Crime Is in the Pipe: The Impact of Water Pollution on Criminal Activities

Emtiaz Hritan

School of Economics
Georgia Institute of Technology

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Motivation

- Majority of the papers exploring pollution-crime relationship focus on air pollution or "Lead Crime Hypothesis"
- Impact of water pollution, specially water-borne lead on crime are not fully explored.
- Very few papers exploring this relationship address endogeneity issues.
- Shedding light on the disputed area: effects of avoidance or compensatory behaviors vs. effects of pollution

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Research Question

Research question

What are the impacts of water pollution on the criminal activities ?

Major Water Pollution Incidents in the US

In the recent US history, the following water crisis are known for exposing the local residents to water-borne lead and other pollutants:

- Flint water crisis, Flint, Michigan
  - Time period: April 25, 2014 – February 1, 2019
  - Cause: Changing water source from Lake Huron and the Detroit river to the Flint river
- Lead contamination in Washington, D.C., drinking water
  - Time period: 2001-present
  - Cause: Change of treatment chemical from chlorine to chloramine
- Newark water crisis
  - Time period: March 2016-present
  - Cause: Reduction in the effectiveness of the corrosion inhibitor

Related Literature

Papers	Respnse variable	Empirical Strategy	Identification Strategy
Burkhardt et al. 2019	Crime count of crime type j in county c on day t	Poisson quasi-maximum likelihood	High-dimensional fixed effects
Herrnstadt et al. 2021	Log of the total daily number of violent or property crimes	2SLS with wind direction as an instrument	Exploits variation in pollution driven by daily changes in wind direction
Lu et al. 2018	Crime count of seven major categories in city-year	FE Poisson regression models via MLE	Exploits quasi-experimental variation in air pollution driven by daily wind direction changes
Bondy, Roth, and Sager 2020	The number of crimes in ward i on day t	Poisson pseudo-maximum likelihood (PPML)	Ward fixed effects and using atmospheric inversions and wind direction as instruments
Chen and Li 2020	Log of total crime count per 1000 people in county-year-season cell	Use a triple-difference framework	Quasi-experiment: the NOx Budget Trading Program

Table: Literature

Related Literature

Papers	Respnse variable	Empirical Strategy	Identification Strategy
Hener 2022	Violent crime rate per 100,000 inhabitants	2SLS regression	Daily variation in aircraft landing approaches to instrument noise levels
Ranson 2014	Number of crimes city-month-year-county-state	FE Poisson regression model via MLE	State-by-month fixed effects
Feigenbaum and Muller 2016	Count of homicide deaths	IV negative binomial regression using control function estimation	Effect of cities' use of lead pipes instrumented by their distance by rail from the nearest lead refinery
Jones 2022	Cumulative count of incidents in crime category-county-day	Poisson pseudo-maximum likelihood (PPML)	weather conditions and high-dimensional fixed effects,

Table: Literature

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Timeline: Flint Water Crisis

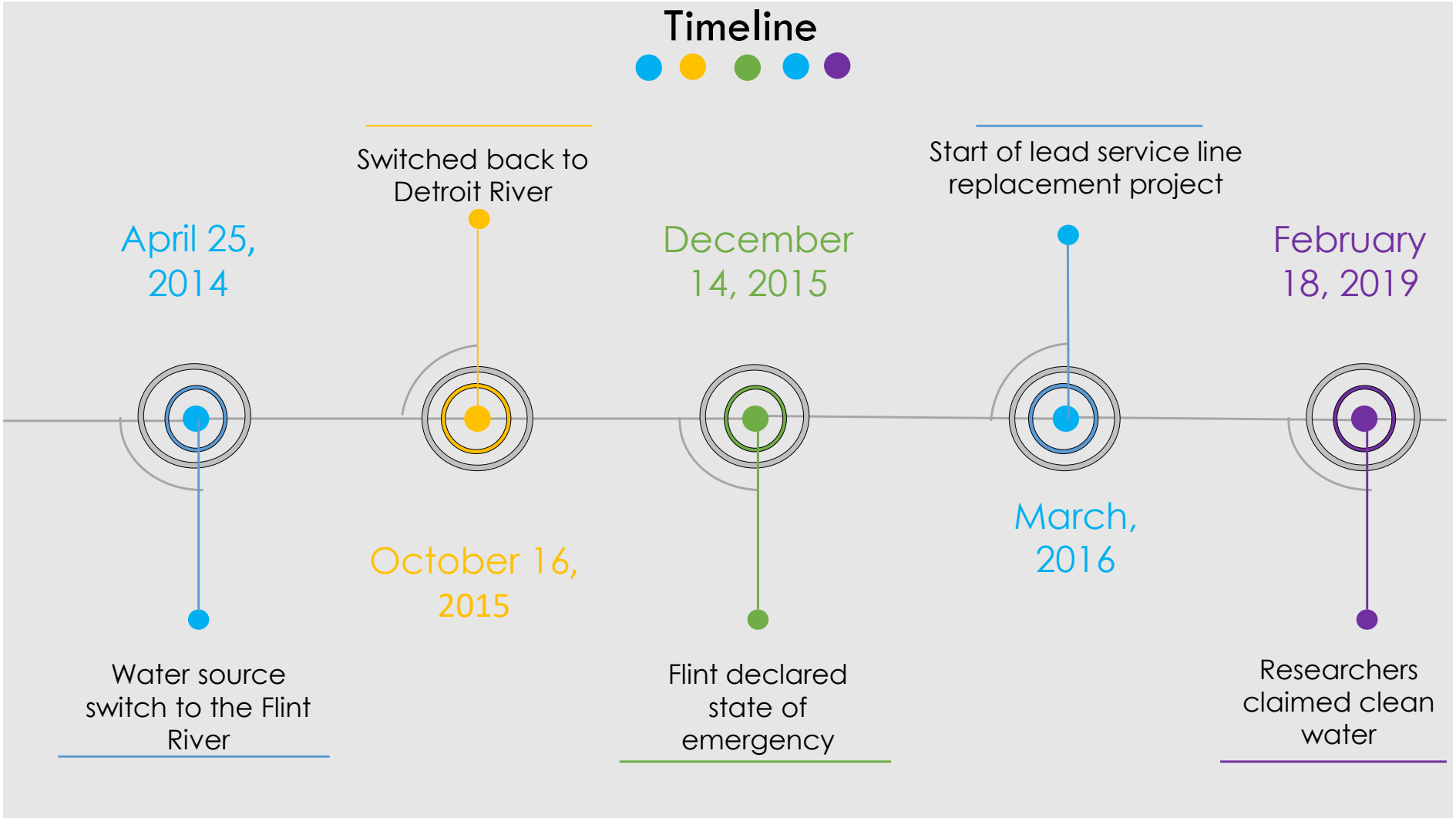

Figure: Timeline of Events

Natural Experiment: Flint Water Crisis

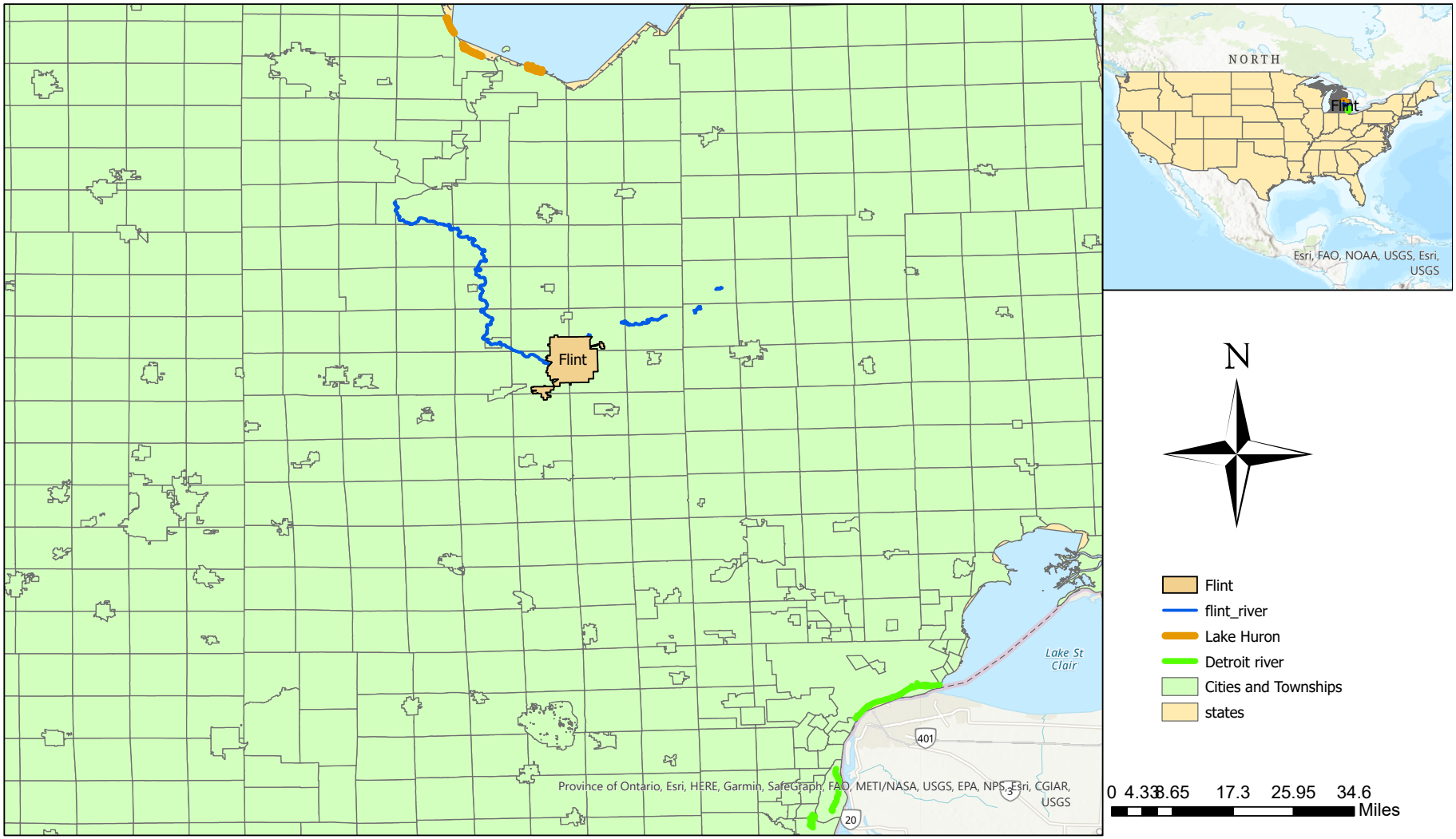

Figure: Research Design

Crimes in Flint

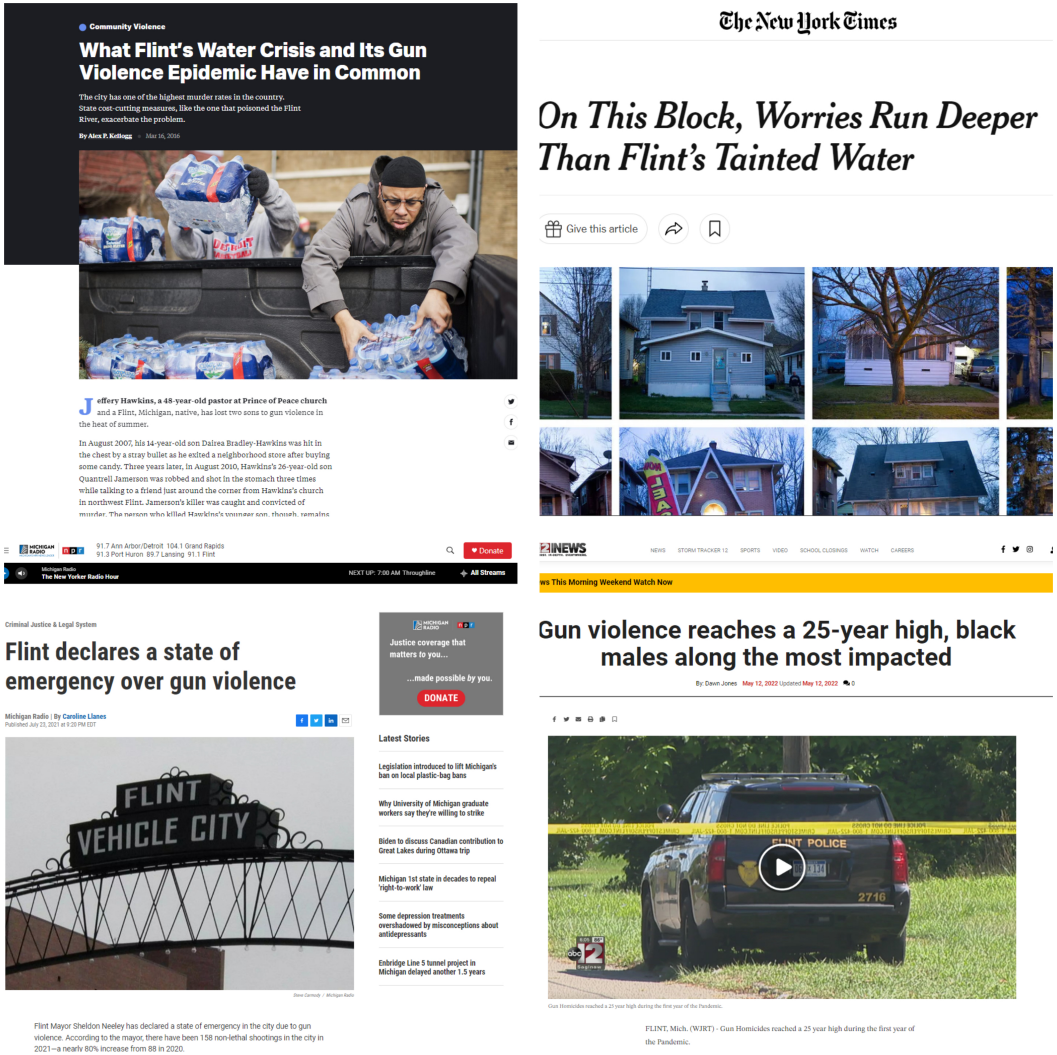

Figure: Headlines of crime in Flint, MI

Crimes in Flint, MI

NeighborhoodScout

"Relative to Michigan, Flint has a crime rate that is higher than 88% of the state's cities and towns of all sizes. In fact, after researching dangerous places to live, NeighborhoodScout found Flint to be one of the top 100 most dangerous cities in the U.S.A."

The Flint Journal,December 27, 2016.

From 2010 to 2012, Flint ranked as the city with the highest violent crime rate among cities with over 100,000 population

Challenges: Flint as a natural experiment

- Several crime reduction program taken by Flint PD, specially around 2011.
- Legionnaires' disease between June 2015, and January 2016
- Lack of information on the water quality before 2014.

Research Design

Based on the existing literature and definition of reporting agencies, treatment and controls are defined as:

Treatment

Crime incidences in the jurisdiction of Flint PD agency.

Control

Crime incidences in the jurisdiction of all other city level reporting agencies.

Hypothesis

Based on the existing literature, I have come up with following four hypotheses:

- Hypothesis 1: *There is a statistically significant relationship between water pollution and criminal activities*
- Hypothesis 2: *There may be a modest short-run increase in the crimes given the combination of water pollution exposure and lack of information available to the affected.*
- Hypothesis 3: *Due to the excessive media coverage, avoidance effect will kick in shortly and the criminal incidents will be significantly reduced comparing to the rest of Michigan*
- Hypothesis 4: *Due to the mobility of the criminals. the crime rate of the adjacent areas will be significantly affected.*

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Data

Sample: Agency-level daily crime data from January 2010 through December 2019 in the state of Michigan

- **Crime data:** National Incident Based Reporting System (NIBRS) of the Federal Bureau of Investigation

  Key variables: date, year and type of criminal incidence, demography of the offender and victims, reporting agency information including yearly population and employee.

- **Weather data:** PRISM Climate Group at Oregon State University

  Key variables: precipitation (ppt in inches), minimum and maximum temperature (degrees F).

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Crimes in Flint, MI

Year	Population	Violent crime	Murder/ manslaughter	Rape	Robbery	Aggravated assault	Property crime	Burglary	Larceny/ theft	Motor vehicle theft	Arson
2005	119,814	2,708	48	105	566	1,989	7,709	2,634	3,492	1,583	188
2006	118,256	3,070	54	143	627	2,246	8,117	3,058	3,538	1,521	186
2007	116,024	2,741	30	109	665	1,937	7,246	3,241	2,965	1,040	240
2008	113,462	2,297	32	103	686	1,476	6,889	3,273	2,707	909	145
2009	111,657	2,244	36	91	590	1,527	6,397	3,057	2,664	676	173
2010	109,245	2,412	53	92	670	1,597	6,237	3,648	1,936	653	343
2011	102,357	2,392	52	85	607	1,648	6,618	3,628	2,220	770	287
2012	101,632	2,774	63	108	673	1,930	5,645	2,979	2,207	459	226
2013	99,941	1,907	48	145	447	1,267	4,261	1,941	2,000	320	110
2014	99,166	1,694	28	115	277	1,274	3,891	1,677	1,944	270	133
2015	98,221	1,451	47	77	272	1,055	3,538	1,391	1,880	267	79
2016	97,548	1,545	45	96	249	1,155	3,323	1,213	1,867	243	63
2017	96,448	1,879	37	104	272	1,466	2,632	961	1,397	274	
2018	95,943	1,739	32	130	189	1,388	2,584	796	1,488	300	
2019	95,212	1,284	23	64	78	1,119	1,986	559	1,220	207	

Table: Annual Crimes in Flint, MI

Summary Statistics

	Flint					Michigan				
Variable	Mean	S.D.	Min.	Max.	N	Mean	S.D.	Min	Max.	N
Murder	1.128	.3572	1	3	376	1.465	.804	1	7	5,141
Rape	1.277	.528	1	4	766	1.230	.652	1	12	43,037
Robbery	2.480	1.475	1	11	3,742	6.808	6.941	1	42	79,060
Burglary	8.226	4.509	1	26	18,670	10.045	15.757	1	84	457,791
Motor Cycle Theft	2.381	1.364	1	9	3,824	14.294	15.863	1	71	210,700
Aggravated Assault	4.307	2.070	1	13	11,007	9.709	11.802	1	52	237,788
Minimum Temperature	40.461	18.403	-21.9	76.6	107,668	41.619	18.247	-35.9	79.2	5,180,267
Maximum Temperature	59.879	20.782	-.2	99.4	107,668	60.102	20.622	-13.3	103.8	5,180,267
Precipitation	.094	.249	0	4.53	107,668	.102	.255	0	6.6	5,180,267

Table: Annual Crimes in Flint, MI

Model I Specifications: Using Crime Index

I estimate the following TWFE model to identify the effect of water pollution on crime:

Model I:

$$Crime^{j}_{a,t} = \theta D_{a,t} + W^{'}_{a,t}\gamma + \rho_a + \phi(t) + \epsilon_{a,t}$$

Here

- $Crime^{j}_{a,t}$: log of the total count of crimes of type j per 1000 people in agency a on month t
- $D_{a,t}$: a dummy variable indicating that crime occurred in the jurisdiction of treatment agency a and post April 2014
- $W^{'}_{a,t}$: a vector of weather control variables including monthly maximum temperature, minimum temperature, and precipitation
- ρ_i : agency fixed effects
- $\phi(t)$: time(month of the year) fixed effect
- $\epsilon_{a,t}$: standard errors are clustered at the county level

Model I Specifications: Using Crime Index

$Crime^{j}_{a,t}$: Initially, three types of crime are used:

- Crimes against persons
- Crimes against properties
- Crimes against society

$W'_{a,t}$: Following Ranson 2014 and Chen and Li 2020, I have used the following bin indicators to model the distribution of temperatures and precipitations:

- Minimum Temperature: $(-\infty, 28.3], (28.3, 42.4], (42.4, 57.1], (57.1, \infty)$
- Maximum Temperature: $(-\infty, 42.8], (42.8, 63], (63, 78.3], (78.3, \infty)$
- Precipitation: Dummy variable equal to 1 if $monthlypreipitation > .07ppt$

Model II Specifications: Using Count of Crime

I estimate the following model via Poisson pseudo-maximum likelihood (PPML) to identify the effect of water pollution on crime:

Model II:

$$Crime^{j}_{a,t} = \theta D_{a,t} + W^{'}_{a,t}\gamma + \rho_a + \phi(t) + \epsilon_{a,t}$$

Here

- $Crime^{j}_{a,t}$: total count of crimes of type j in agency a on day t
- $D_{a,t}$: a dummy variable indicating that crime occurred in the jurisdiction of treatment agency a and post April 2014
- $W^{'}_{a,t}$: a vector of weather control variables including daily maximum temperature, minimum temperature, and precipitation
- ρ_i : agency fixed effects
- $\phi(t)$: time fixed effect
- $\epsilon_{a,t}$: standard errors are clustered at the county level

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Results I

Crime Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treated	-0.120***	-0.120***	-0.120***	-0.313***	-0.314***	-0.314***	-0.308***	-0.307***	-0.307***
	(0.022)	(0.023)	(0.023)	(0.015)	(0.015)	(0.015)	(0.023)	(0.023)	(0.023)
Weather Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Agency-Month of Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agency-Month of Year-Year FE	No	No	Yes	No	No	Yes	No	No	Yes
Crime Type	Person	Person	Person	Property	Property	Property	Society	Society	Society
N	41471	41471	41471	45504	45504	45504	33245	33245	33245
R-sq	0.664	0.664	0.664	0.611	0.612	0.612	0.589	0.589	0.589
Standard errors in parentheses									
="* p<0.05	** p<0.01	*** p<0.001"							

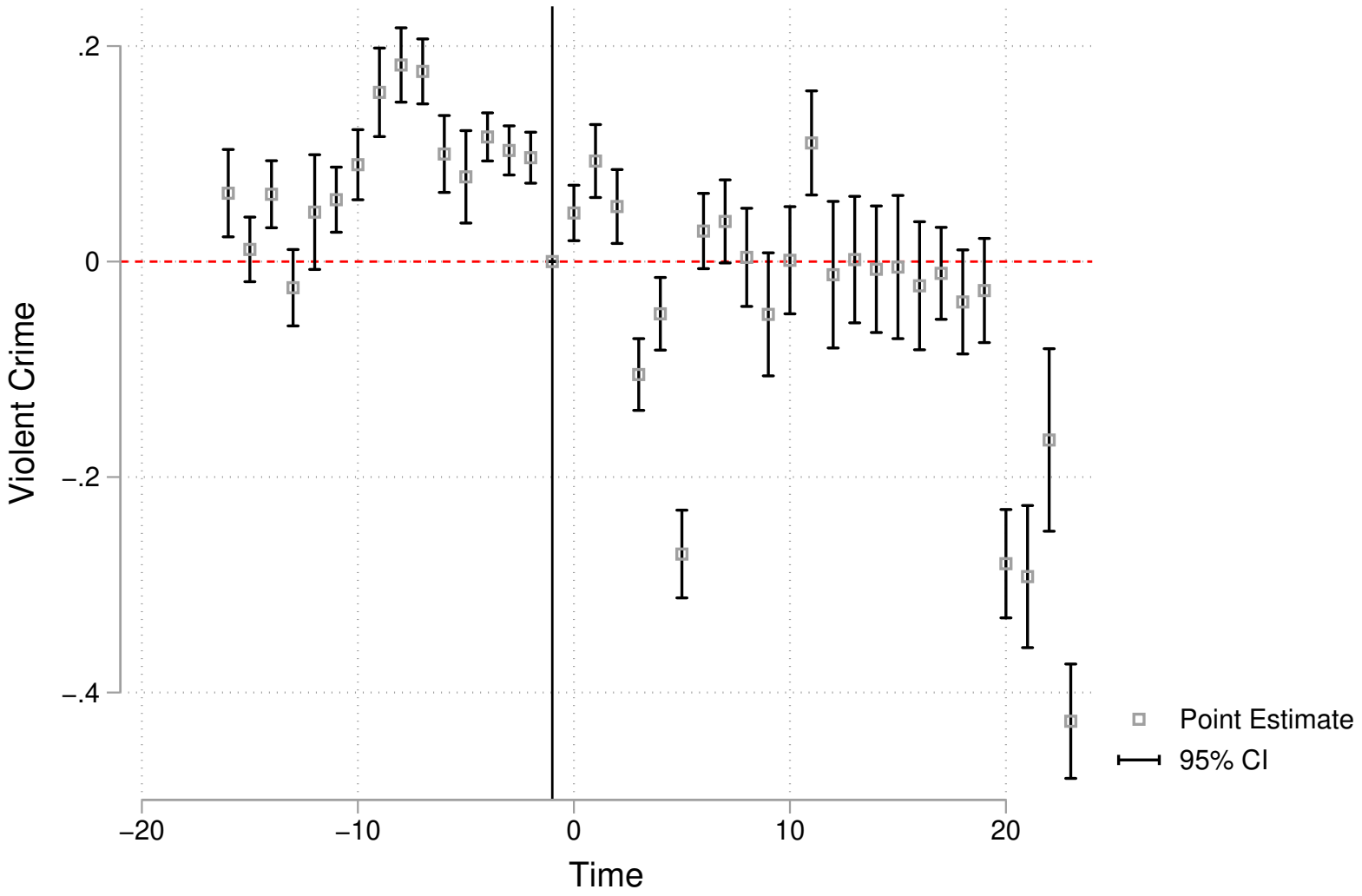
Table: Results of Equation 1 Estimation via TWFE models

Results II

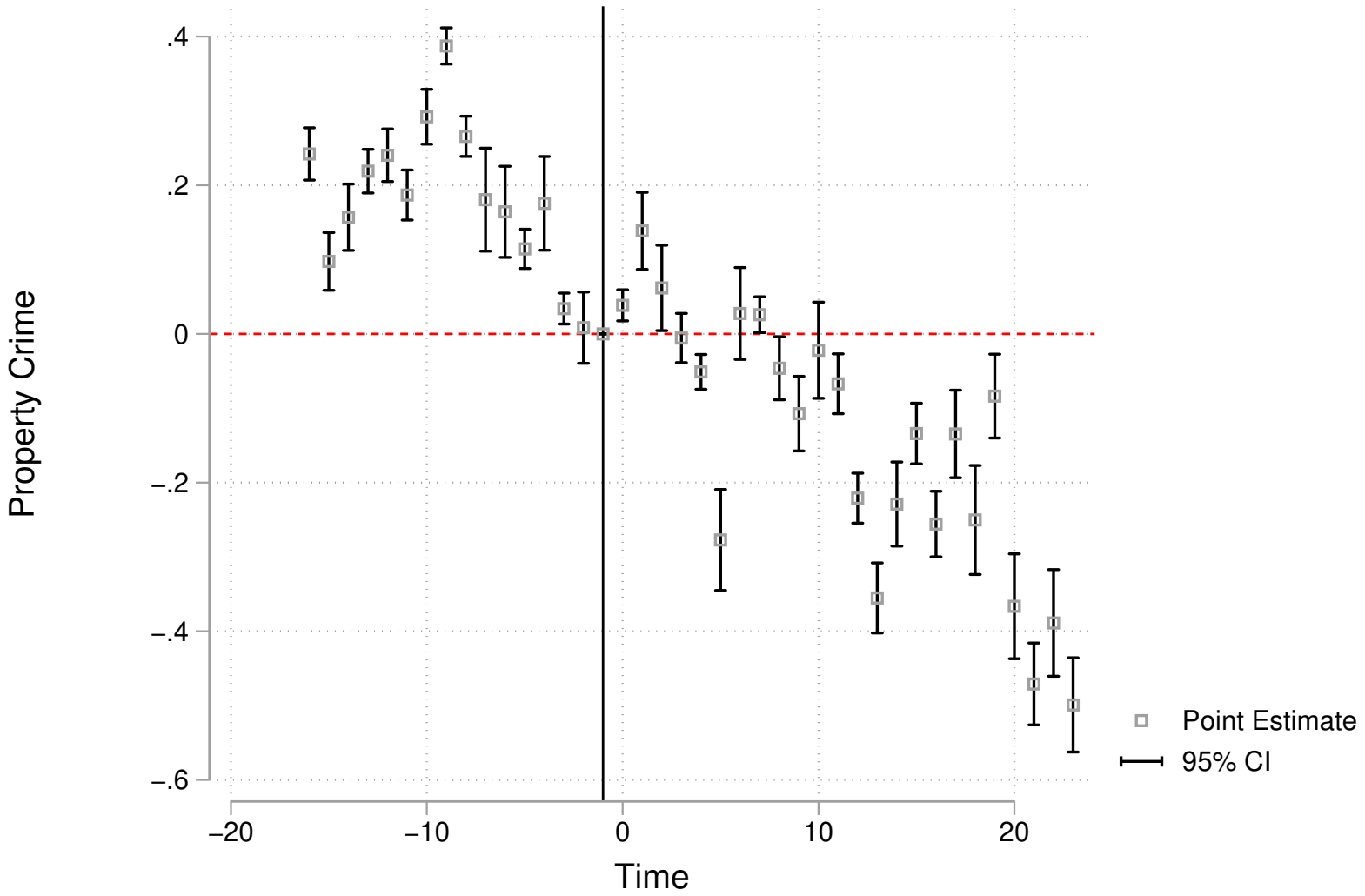
Count of Crime	(1)	(2)	(3)	(4)	(5)	(6)
Treated	-0.204***	-0.142***	-0.481***	-0.245***	0.035***	0.014
	(0.000)	(0.005)	(0.000)	(0.010)	(0.001)	(0.047)
Weather Controls	No	Yes	No	Yes	No	Yes
Agency-Day of Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Agency-Day of Week -Month of Year-Year FE	No	No	Yes	No	No	Yes
Crime Type	Person	Person	Property	Property	Society	Society
N	1079613	1079613	2558523	2558523	400990	400990
Standard errors in parentheses						
="* p<0.05	** p<0.01	*** p<0.001"				

Table: Results of Equation 2 Estimation via PPML

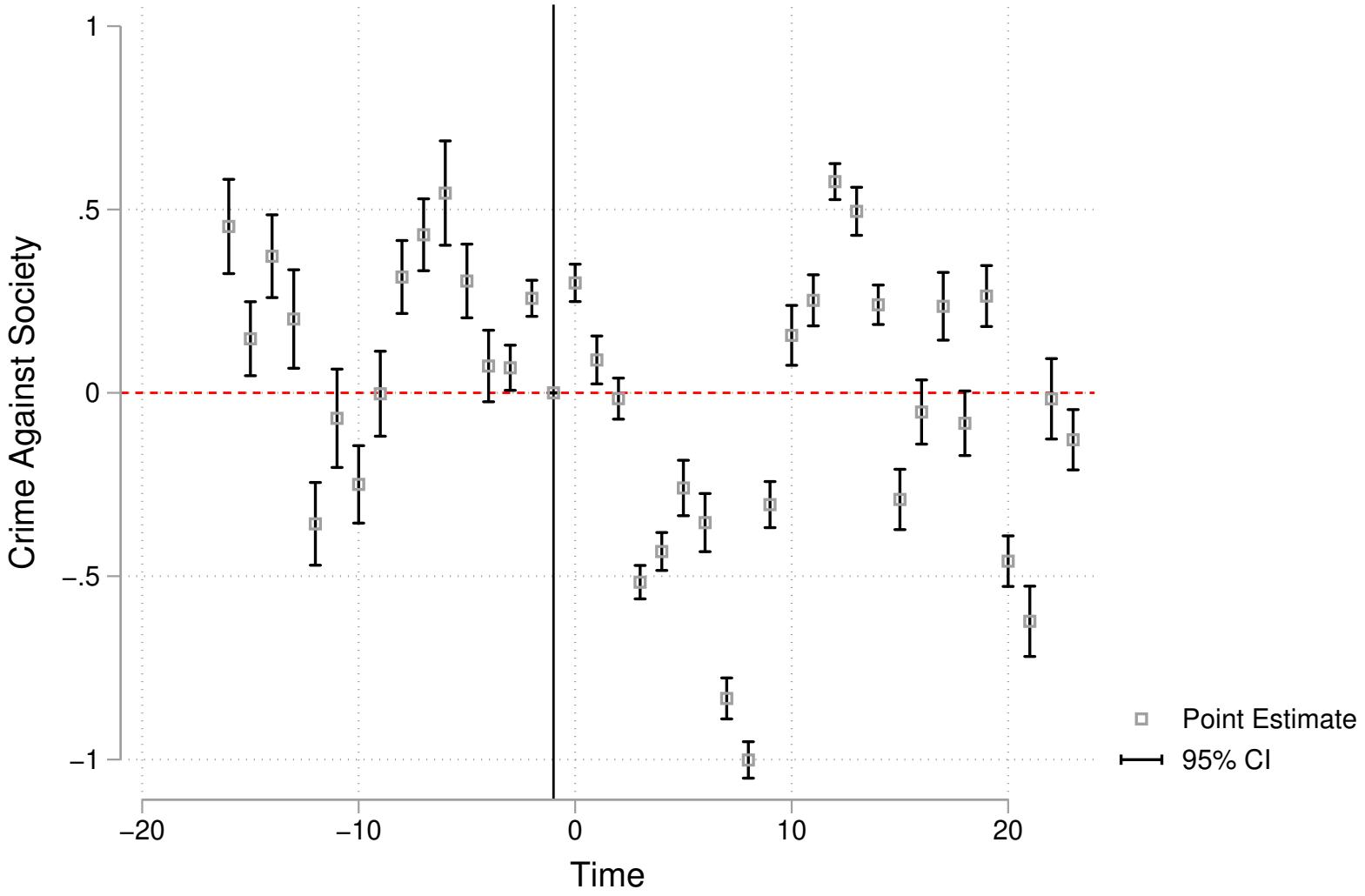
Event-study analysis: Crime Against Persons



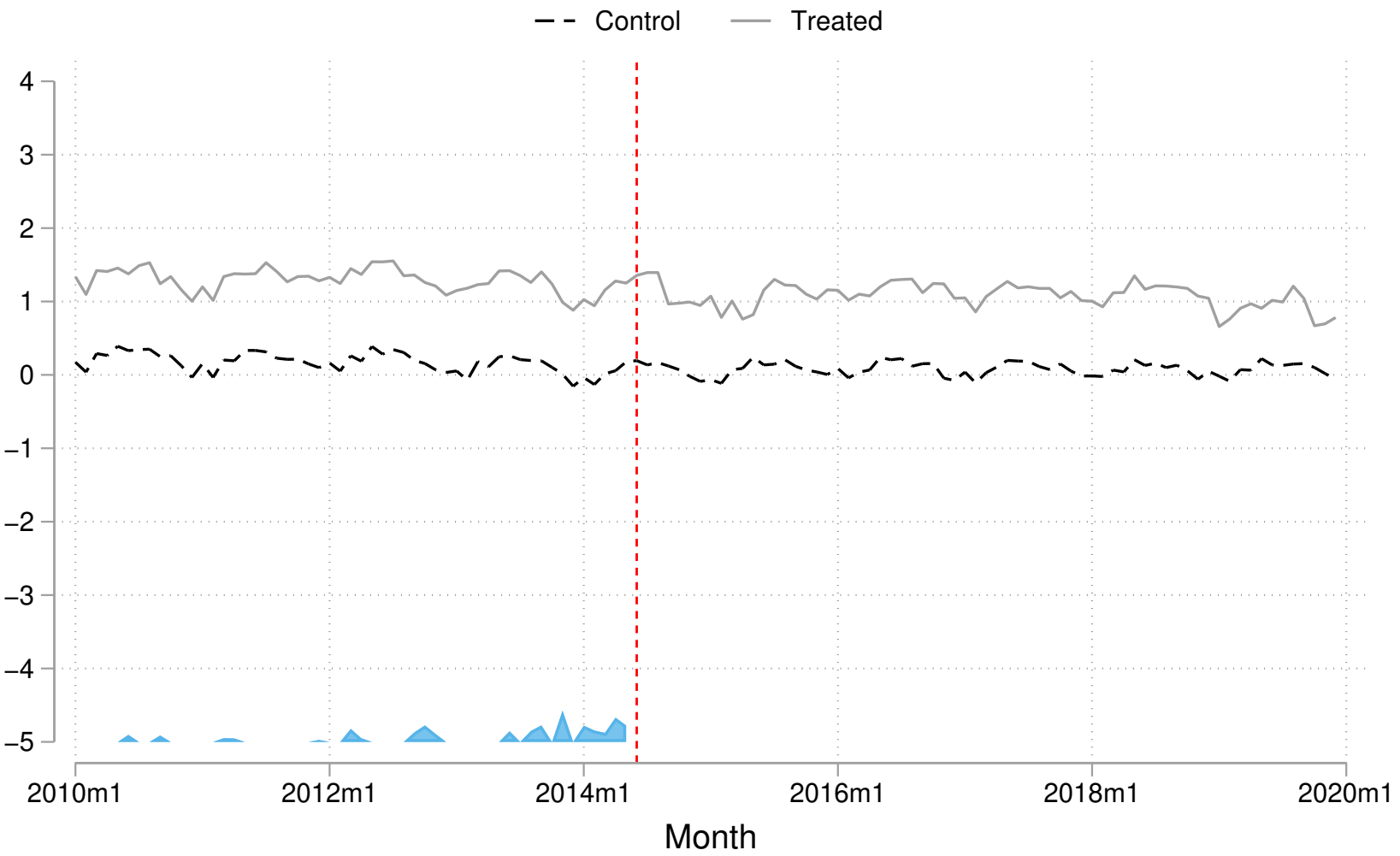
Event-study analysis: Crime Against Property



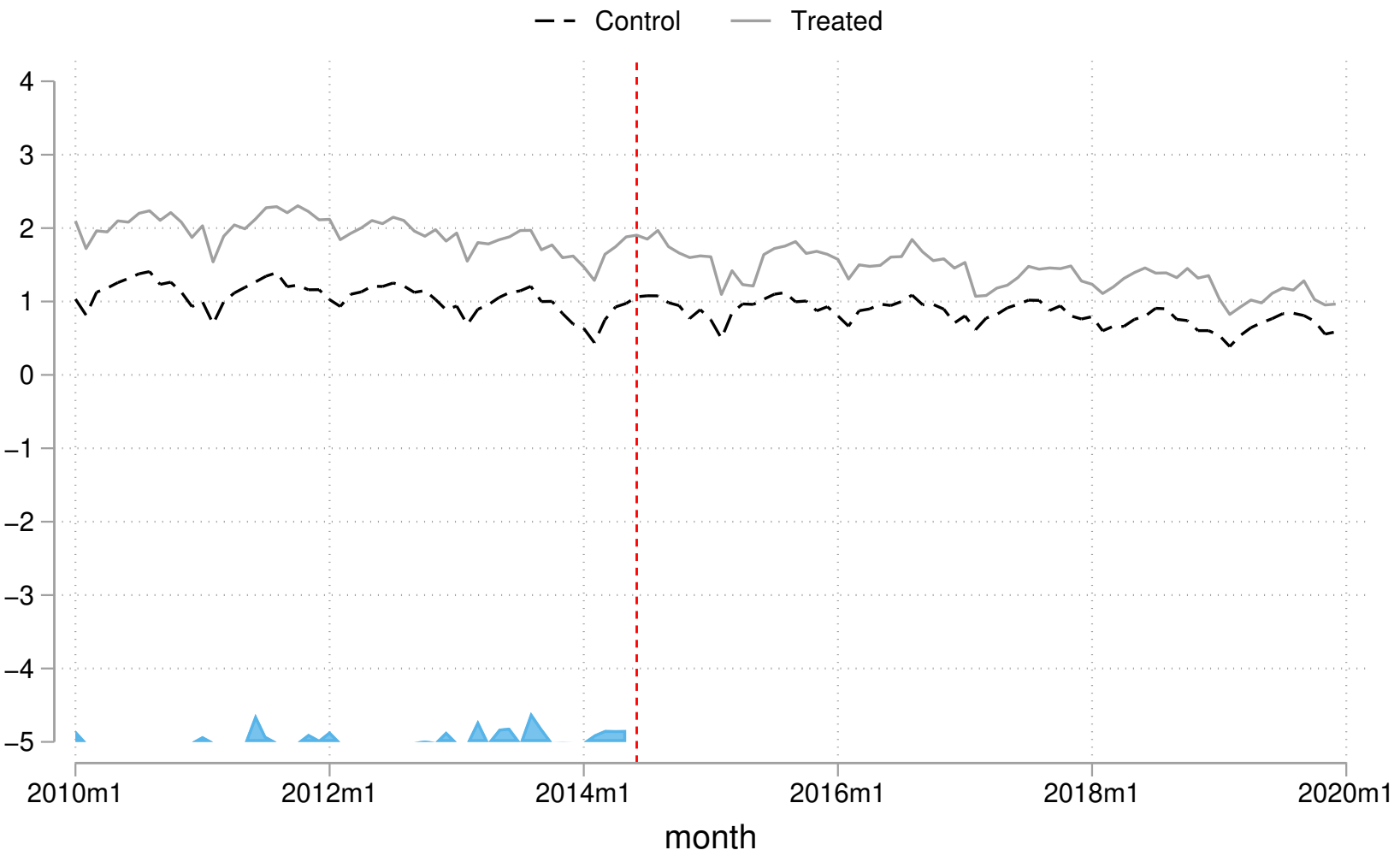
Event-study analysis: Crime Against Society



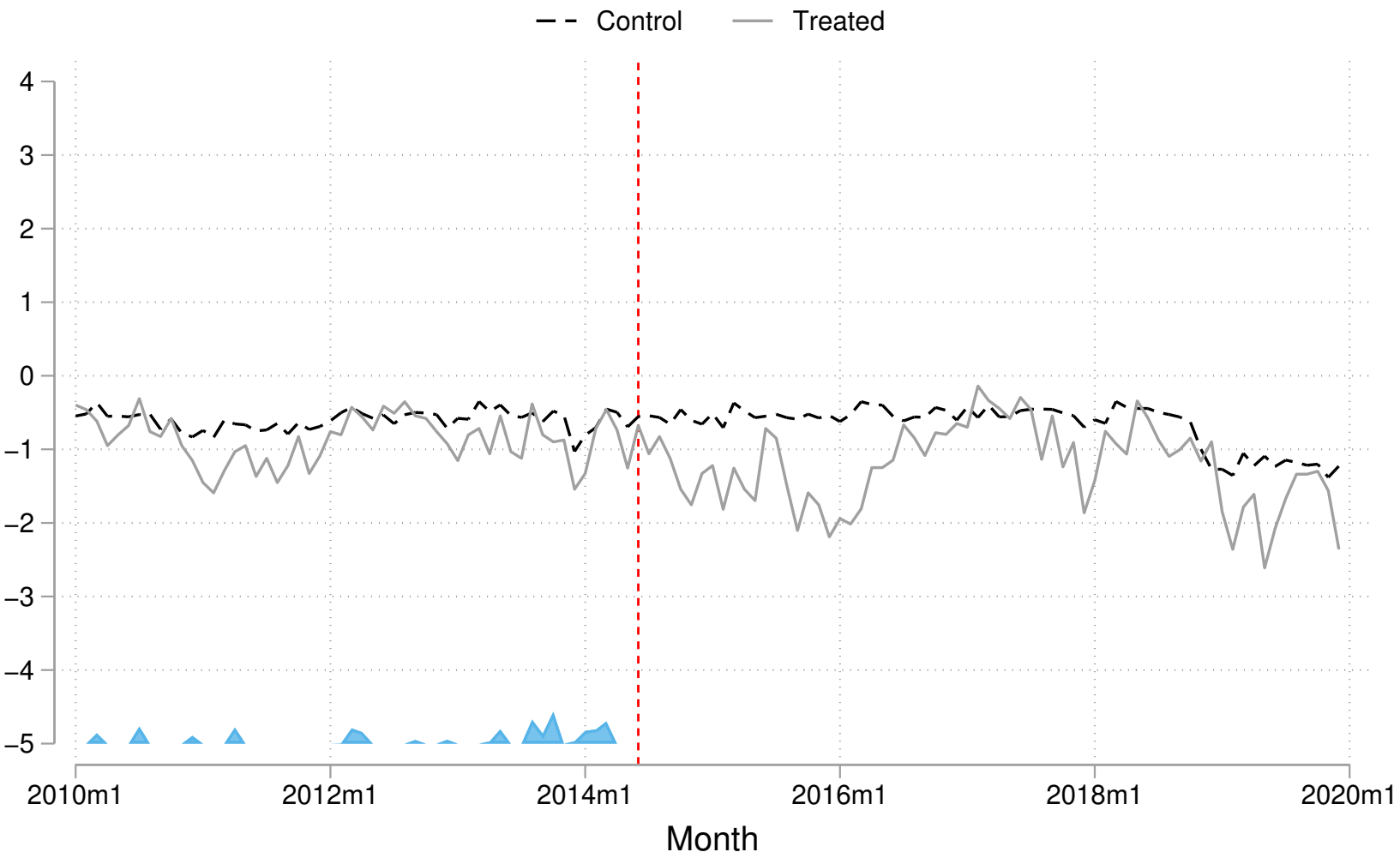
Synthetic DID: Crime Against Persons



Synthetic DID: Crime Against Property



Synthetic DID: Crime Against Society



Spillover Effects

To detect the potential spillover effect of lead-contamination of Flint, crimes in the adjacent counties of Flint relative to the nonadjacent counties.

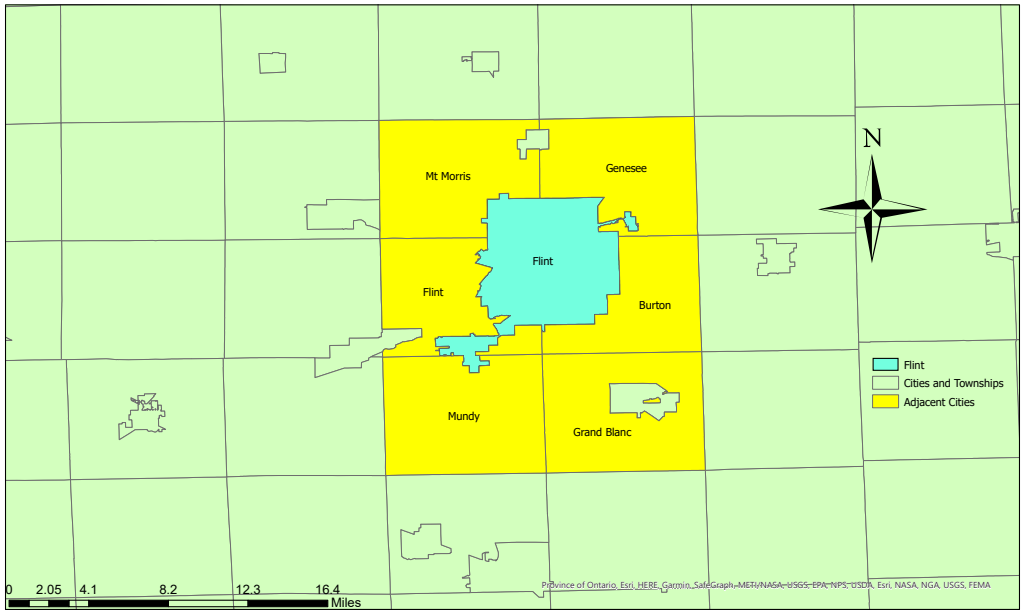


Figure: Spillover effects

Spillover Effects:Results

Crime Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treated	-0.119***	-0.119***	-0.119***	-0.174***	-0.175***	-0.175***	0.081***	0.082***	0.082***
	(0.022)	(0.022)	(0.022)	(0.014)	(0.014)	(0.014)	(0.023)	(0.023)	(0.023)
Weather Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Agency-Month of Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agency-Month of Year-Year FE	No	No	Yes	No	No	Yes	No	No	Yes
Crime Type	Person	Person	Person	Property	Property	Property	Society	Society	Society
N	41351	41351	41351	45384	45384	45384	33125	33125	33125
R-sq	0.662	0.662	0.662	0.610	0.611	0.611	0.589	0.589	0.589
Standard errors in parentheses									
="* p<0.05	** p<0.01	*** p<0.001"							

Table: Results of Spillover Analysis

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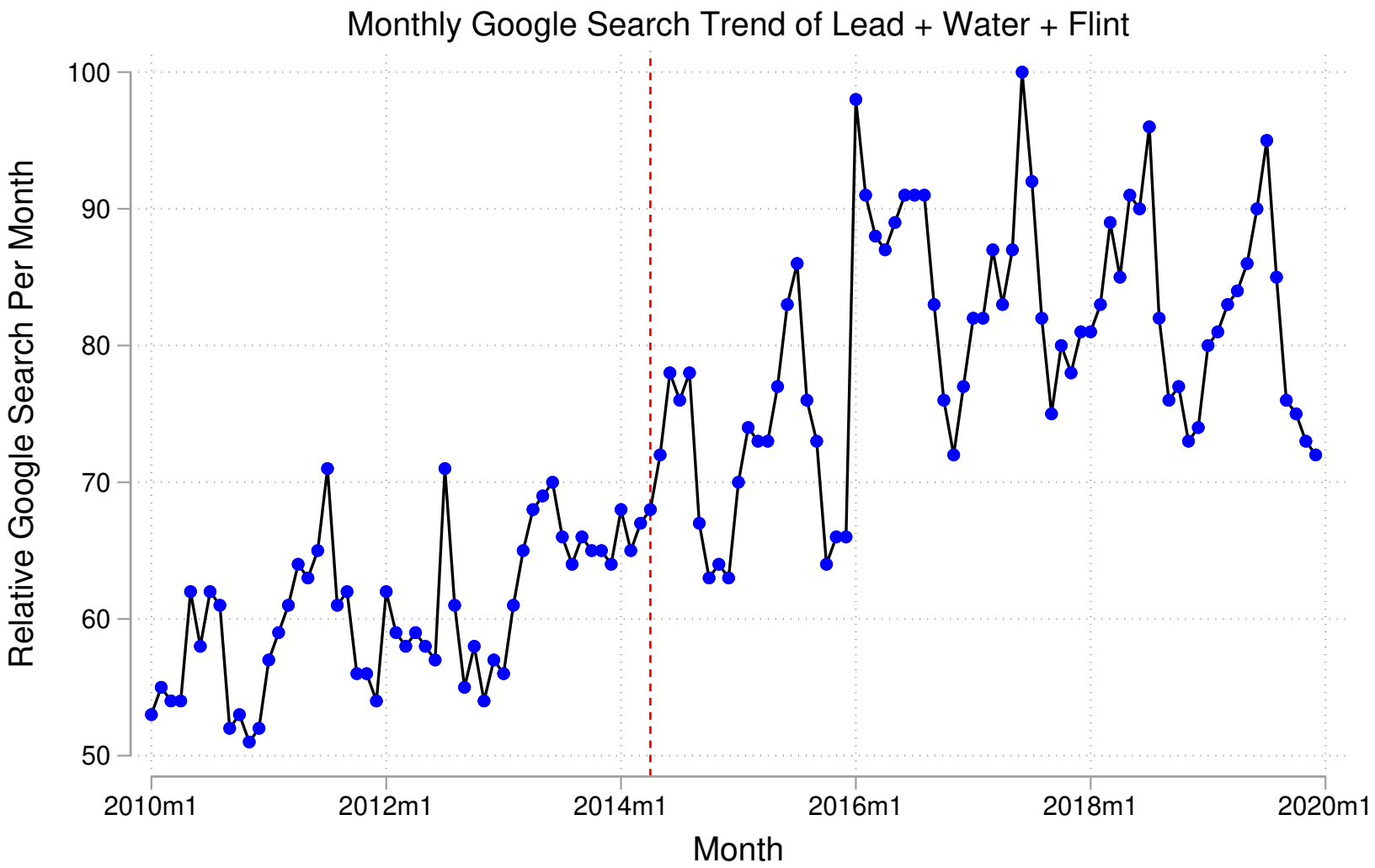
Avoidance Behavior



Key Findings

- There is a significant relationship between water pollution and crime, but not robust.
- The avoidance effect outweighs the effect of pollution.
- Water pollution in one area affects the crimes of nearby local areas; however, there is heterogeneity based on crime types.

Future steps

- Exploring both Newark and Washington water crisis for a better external validity.
- Running Synthetic event study!
- Incorporating theories on information effects of pollution.

Concluding Remarks

- The effects of water pollution on crime are statistically significant in the main analysis.
- Though the information of pollution seems dominating; a robust interpretation is needed.

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