.207***
	(0.0212)	(0.0343)	(0.0903)
Fishing License (0/1)	-0.0347*	-0.0349*	-0.0236
	(0.0185)	(0.0212)	(0.0276)
Boating License (0/1)	0.0336	0.0330	0.0659**
	(0.0231)	(0.0262)	(0.0313)
log(NumeraireGood) (1000s)	0.0859***	0.0853***	0.119***
	(0.0189)	(0.0189)	(0.0225)
Observations	4,553	4,553	4,553
First Stage F-Test	-	96.75	54.02

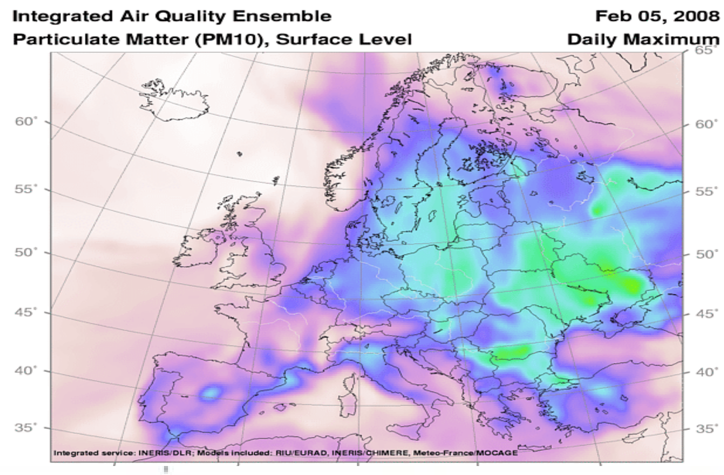
Does it matter?

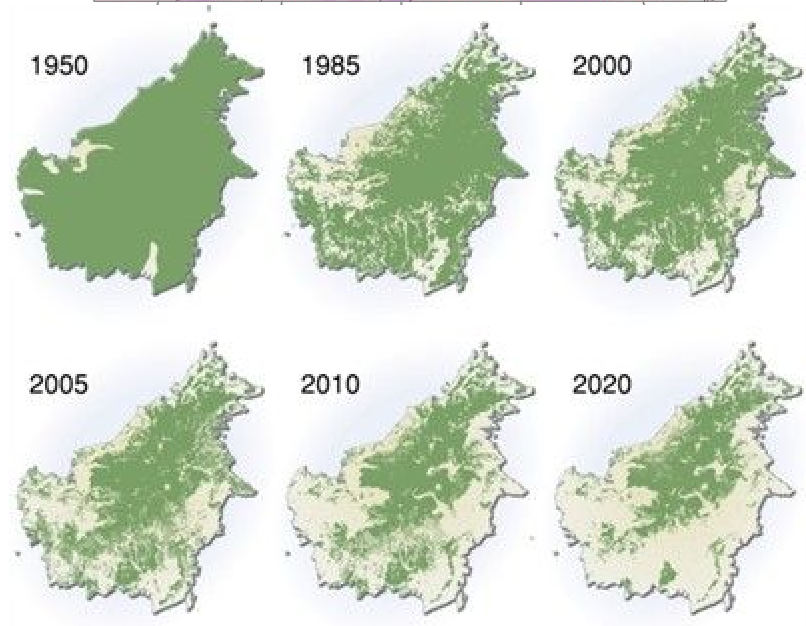
- 2012 Great Lakes Water Quality Agreement (GLWQA) calls for a 40% reduction phosphorous loadings.

- Welfare gains from GLWQA:
  - 1st stage point estimate: $1,465 per household
  - 2nd stage demand estimate: $3,215 per household
  - Aggregate benefits: $136 million per year

Broad Applicability

- Useful in valuing other public/environmental goods (i.e. air/light pollution, deforestation, land use change, etc.)
- Easier to implement given expansion of satellite imagery
- Can couple with climate change IAMs, land use and hydrology models

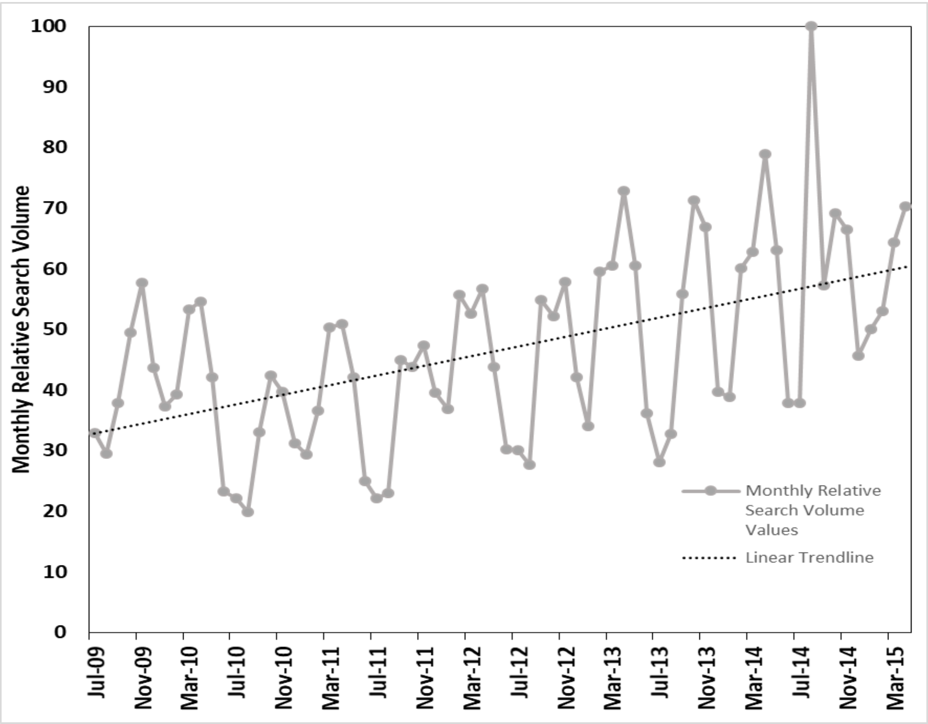


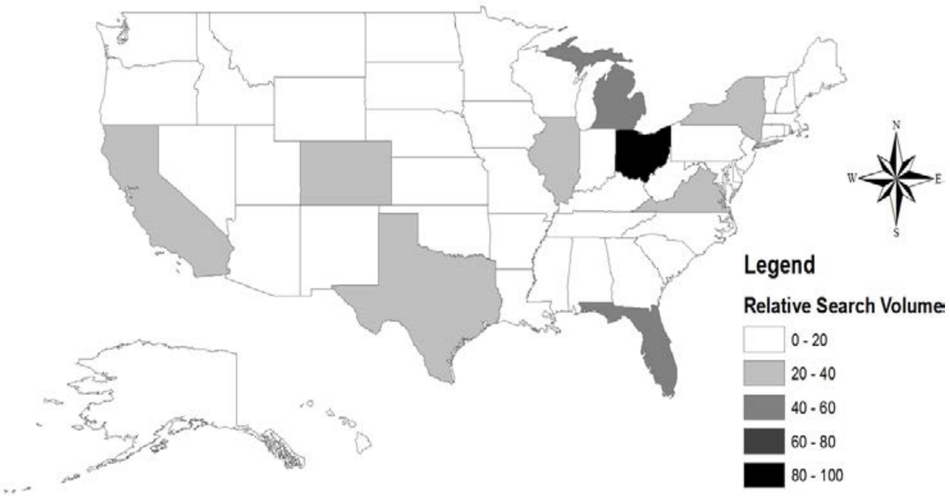


Questions?

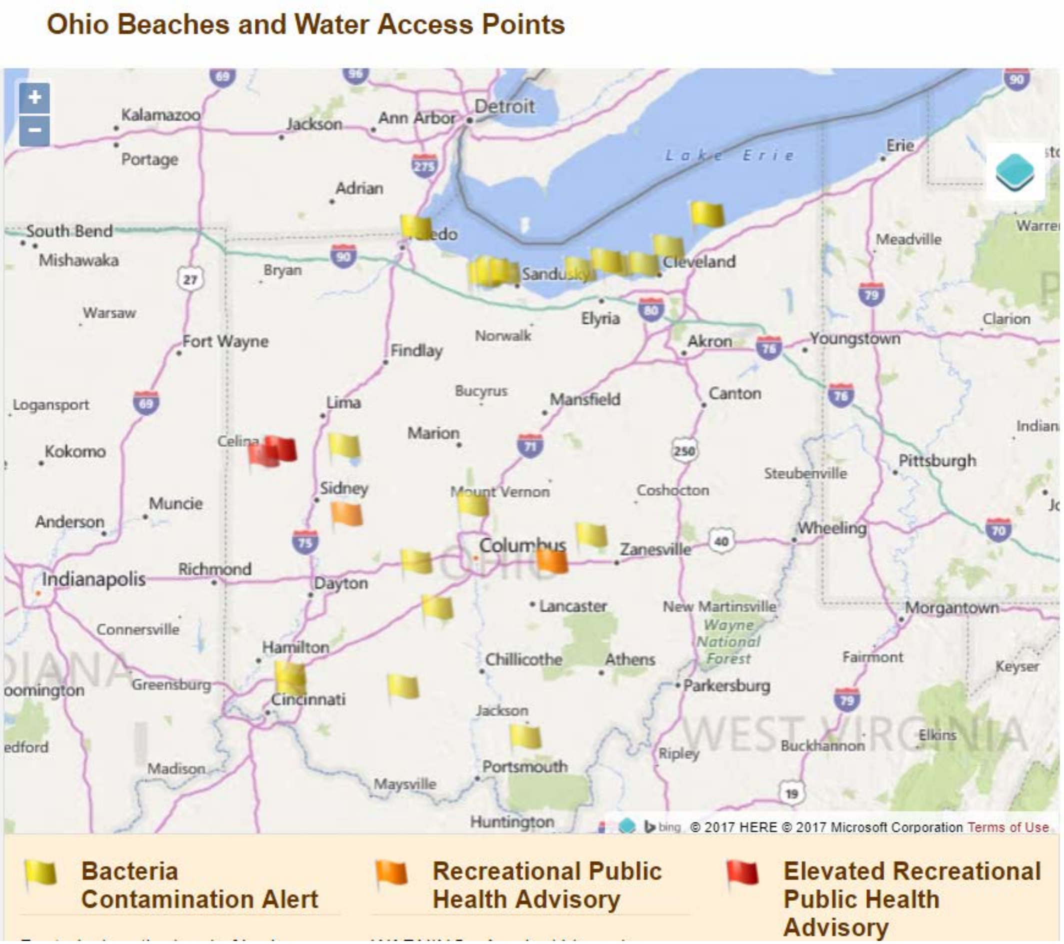
HAB Awareness (1)

Google Trends





HAB Awareness (2)



HAB Awareness (3)

Lake Erie Harmful Algal Bloom Bulletin

20 July, 2017, Bulletin 03

The *Microcystis* cyanobacteria bloom is present in low concentrations in the western basin, extending Bay stretching along- and offshore the Michigan coast to Brest Bay with a small patch offshore the Oh the mouth of the Toussaint River. Measured toxin concentrations are below recreational thresholds th extent.

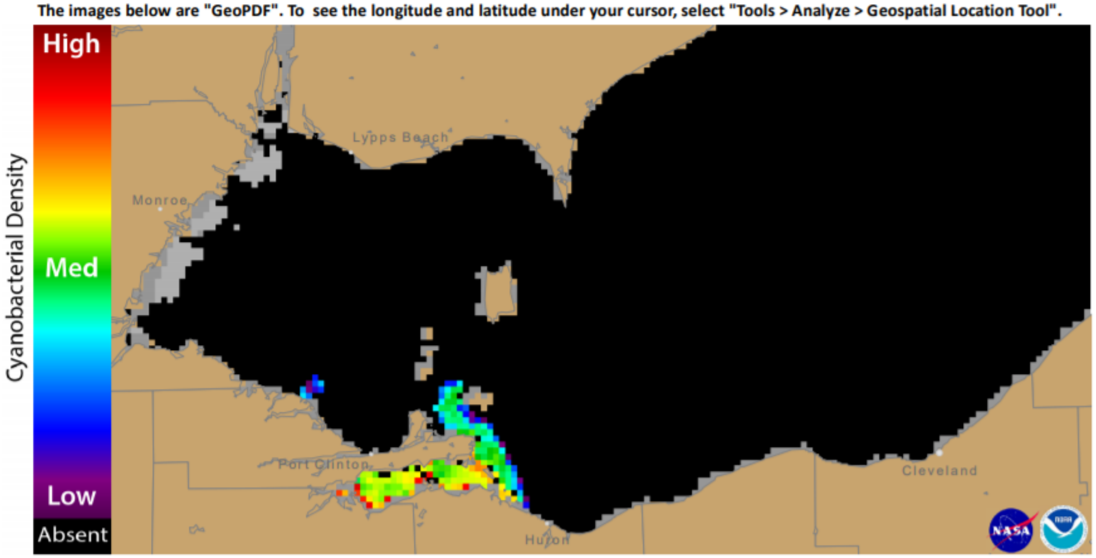
Forecast winds (5-10kn) today through Saturday (7/20-22) may promote a slight potential for mixing c concentrations of *Microcystis*.

The persistent cyanobacteria bloom of *Planktothrix* continues in Sandusky Bay and extends into Lake Erie.

NOAA's GLERL provides additional HAB data: https://www.glerl.noaa.gov/res/HABs_and_Hypoxia.

- Kavanaugh, Urízar

The images below are "GeoPDF". To see the longitude and latitude under your cursor, select "Tools > Analyze > Geospatial Location Tool".



The Columbus Dispatch

k operators to open rant next month | Swiss police ID chainsaw-wielding attacker as... | Trump: Health vote is last chance for GOP to do right... | City Council will wait on plan to add members, districts | Foxconn nearing decision to locate plants in...

BREAKING 12:49 PM One dead, one injured in Newark shooting

Toxic-algae alert system in the works for Ohio lakes

GREAT LAKES ECHO

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Algae fighters get $16 million boost

OCT 10 2012 DAVID POULSON NO COMMENTS

Farm runoff fuels green algae blooms in Lake Erie that are visible in satellite images. Photo: NOAA CoastWatch

Canadian officials Tuesday announced a $16 million investment to understand and control algae in the Great Lakes.

The Great Lakes Nutrient Initiative will focus on Lake Erie which is particularly vulnerable to toxic and nuisance algae. That's a lot of money to address excessive phosphorus discharges from farming and sewers.

Is it enough?

To get a sense of the challenge, last week the Columbus Dispatch reported if 80 percent of the phosphorus that drains into Ohio's Grand Lake were cut, it still would take 20 to 40 years to clear the water.

In 2010, a liver toxin associated with algae was so concentrated in Grand Lake St. Marys that the state warned people not to touch the water, the paper reports. Last year a record bloom of algae on Lake Erie stretched from Toledo to Cleveland.

LOCAL

Lake Erie algal bloom likely to be 1 of largest

Bloom expected to be among largest on record

By Tom Henry | BLADE STAFF WRITER

Published on July 13, 2017 | Updated 5:12 p.m.

HMDA Matched vs. Entire Sample

Variable	Observable Income (N = 140708)	Unobserved Income (N = 78623)	Difference
Purchase Price (1000s)	169.4	164.7	4.6
PricePerSquareFoot	95.69	94.77	0.93
Total number of rooms	6.53	6.41	0.12
Total number of baths	1.77	1.76	0.01
Square Feet (100s)	17.47	17.1	0.37
Acres	0.37	0.37	0
Age	44.9	42.98	1.91
Stories	1.49	1.43	0.05
Fireplace	0.48	0.45	0.03
Garage	0.92	0.9	0.02
Basement	0.77	0.71	0.06
Pool	0.02	0.02	0
Central AC	0.55	0.55	0
Distance to lake (100s)	100.66	100.70	-0.34

Notes: ***, **, * indicates significance at the 1%, 5% and 10% level respectively.
Mean difference estimates are derived using two-sample t-tests.

Robustness to FE

	No Fixed Effects			Tract Fixed Effects			Tract and Year Fixed Effects	
Commuting Zone	Boom (2002 - 2007)	Bust (2008 - 2015)	Commuting Zone	Boom (2002 - 2007)	Bust (2008 - 2015)	Commuting Zone	Boom (2002 - 2007)	Bust (2008 - 2015)
Ashtabula	-0.0283	-0.0348***	Ashtabula	-0.0180	-0.0322**	Ashtabula	-0.0160	-0.0273**
	(0.0198)	(0.00992)		(0.0176)	(0.0130)		(0.0173)	(0.0121)
Cleveland	-0.101***	-0.0437	Cleveland	-0.0390**	0.00267	Cleveland	-0.0402*	0.0203
	(0.0306)	(0.0581)		(0.0193)	(0.0214)		(0.0230)	(0.0215)
Erie	-0.0632**	-0.0799***	Erie	-0.0464***	-0.0741***	Erie	-0.0479***	-0.0715***
	(0.0256)	(0.0213)		(0.0155)	(0.0184)		(0.0153)	(0.0185)
Toledo	-0.0236	-0.0162	Toledo	-0.0450***	-0.0161	Toledo	-0.0468***	-0.0143
	(0.0346)	(0.0245)		(0.0133)	(0.0160)		(0.0135)	(0.0156)

Notes: ***, **, * indicates significance at the 1%, 5% and 10% level respectively. Standard Errors have been clustered at the tract level in all specifications.

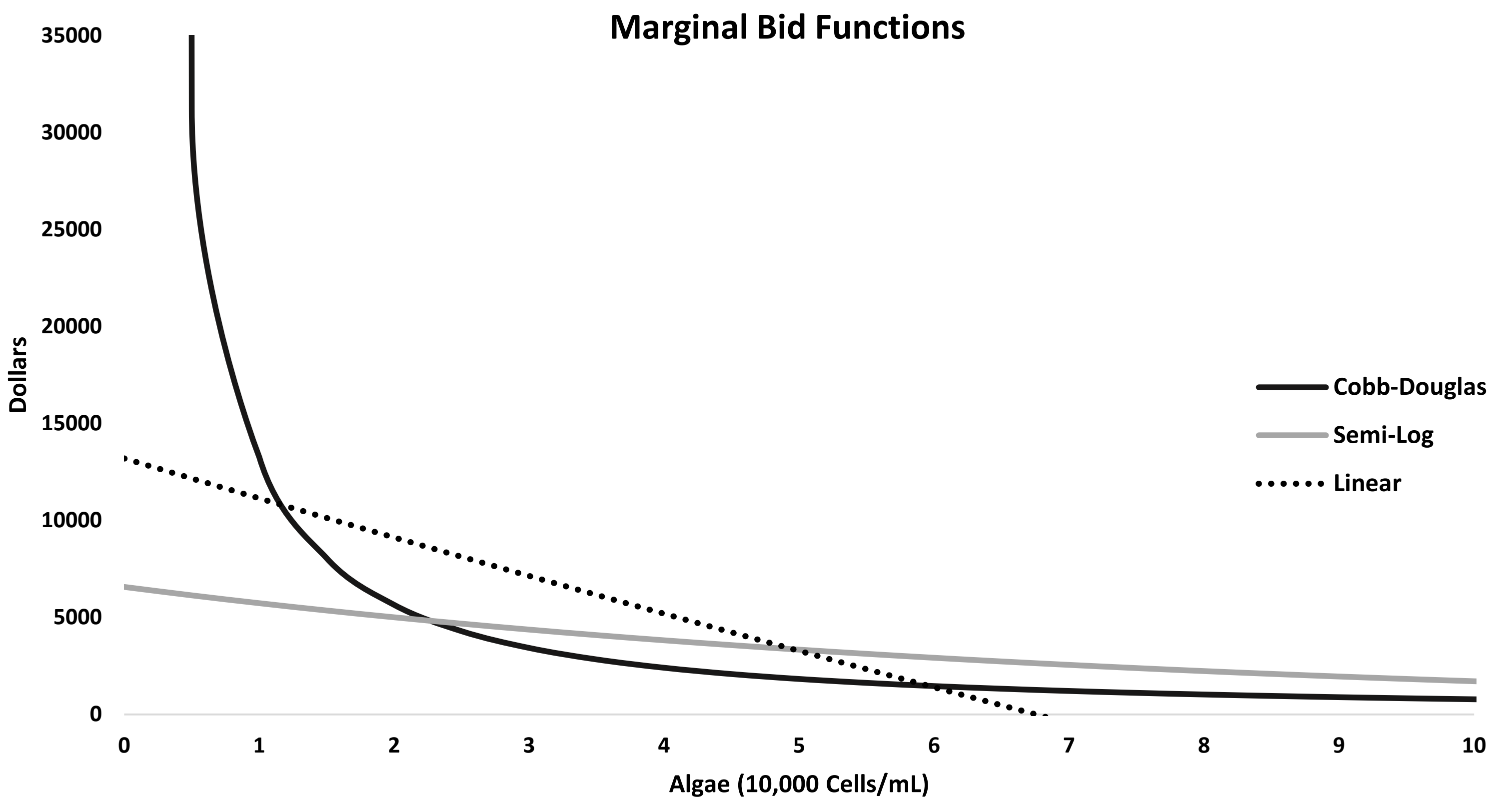
First-Stage Model and MWTP Estimates

$$(1)\ \ln P_{ijt}{}^{m} = \alpha_0 + \boldsymbol{\alpha_1 X_i} + \boldsymbol{\alpha_2 Z_j} + \boldsymbol{\alpha_3 Y_t} + \boldsymbol{\alpha_4 M_t} + \alpha_5 LakeAdj_i + \alpha_6 NearLake_i * Distancetolake_i + \alpha_7 Distancetolake_i + \alpha_8 (NearLake_i + LakeAdj_i) * \log(Algae_{it}) + \epsilon_{ijt}$$

$$(2)\ \mathrm{MWTP_{ijt}}{}^{\mathrm{m}} = \frac{\partial \widehat{\mathrm{P_{ijt}}}}{\partial \mathrm{algae}} = \widehat{\alpha_8} * \mathrm{P}_{ijt}\left(\frac{NearLake_i + LakeAdj_i}{Algae_{it}}\right)$$

- NearLake distance threshold set to 500 meters (Wolf and Klaiber 2016).

Marginal Bid Functions



Second Stage Robustness

	Semi-Log Specification		
Variable	OLS	Market IV	Discharge
Algae	-0.0765***	-0.121***	-0.121***
	(0.00801)	(0.0117)	(0.0105)
Fishing License (0/1)	-0.0537*	-0.0329	-0.0330
	(0.0318)	(0.0617)	(0.0579)
Boating License (0/1)	-0.00955	0.0870	0.0864
	(0.0399)	(0.0814)	(0.0785)
NumeraireGood (1000s)	5.13e-05	0.000516*	0.000631***
	(0.000258)	(0.000287)	(0.000243)
Observations	4,553	4,553	4,553
First Stage F-Test	-	20.58	56.7

Notes: ***, **, * indicates significance at the 1%, 5% and 10% level respectively.
Bootstrapped standard errors have been clustered at the tract level.

Partial Correlation Table

	Algae	Log(Algae)	DischargeMax	DischargeMean	Log(DischargeMax)	Log(DischargeMean)
Algae	1.00					
Log(Algae)	0.87	1.00				
DischargeMax	0.19	0.23	1.00			
DischargeMean	0.19	0.22	0.84	1.00		
Log(DischargeMax)	0.15	0.18	0.99	0.83	1.00	
Log(DischargeMean)	0.16	0.18	0.85	0.98	0.87	1.00