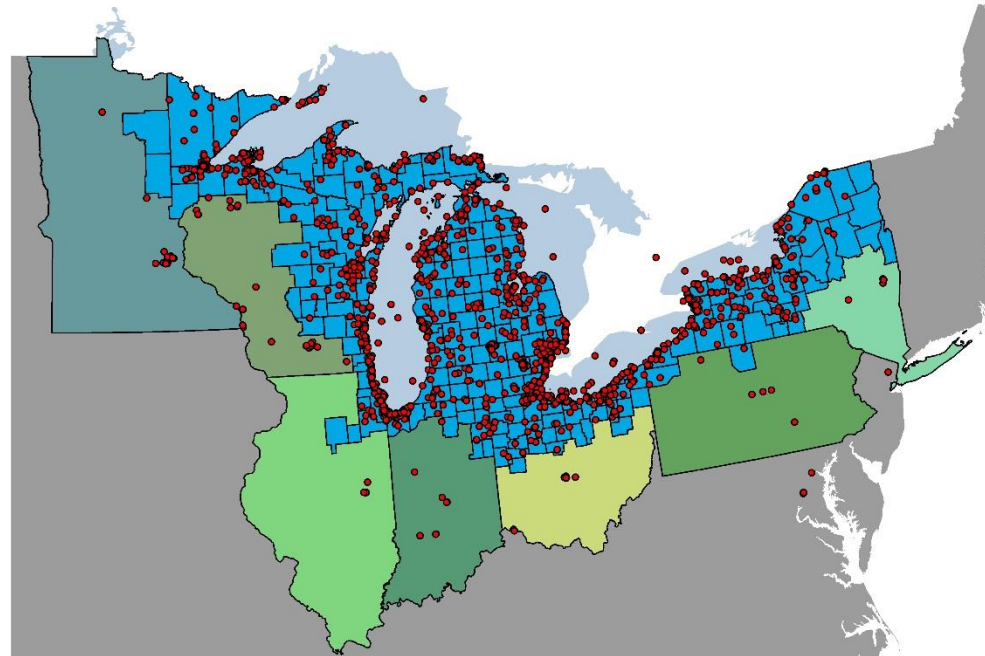# Great Lakes Restoration Initiative Socioeconomic Impact Analysis
REMI Users Conference San Diego CA

October 10, 2018

Research Seminar in Quantitative Economics

Summary of Results

➢ Every dollar of federal spending on GLRI projects from 2010–2016 will produce $3.35 of additional economic activity in the Great Lakes region through 2036.

➢ Every dollar of GLRI spending from 2010–2016 produced improvements in quality of life in Great Lakes communities worth $1.08 to local residents.

➢ GLRI spending generated or supported over 1,600 jobs in tourism-related industries in the Great Lakes region as of 2016.

➢ GLRI spending produced positive impacts in the 8 case study locations, particularly in the smaller geographical areas. We estimate that GLRI funds are responsible for 9.4% of total observed job growth in Ashtabula County, OH; 3.2% in Sheboygan, WI; and 4.2% in Duluth, MN.

Overview

➢ Overall purpose of the project is to assess the socioeconomic impacts of the Great Lakes Restoration Initiative (GLRI) on the Great Lakes region over the years 2010–2036.

➢ In this component, we conduct an economic impact analysis of GLRI projects where funding started between 2010–2016.

- Focus on population, employment, income, and quality of life/amenity effects.

- Analysis was conducted using the REMI PI+ model with 23 sectors and 227 regions, including the balance of the U.S. region.

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GLRI Project Data

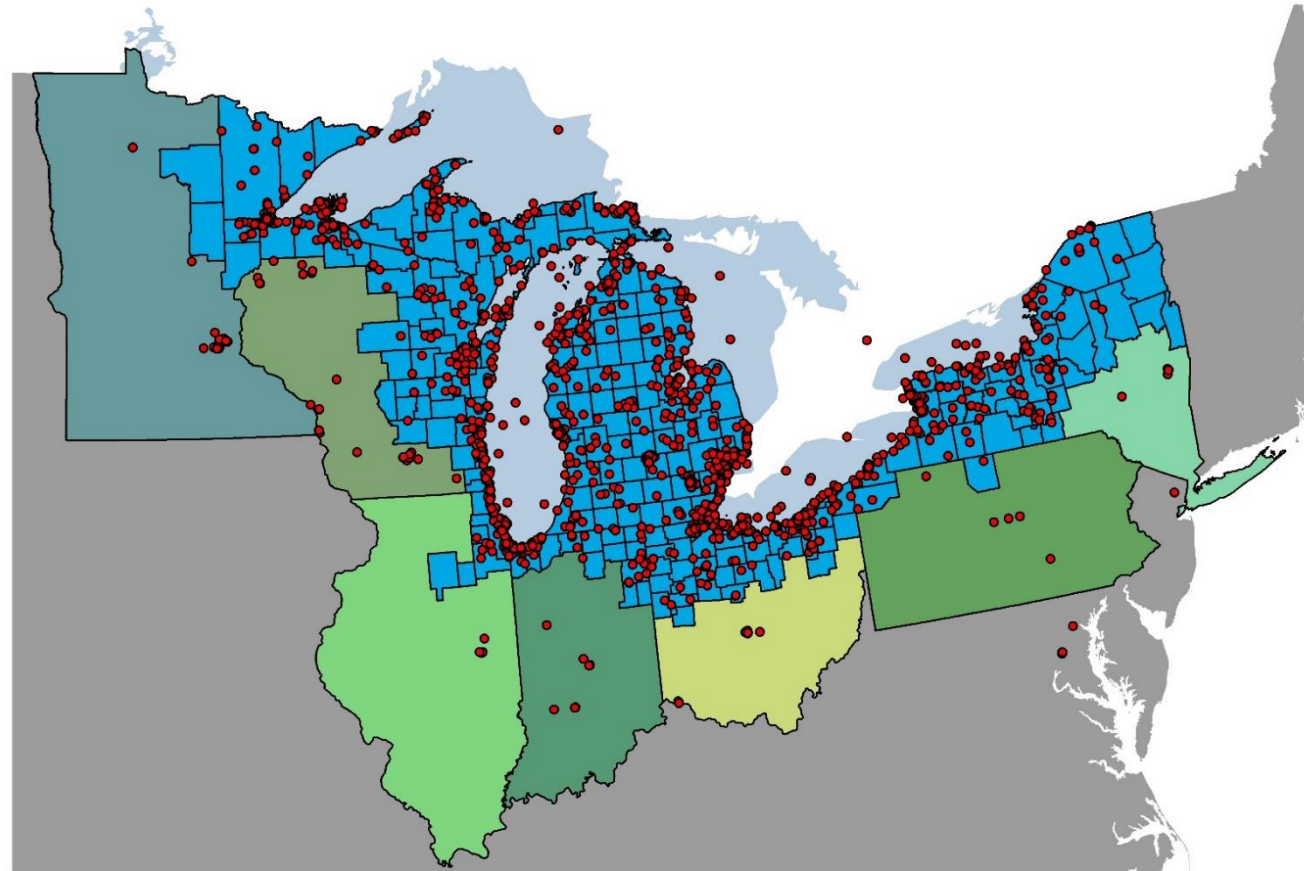➢ Project-Level data comes from the EPA's Environmental Accomplishments in the Great Lakes (EAGL) dataset.

- 3,652 project listings worth $1.8 billion in federal funding.
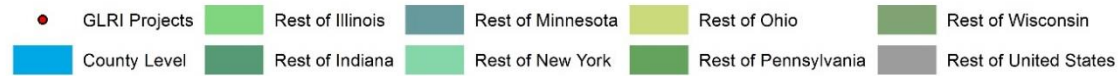
➢ Dataset includes information on

- Unmatched federal funding
- Funding agency
- Project title and description
- Focus area
- Project start and end dates
- Latitude and longitude
- States affected by project
- "Primary Measure of Progress"

Projects and Funding by Focus Area

Focus Area	Number of Projects	Funding Amount ($ millions)
Toxic Substances and Areas of Concern	694	590
Invasive Species	446	296
Nonpoint Source Pollution Impacts on Nearshore Health	457	227
Habitats and Species	1,444	455
Foundations for Future Restoration Actions	277	101
Multiple Focus Areas	334	175
Total	3,652	1,844

GLRI Project Locations and Regions of the REMI Model

REMI Model Regions and GLRI Project Locations

- GLRI Projects
- County Level
- Rest of Illinois
- Rest of Indiana
- Rest of Minnesota
- Rest of New York
- Rest of Ohio
- Rest of Pennsylvania
- Rest of Wisconsin
- Rest of United States

Preparing GLRI data for the REMI Model

➤ There are 6 main questions that must be answered in order to determine the economic impacts of a GLRI funded project:

1. <u>Location</u>: where did project work and spending occur?

2. <u>Timing</u>: when was the money spent?

3. <u>Amount</u>: how much money was spent?

4. <u>Industry</u>: in what industries was the money spent?

5. <u>Amenities</u>: did the project have effects on amenities or quality of life?

6. <u>Tourism</u>: did the project have effects on local tourism activity

Preparing GLRI data for the REMI Model

1. <u>Location</u>: where did project work and spending occur?

   ➤ Latitude/longitude are used to identify project spending by county.

2. <u>Timing</u>: when was the money spent?

   ➤ Real spending, in $2009, is allocated evenly across the project period using start and end dates in EAGL.

3. <u>Amount</u>: how much money was spent?

   ➤ We use EPA-provided data on average match rates by federal agency for GLRI projects to scale EAGL data and estimate total leveraged funding.

   ➤ We restrict to projects with valid funding and timing information in EAGL that can also be geocoded to a United States county.

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GLRI Match Rates by Federal Agency

➢ EPA provided us with a listing of required matching funds for projects administered by seven different agencies that account for 93% of all real GLRI spending from 2010–2016.

Table 1: Matching Rates by Administering Agency

Administering Agency	Direct GLRI Spending, 2010-16 (Real 2009 Dollars)	Match Rate (%)
Environmental Protection Agency	571,000,000	32.8
Army Corps of Engineers	165,000,000	16.0
Fish and Wildlife Service	147,000,000	69.8
National Oceanic and Atmospheric Administration	125,000,000	23.6
National Resources Conservation Service	108,000,000	22.8
U.S. Geological Survey	70,300,000	5.0
U.S. Forest Service	40,200,000	40.0
All Other Agencies	93,567,102	34.5

Note: the match rate of 34.5% for all other agencies is a weighted average of the listed agencies' match rates weighted by nominal dollar spending.

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Annual GLRI Spending

➢ Total real federal spending from 2010 to 2016 amounts to $1.4 billion 2009 dollars

➢ Matching funds accounted for an additional $364 million

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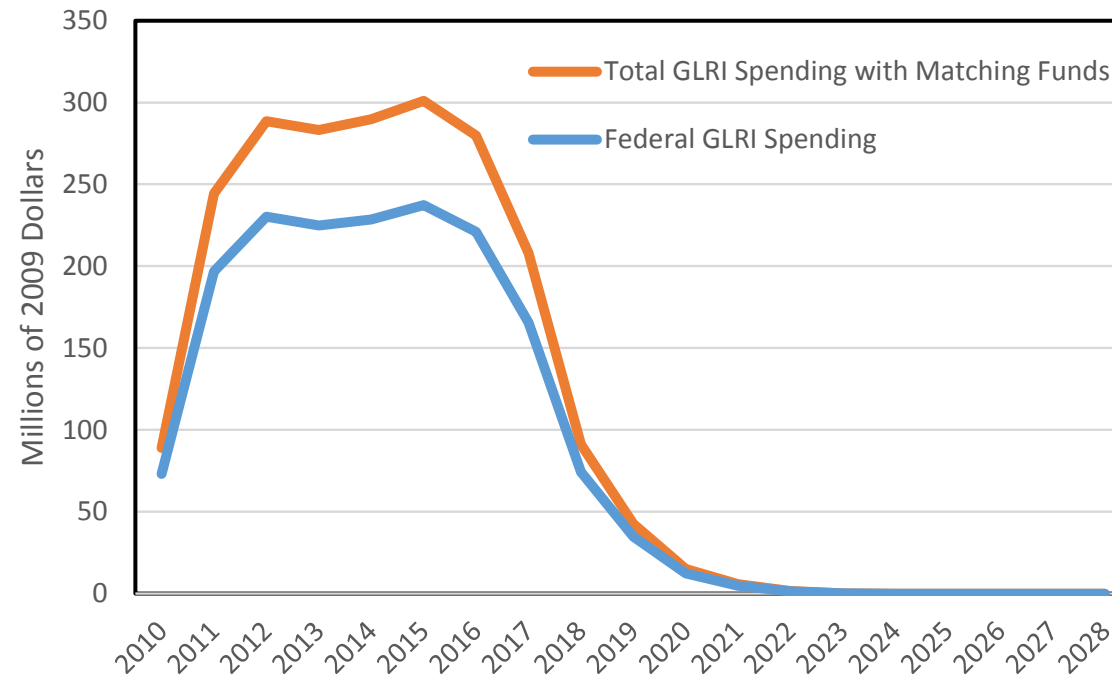
The REMI Model

➢ The REMI PI+ model is well known and is widely used by researchers for policy analysis and economic impact assessments.

➢ The model represents a combination of input-output, general equilibrium, econometric, and regional science methods, and is highly customizable.

➢ Our version of the model divides economic activity into 23 sectors and distributes among 227 distinct geographic regions.

The 23 Sectors of the REMI Model

- Forestry, Fishing, and Related Activities
- Mining
- Utilities
- Construction
- Manufacturing
- Wholesale Trade
- Retail Trade
- Transportation and Warehousing
- Information
- Finance and Insurance
- Real Estate and Rental and Leasing
- Professional, Scientific, and Technical Services

- Management of Companies and Enterprises
- Administrative and Waste Management Services
- Educational Services; private
- Health Care and Social Assistance
- Arts, Entertainment, and Recreation
- Accommodation and Food Services
- Other Services, except Public Administration
- State and Local Government
- Federal Civilian
- Federal Military
- Farm

4) How do we allocate spending to REMI Industries?

➢ We use the data provided by EPA to estimate the proportion of spending on personnel wages and salary, fringe benefits, and indirect costs by spending agency. This spending is allocated to:

- Federal Government civilian output (50 percent)

- State Government output (25 percent)

- Local Government output (25 percent)

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Allocating Remaining Spending to REMI Sectors

➢ We conduct a keyword search of the project descriptions in the EAGL database, and we allocate the remaining balance of spending to "Exogenous Final Demand" in the following sectors:

- Construction

- Professional and Business Services

- Forestry, Fishing, and Related Activities

- Farming

- Many of the key words appear multiple times for the same project

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Project Description Keyword Search Terms

REMI Industry				
Search Terms	**Professional & Buiness Services**		**Construction**	**Forestry & Fishery**	**Farm**
	analy	map	acre	hatchery	agricultur
	assess	measure	barrier	forest	best management
	build capacity (variations)	model	construct	sturgeon	bmp
	characteriz	monitor	control		farm
	communicat	outreach	dredg		
	compliance	plans	erod		
	control	quantify	erosion		
	coordinat	research	excavat		
	design	sampl	improv		
	determin	scientist	infiltrat		
	develop	studies	install		
	educat	study	maintenance		
	evaluat	survey	reconnect		
	forecast	technical	remediat		
	identif	test	remov		
	inform	train	reopen		
	investigat		replace		
	knowledge		restor		
	manag		sewage		

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Allocation of Contractual Spending to REMI Sectors

Keyword Associations					Project Count	Project Percent	Industry Spending Allocation
Construc-tion	Forestry & Fishing	Farm	Prof. Services	No Match			
X			X		1,419	39%	91.5% Construction, 8.5% Professional Services
			X		883	24%	100% Professional Services
X					555	15%	100% to Construction
X		X	X		267	7%	45.75% Construction, 45.75% Farm, 8.5% Professional Services
X	X		X		142	4%	45.75% Construction, 45.75% Forestry & Fishing, 8.5% Professional Services
				X	104	3%	50% Construction, 50% Professional Services
X	X				87	2%	50% Contruction, 50% Forestry & Fishing
	X		X		86	2%	91.5% Forestry & Fishing, 8.5% Professional Services
X		X			51	1%	50% Contruction, 50% Farm
		X	X		36	1%	91.5% Farm, 8.5% Professional Services
	X				13	0%	100% Forestry & Fishing
		X			5	0%	100% Farm
X	X	X			3		33% Construction, 33% Forestry & Fishing, 33% Farm
	X	X	X		2		45.75% Forestry & Fishing, 45.75% Farm, 8.5% Professional Services
X	X	X	X		2	0%	30.5% Construction, 30.5% Forestry & Fishing, 30.5% Farm, 8.5% Professional Services

5. <u>Amenities</u>: did the project have effects on amenities or quality of life?

   ➢ Projects that improve the Great Lakes, or affect quality of life in some way, should have an associated amenity effect that results in migration to the area.

   ➢ We originally planned to use the "Non-Pecuniary (Amenity) Aspects" policy variable that enters the migration equation.

   ➢ Instead, we decided to use the "Residential Real Estate Price" policy variable, which changes the effective cost of housing and also feeds into the migration equation. More consistent with literature on effect of environmental improvements and we could estimate effect on residential real estate prices uses data on housing prices by zip code.

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House Price Analysis

House Price Change by Zip Code

➢ Compare house prices in adjacent zip codes

- FHFA now provides a zip code-level index

➢ Neighboring zip codes should provide valid controls for one another

- Price trends should be similar in absence of GLRI funding

- Similar economic characteristics and employment opportunities

➢ Regressing differential appreciation rates on differential GLRI spending should recover causal impact on prices

➢ Panel data gives greater power, allows for robustness checks

Regression Results

$$\Delta HPI_{it} - \overline{\Delta HPI_{jt}} = \alpha + \beta \left(\frac{GLRI09_{it}}{Housing\ Units_i} - \overline{\frac{GLRI09_{jt}}{Housing\ Units_j}} \right) + \varepsilon_{it}.$$

Table 1: GLRI Project Spending and House Price Appreciation 2010-2016

|	(1)	(2)	(3)	(4)
Annual Real GLRI Spending	0.0025	0.0024	0.0032	0.0001
Standard Error	(0.0010)	(0.0013)	(0.0014)	(0.0001)
p-value	{0.012}	{0.064}	{0.026}	{0.351}
Number of Observations	2769	2769	2769	3633
R-squared	0.003	0.193	0.002	0.000
Spending Included	All	All	Construction	All
Area Included	Coastal Counties	Coastal Counties	Coastal Counties	Great Lakes Basin
Additional Controls	None	County x Year Fixed Effects	None	None

Note: Unit of observation is the zip code. Real GLRI spending includes matching funds. Please see the text for a full description of the regressions.

Parallel Trends Assumption

➢ Treatment is not binary, so not standard case

➢ Separated zip codes into two groups:

- Coastal counties that received GLRI funding

- Neighboring zip codes that did not also receive funding

➢ 40% belong to the group with funding
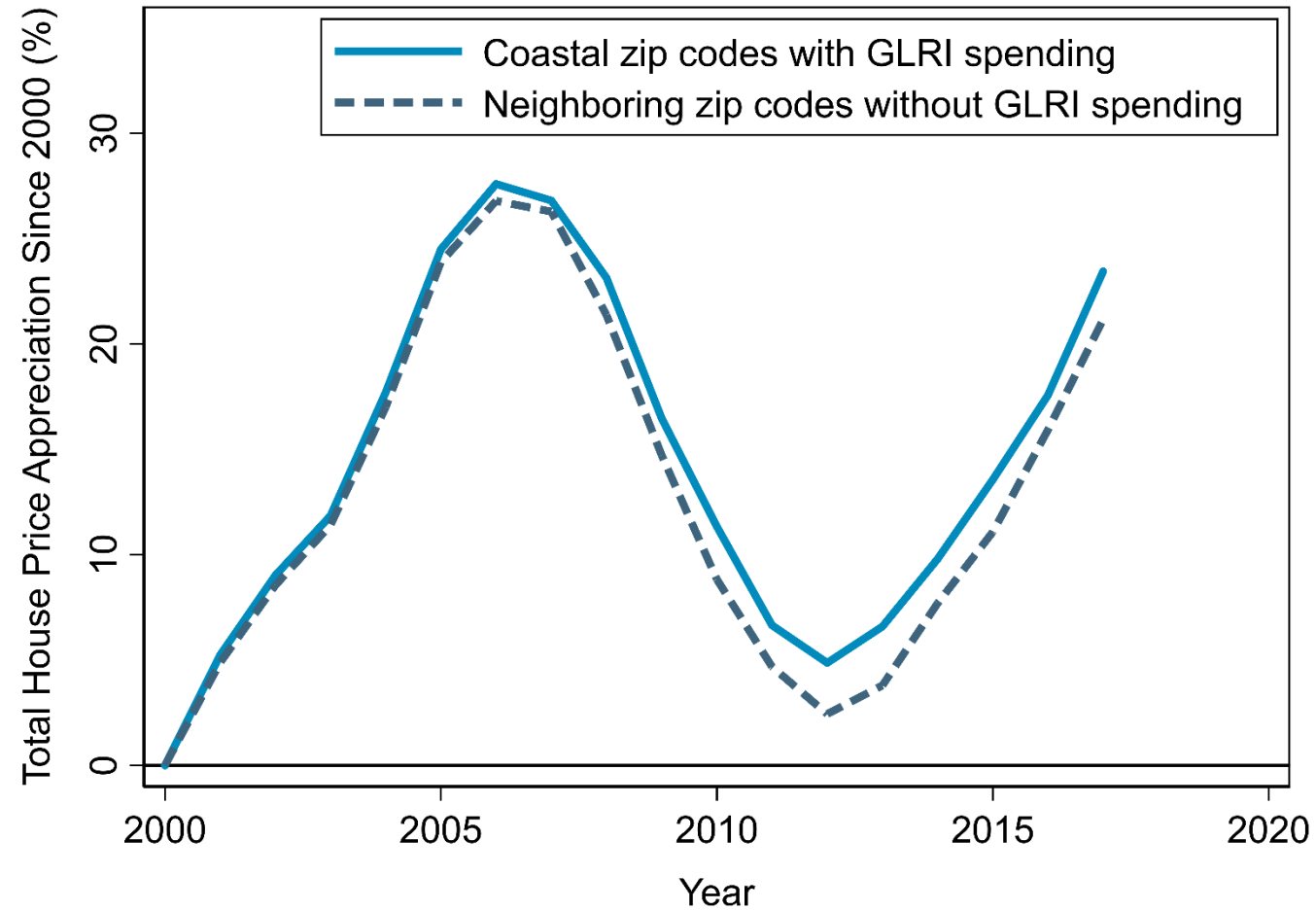
➢ 60% belong to the group without funding

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Parallel Trends Assumption cont'd

Trends in Average Annual House Price Appreciation, 2000–2017
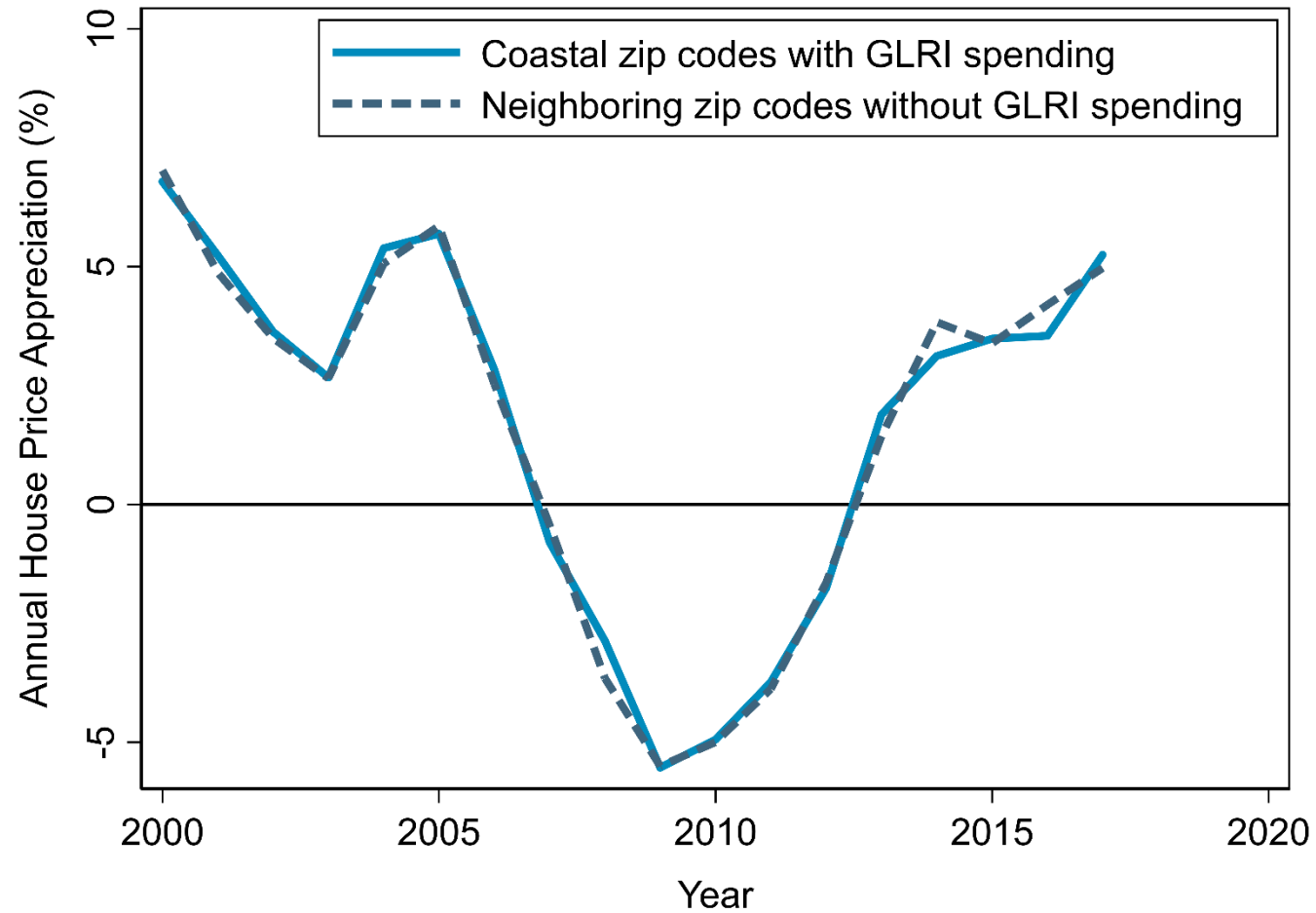
Parallel Trends Assumption cont'd

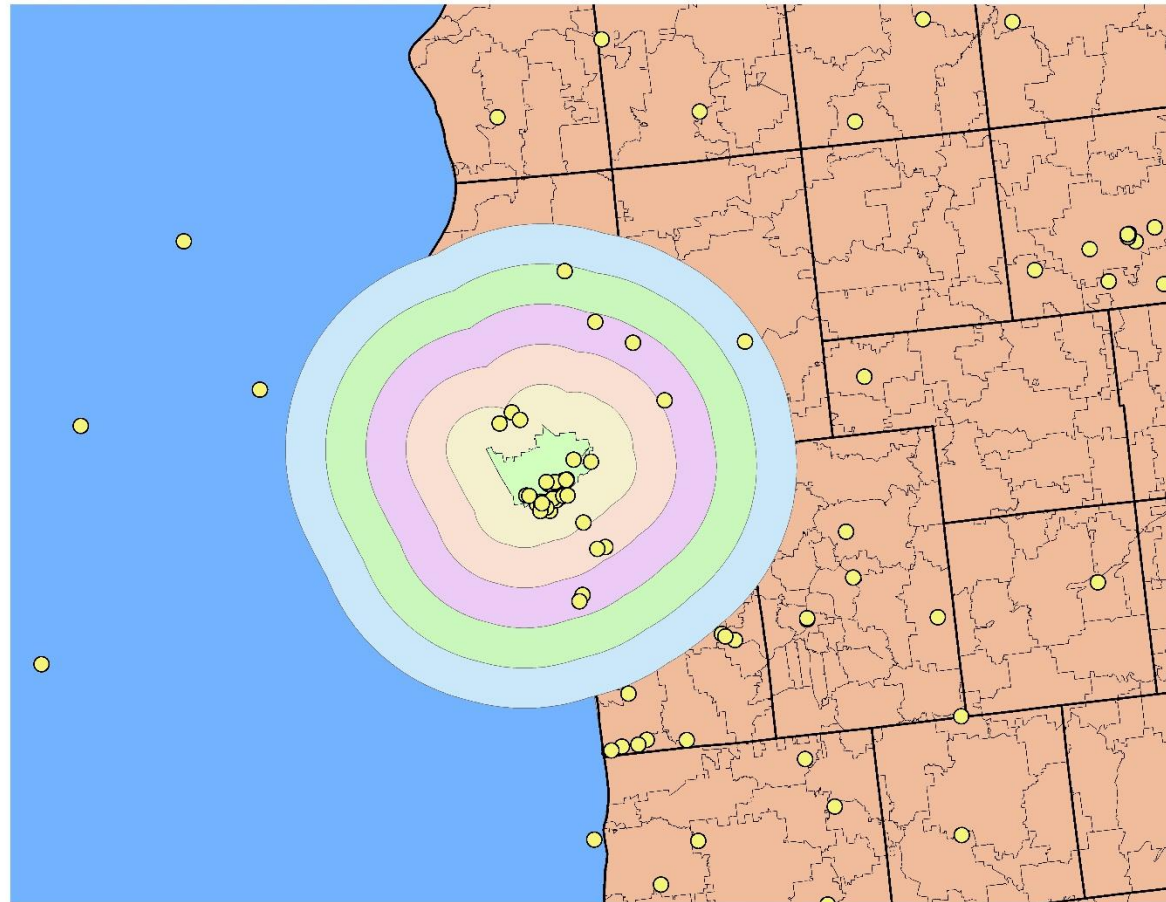Trends in Average Cumulative House Price Appreciation, 2000–2017

Zip code 49445 in Muskegon, MI
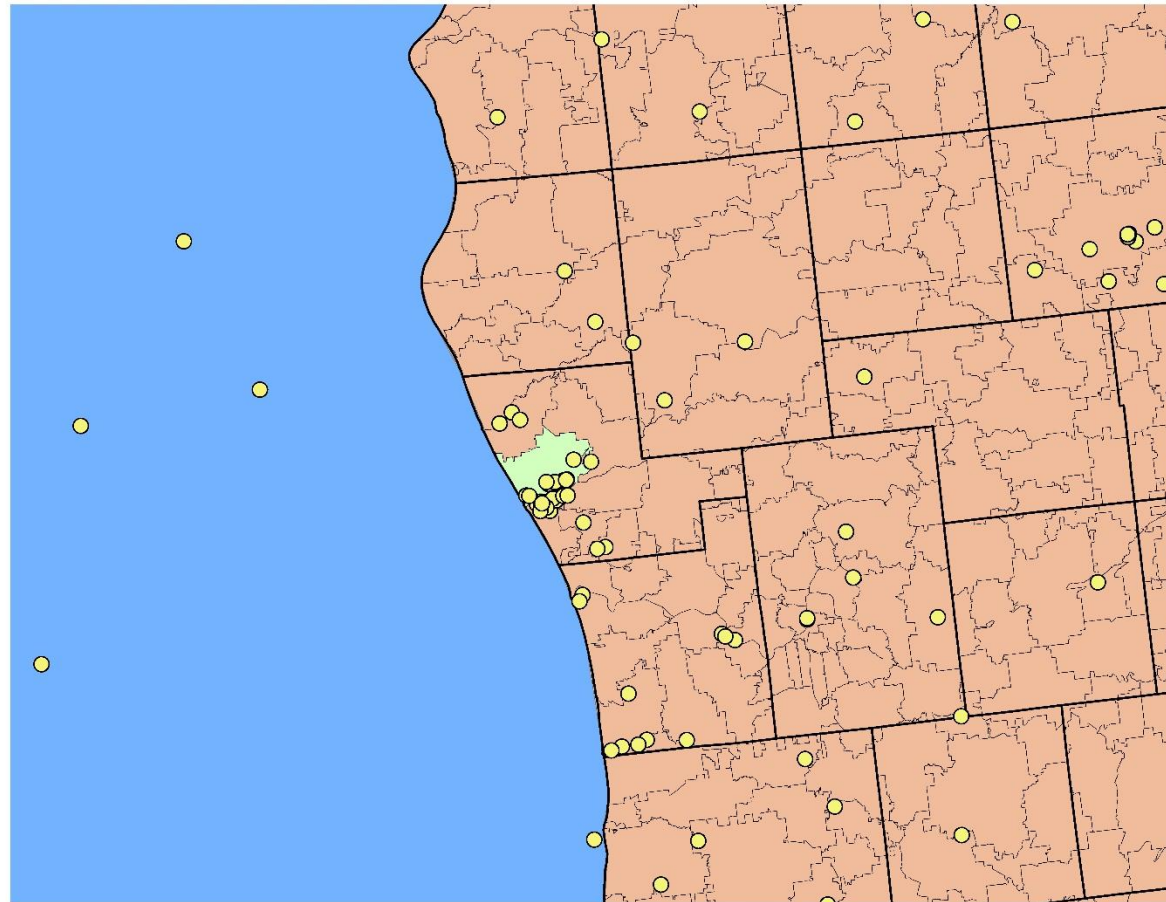
Spatial Hedonic Analysis—Illustration

5-mile wide rings around zip code 49445 Muskegon, MI

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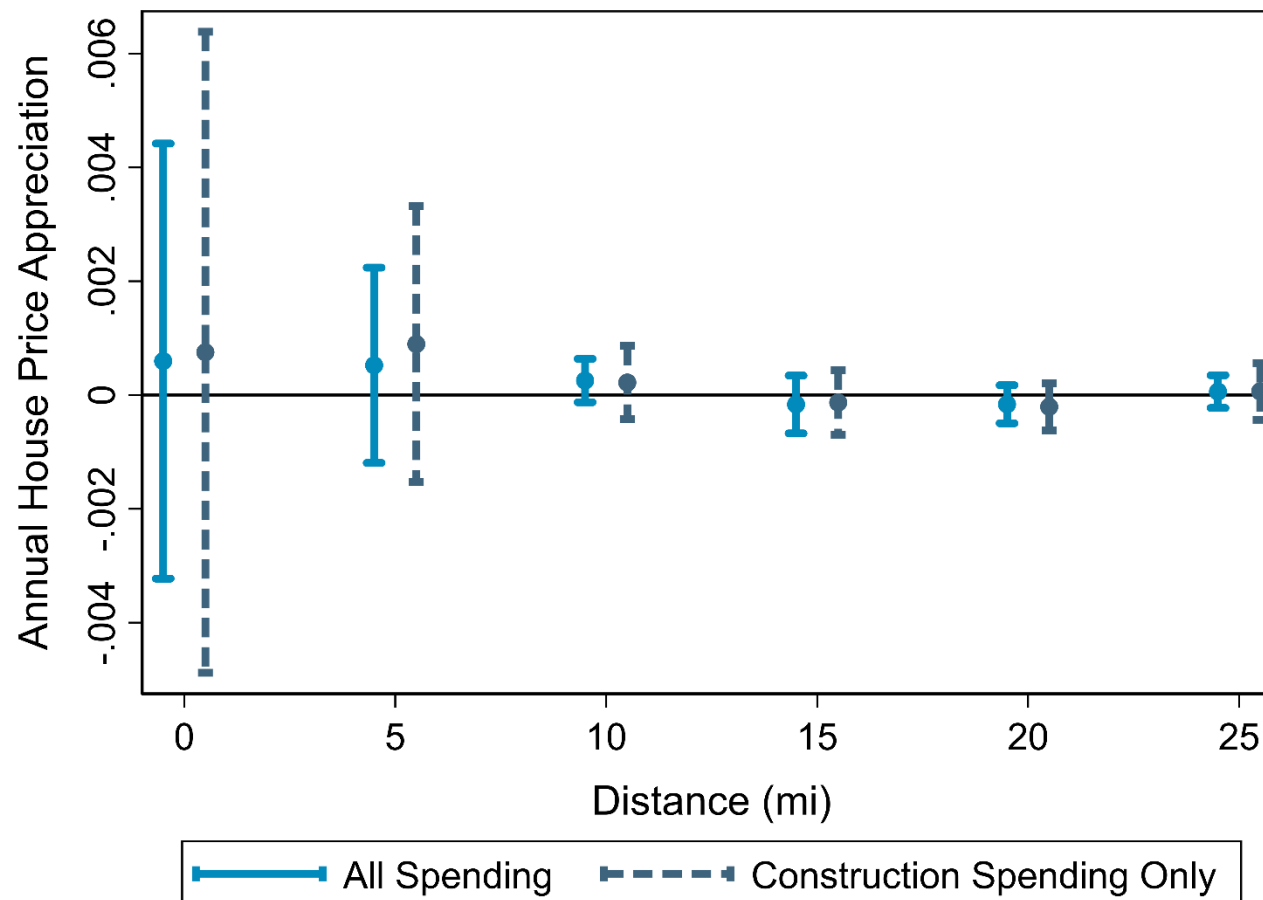
Spatial Hedonic Analysis—Equation

$$\Delta HPI_{it} = \alpha + \beta \left(\frac{GLRI09_{it}}{Housing\ Units_i} \right) + \sum_{d \in D} \gamma_d \left(\frac{GLRI09_{dt}}{Housing\ Units_i} \right) + \mu_i + \varepsilon_{it}.$$

➢ The new summation term $\sum_{d \in D} \gamma_d \left(\frac{GLRI09_{dt}}{Housing\ Units_i} \right)$ represents binned spending-by-distance.

➢ We chose a fairly nonparametric approach.

- Annual appreciation at the zip-code level is regressed on spending within the zip code and the binned spending.

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➤ Dollar value impact of estimated results are substantially larger than preferred specification.

- $1 of total GLRI spending leads to a little over $3 increase in house prices.

➤ None of the individual distance effects are statistically significant.

Chart: Annual House Price Appreciation vs. Distance (mi), with legend "All Spending" and "Construction Spending Only"

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Summary of Methodology & Results

➢ Our methodology involves comparing spending and house price appreciation in neighboring zip codes.

➢ Our analysis suggests that every dollar of GLRI spending from 2010 to 2016 created improvements in local quality of life worth $1.08 to residents.

➢ We believe the estimates are conservative:

- Spatial analysis that allows spending to have spillover effects outside of its zip code result in larger impacts, but the results are statistically imprecise.

- The data is noisy with respect to pinpointing the location of spending. This leads to attenuation bias in the results.

6) Tourism Analysis

Tourism Analysis Overview

➢ Measure tourism activity by employment in two major industries:

- Arts, entertainment, and recreation

- Accommodations and food services

➢ Groups account for 65% of all direct tourism jobs

➢ Cross-sectional regressions at county level

➢ Include all Great Lakes Counties

Regression Specifications

$$\frac{\Delta arts_{i,16-10}}{pop_{i,10}} = \alpha + \beta \frac{GLRI09_{i,10-16}}{pop_{i,10}} + X_i'\delta + \epsilon_i$$

$$\frac{\Delta acc_{i,16-10}}{pop_{i,10}} = \alpha + \beta \frac{GLRI09_{i,10-16}}{pop_{i,10}} + X_i'\delta + \epsilon_i$$

➢ Dependent variables represent changes in employment in county *i* of state *s* between 2010 and 2016 per capita.

➢ $X_i'\delta$ is a set of county-level control variables that will vary across the specifications we consider.

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Additional Control Variables

➢ Control variables

- State-level per capita growth in tourism industry in question 2010-2016

- County i's per capita growth in total employment except tourism 2010-2016

- County i's personal income per capita in 2010

- County i's share of population 65 years or older in 2010

- County i's per capita growth in the tourism industry in the years 2004–2010

- County i's employment per capita in the tourism industry in question as of 2010

Arts, Entertainment, and Recreation Results

	Dependent variable: County employment growth per capita in Arts, Entertainment, and Recreation, 2010-2016					
	(1)	(2)	(3)	(4)	(5)	(6)
Cumulative county GLRI spending 2010-2016 per capita	0.00081	0.00044	0.00166	0.00103	0.00311	0.00159
	(0.00092)	(0.00052)	(0.00091)	(0.00051)	(0.00129)	(0.00065)
State per capita employment change in AER, 2010-2016	0.45712	0.45768	0.41399	0.41727	0.38147	0.38285
	(0.1189)	(0.11906)	(0.11532)	(0.11533)	(0.10603)	(0.10607)
Total per capita county employment growth, 2010-2016	0.01011	0.01013	0.01031	0.01029	0.00912	0.00907
	(0.0026)	(0.00256)	(0.00271)	(0.00271)	(0.00249)	(0.00249)
County personal income per capita, 2010	6.55E-08	6.55E-08	1.12E-07	1.13E-07	9.24E-08	9.26E-08
	(1.32E-08)	(1.32E-08)	(1.45E-08)	(1.45E-08)	(1.39E-08)	(1.39E-08)
County share of population 65+, 2010			-0.00207	-0.0023	-0.00393	-0.00418
			(0.00268)	(0.00269)	(0.00246)	(0.00247)
County per capita employment change in AER, 2004-2010			0.01517	0.01408	-0.21167	-0.21563
			(0.03699)	(0.03696)	(0.04314)	(0.04314)
County employment per capita in AER, 2010			-0.10156	-0.10246	-0.02940	-0.02966
			(0.01556)	(0.01559)	(0.01708)	(0.01710)
GLRI Spending Included	Construction	Total	Construction	Total	Construction	Total
Outlier Fixed Effects Used	No	No	No	No	Yes	Yes

Accommodations and Food Services Results

|	Dependent variable: County employment growth per capita in Accommodations and Food Services, 2010-2016					
	(1)	(2)	(3)	(4)	(5)	(6)
Cumulative county GLRI spending 2010-2016 per capita	0.00642	0.00339	0.00290	0.00140	0.00254	0.00124
	(0.0019)	(0.00106)	(0.00198)	(0.00112)	(0.00192)	(0.00108)
State per capita employment change in AFS, 2010-2016	0.44669	0.44920	0.45018	0.45114	0.44679	0.44764
	(0.1343)	(0.13453)	(0.13134)	(0.13139)	(0.12683)	(0.12687)
Total per capita county employment growth, 2010-2016	0.03700	0.03707	0.02254	0.02249	0.02329	0.02326
	(0.0052)	(0.00521)	(0.00552)	(0.00552)	(0.00533)	(0.00533)
County personal income per capita, 2010	1.80E-07	1.80E-07	1.30E-07	1.30E-07	8.81E-08	8.79E-08
	(2.64E-08)	(2.64E-08)	(2.65E-08)	(2.66E-08)	(2.85E-08)	(2.85E-08)
County share of population 65+, 2010			-0.02935	-0.02946	-0.03412	-0.03423
			(0.00568)	(0.00570)	(0.00554)	(0.00555)
County per capita employment change in AFS, 2004-2010			-0.05703	-0.05847	-0.1699	-0.17152
			(0.03419)	(0.03423)	(0.03949)	(0.03951)
County employment per capita in AFS, 2010			0.07884	0.07939	0.06338	0.06380
			(0.01184)	(0.01192)	(0.01168)	(0.01176)
GLRI Spending Included	Construction	Total	Construction	Total	Construction	Total
Outlier Fixed Effects Used	No	No	No	No	Yes	Yes

Coefficients and Results

➢ We use column 6 as our preferred specification

- All spending, to be consistent with house prices

- Control for outliers

➢ $1 million in real GLRI spending generates/supports 1.6 new AER jobs and 1.2 AFS jobs in 2016

- Combined 1,638 jobs added in 2016 in the two tourism industries

➢ $1 of GLRI spending increases regional value added by $1.62 from 2010 to 2036 due to tourism effects

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Economic Impact

Regional Increase in Economic Output from GLRI
Great Lakes States, 2010–2036

RSQE: October 2018
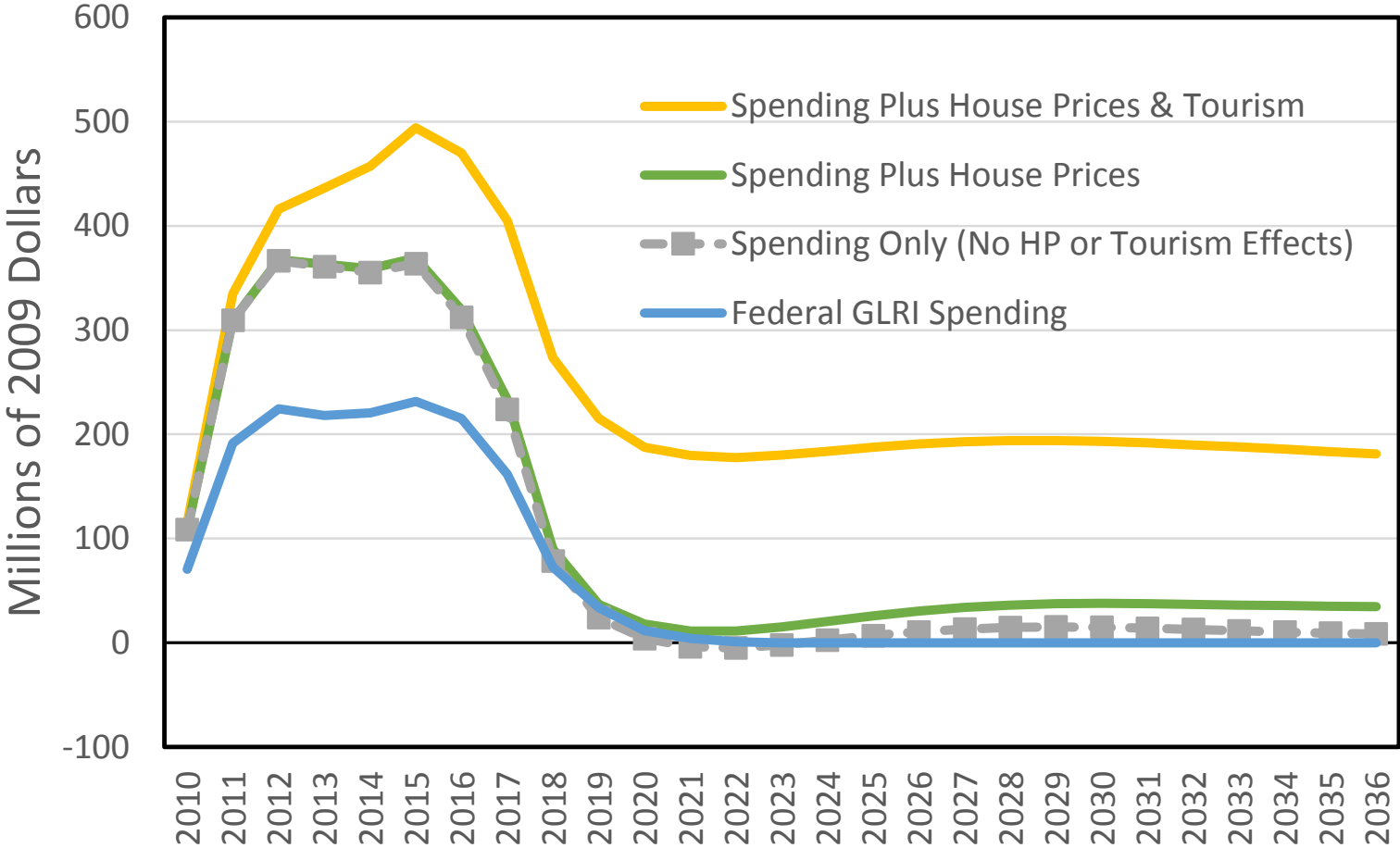
Regional Value-added Multiplier

Inputs	Multiplier
Direct spending impacts only	1.57
Direct spending plus Quality of Life impacts	1.73
Direct spending plus Quality of Life and Tourism impacts	3.35
With 3% discount rate	3.44
With 7% discount rate	2.90

➤ Every dollar of federal spending on GLRI projects from 2010–2016 will produce $3.35 of additional economic activity in the Great Lakes region through 2036.

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Regional Increase in Personal Income & Total Employment from GLRI Great Lakes States, 2010–2036

RSQE: October 2018

lsa.umich.edu/econ/rsqe