American Tornadoes: Tornado Shocks on U.S. Metropolises

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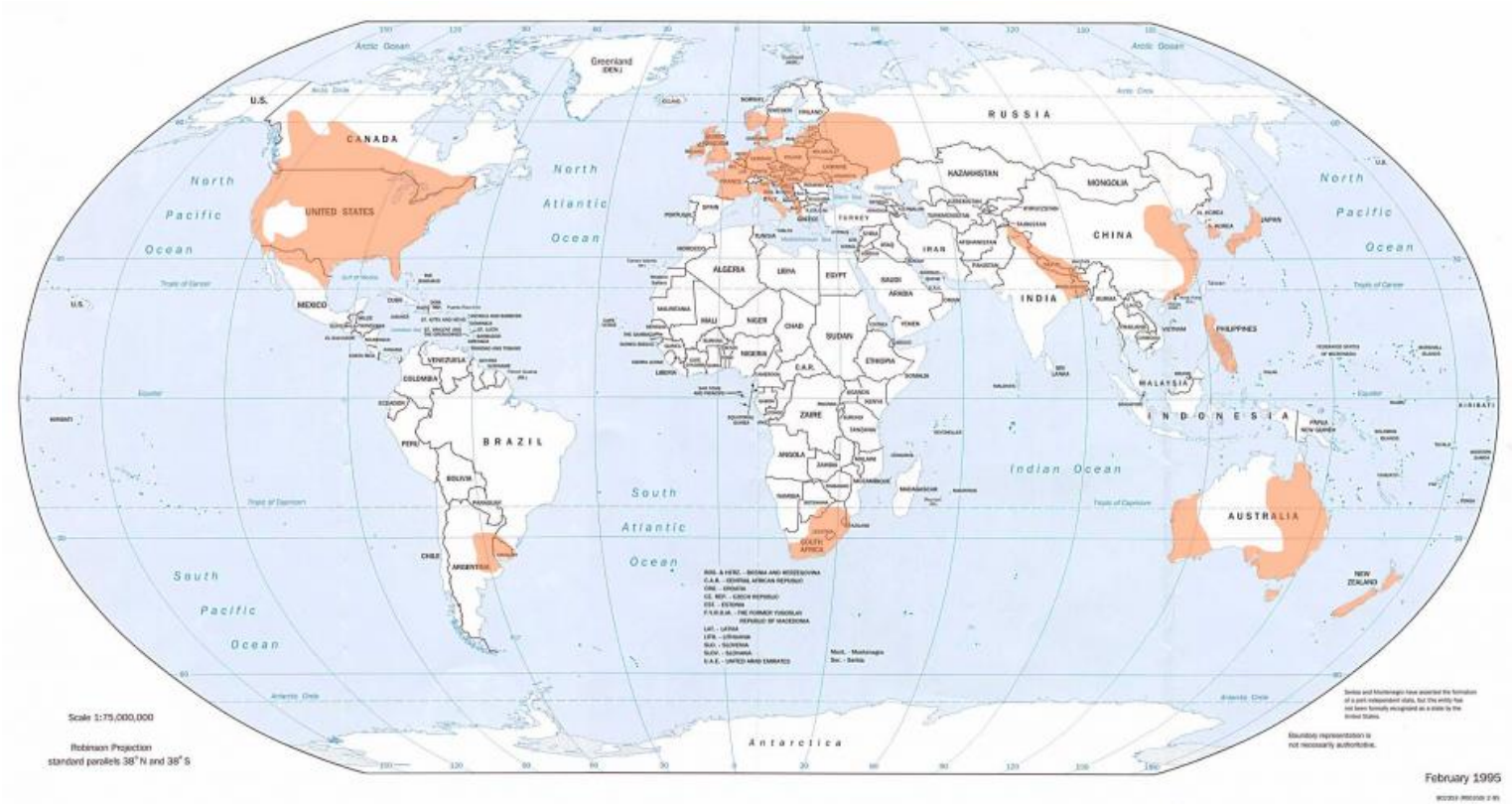
Motivation

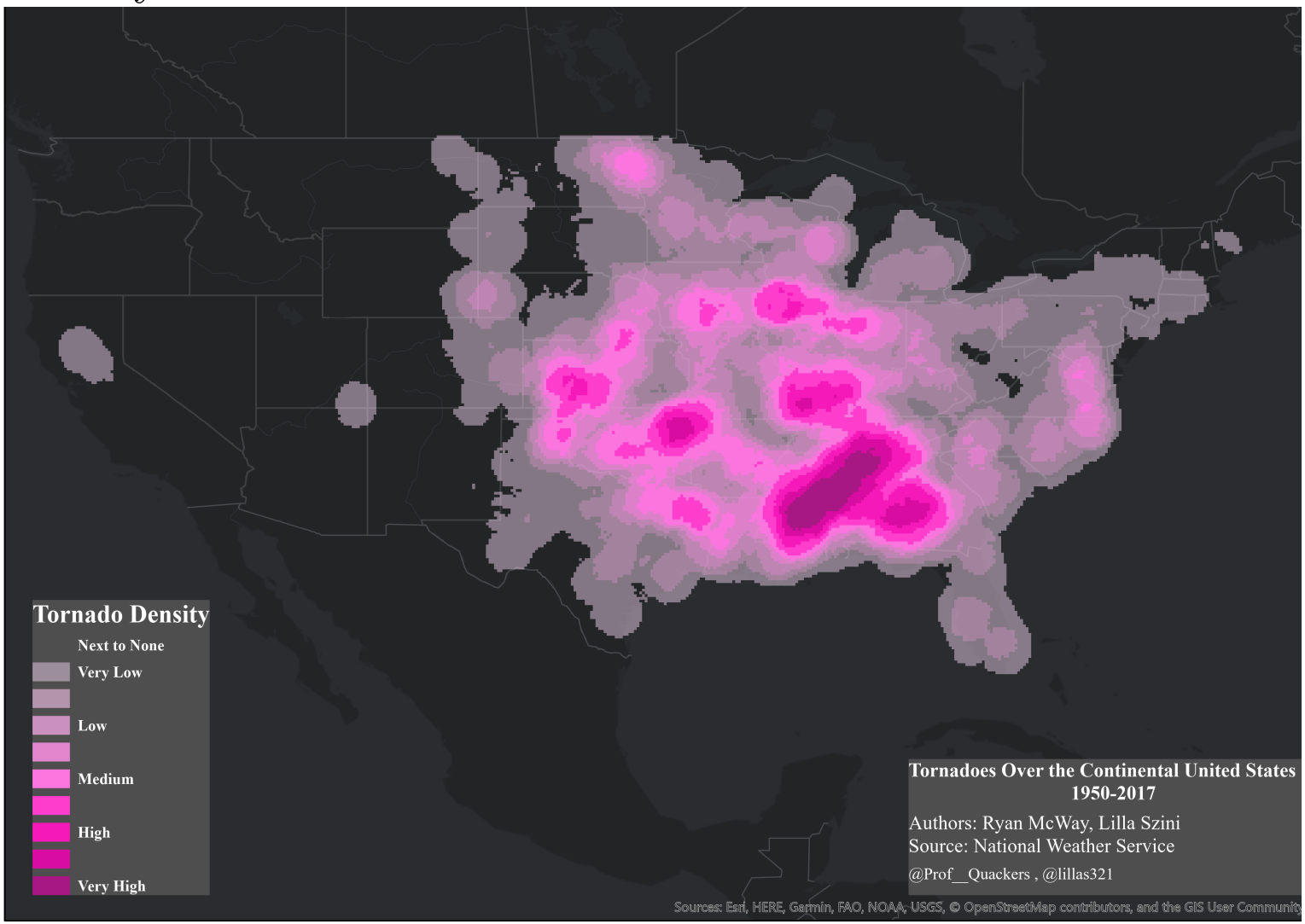
- Tornadoes are primarily a concern for the United States



Source: National Centers for Environmental Information (NOAA)

Motivation

- Mainly concentrated near Midwestern and Southern States



Motivation

- Tornadoes the deadliest and most destructive weather pattern in the United States (Brook, 1967; Perry and Reynolds, 1993; Curtis and Fagan, 2013)
- Natural disasters are highly destructive and disasters should have strong aggregate effects (Hsiang, 2014; Anttila-Hughes, 2013; Botzen et al., 2019)
- Poverty damages result from natural disasters, and while primarily documented in developing nations, should also see effects in developed nations (Rashed and Weeks, 2003; Donner, 2007; Donner and Rodriquez, 2008)

Research Questions

1. Do tornadoes create short-run aggregate effects?
2. How do tornadoes impact different sectors of local economies?
3. Do tornadoes produce an environmental poverty trap?

Literature Review

1. Tornadoes
   - Tornadoes are the most destructive weather event in the U.S. (Perry and Reynolds, 1993; Brook, 1967)
   - Recovery process at household and aggregate level from natural disasters have long time horizons (Baker et al., 2007)
2. Disasters and Production
   - Recovery takes substantial government investment and averages 10 years (Paul and Che, 2011)
   - Disasters have massive economic growth effects and are a major hurdle for certain economies (Hsiang, 2010; Anttila-Hughes, 2013; Botzen et al., 2019)
3. Environmental Poverty Traps
   - Demographic vulnerability for poor, less educated, migrant communities comprising of disproportional population of those effected by disasters (Donner, 2007; Donner and Rodriquez, 2008)

Data

1. Tornadoes
   - National Weather Service, NOAA
   - Best tracks from 1950 - 2017 across the United States (N = 63,160)
2. Metropolitan Statistical Area (MSA) GDP by Sector
   - U.S. Census Bureau
   - 2001 - 2018 GDP for 87 sectors and 384 mirco- and metropolis (N = 6,518)
3. Treatment Definition
   - Tornado Count at the MSA-level for each tornado category in a given year
     (e.g. Count of tornadoes for category 0–5 in Chicago area in 2015)

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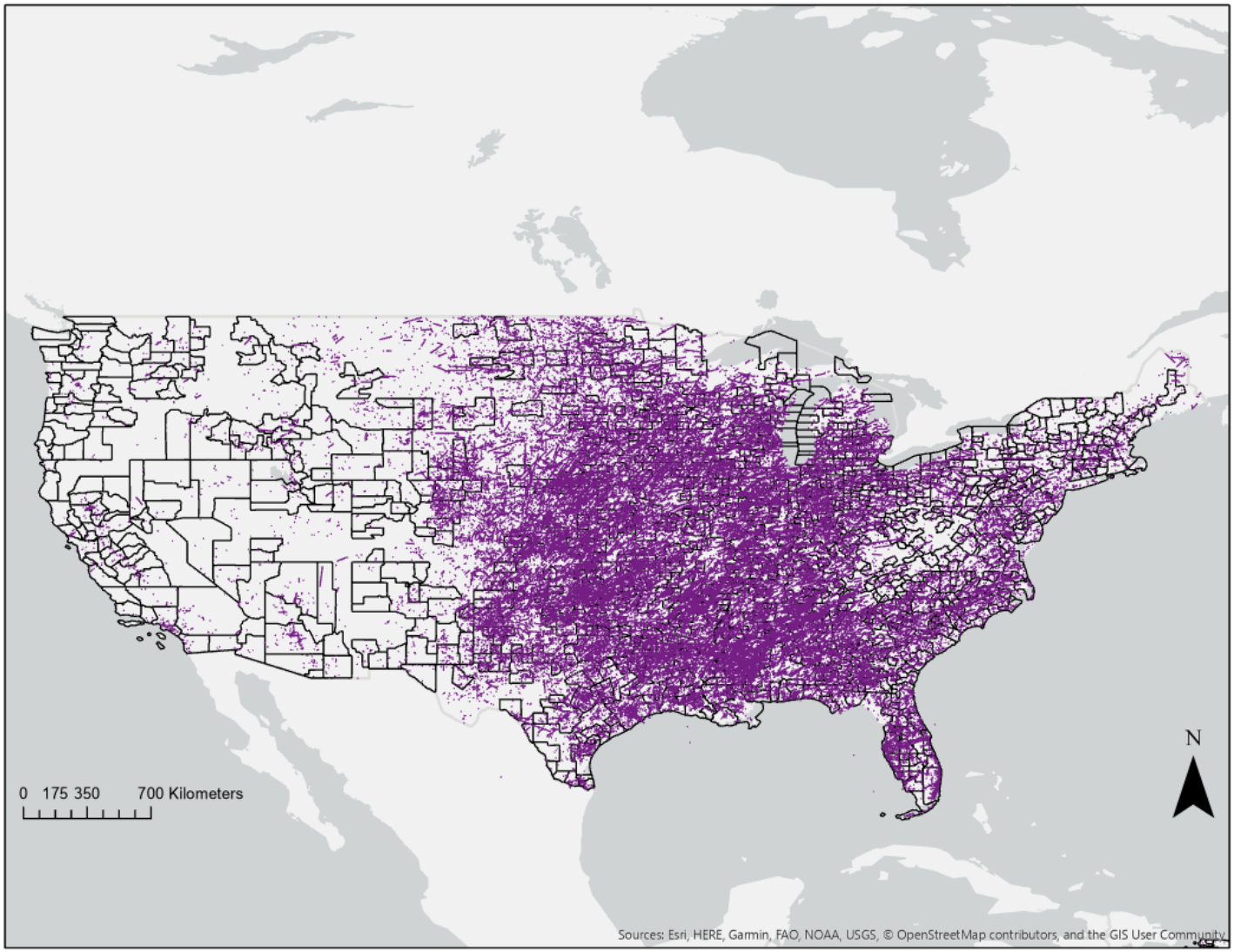
Spatial Distribution



Tornado Descriptives

Variable	Obs	Mean	Std. Dev.	Min	Max
Treated: Exp. Tornado Activity	6,518	.35	.48	0	1
Tornado Count	6,518	.99	2.32	0	36
Tornado Count Cat 0	6,518	.45	1.25	0	25
Tornado Count Cat 1	6,518	.38	1.07	0	16
Tornado Count Cat 2	6,518	.11	.44	0	6
Tornado Count Cat 3	6,518	.04	.23	0	5
Tornado Count Cat 4	6,518	.01	.12	0	4
Tornado Count Cat 5	6,518	0	.03	0	1
Highest Category Tornado	2,245	1.11	1.03	0	5
# of Tornado Injuries	2,249	7.25	61.96	0	1738
# of Tornado Deaths	2,249	.57	5.46	0	158
Dummy: Midwestern State	2,249	.27	.44	0	1
Dummy: Southern State	2,249	.48	.5	0	1
Dummy: Tornado Alley State	2,249	.43	.49	0	1

Balance Table

Variable	(1) Control N	(1) Control Mean (SE)	(2) Treated N	(2) Treated Mean (SE)	T-test Diff. P-value
Local GDP ($)	4,269	25,479,324 (1,207,285)	2,242	52,951,215 (2,748,897)	0.000***
Private Sector GDP ($)	4,269	22,159,824 (1,089,146)	2,242	46,640,190 (2,472,627)	0.000***
Public Sector GDP ($)	4,269	3,319,499 (124,274)	2,242	6,311,027 (298,287)	0.000***
Adj. Unemployment Rate	4,050	6.444 (0.044)	2,206	6.018 (0.048)	0.000***

Notes: The value displayed for t-tests are p-values. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Identification Strategy

1. Panel Fixed Effects

$$\gamma_{i,m,y} = \alpha + \delta_{i,m,y} + \theta_m + \tau_y + \epsilon_{i,m,y} \quad (1)$$

   - δ = treatment effect
   - θ = MSA fixed effects
   - τ = Year fixed effects

2. Outcomes of Interest: γ
   - Log(GDP), Annual Difference in Log(GDP), Unemployment

3. Identifying Assumption
   - Tornadoes are a plausibly exogenous weather shock conditional on spatial-temporal (MSA and year) fixed effects (Dell et al., 2012; Hsiang, 2016)

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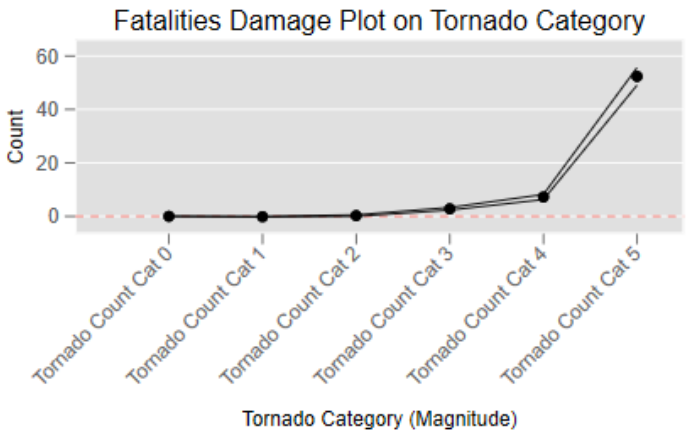
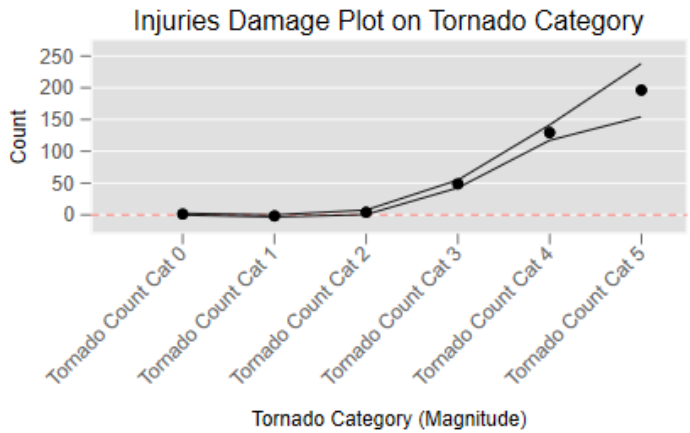
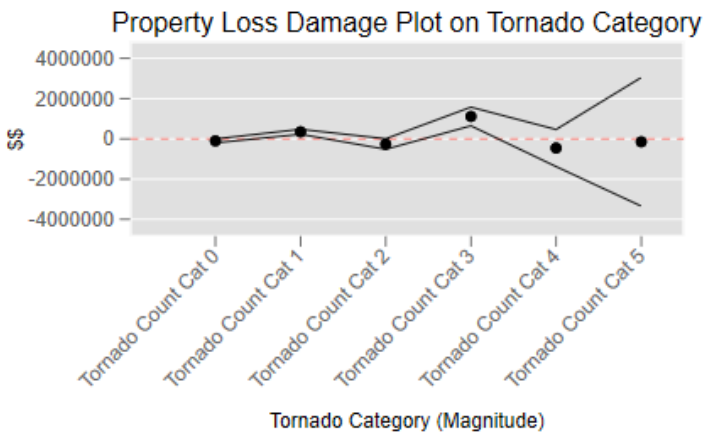
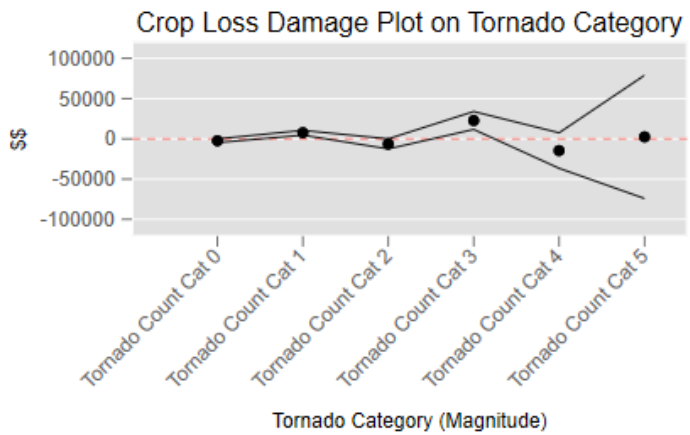
Tornado Damages

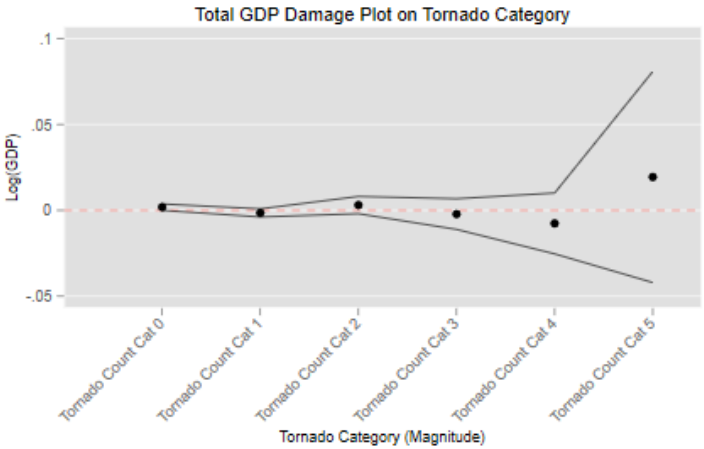


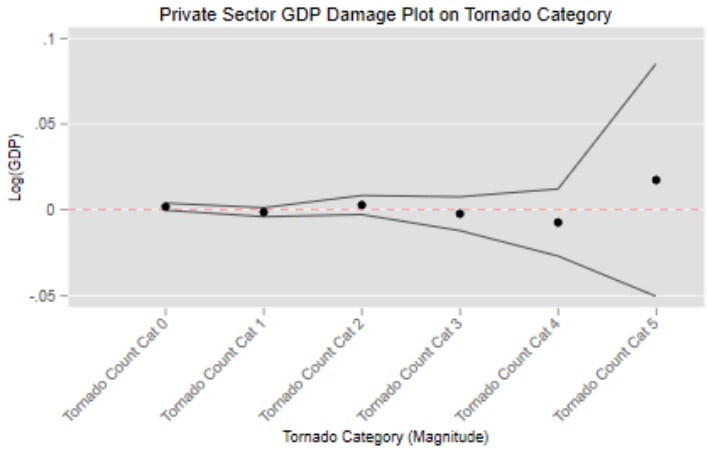


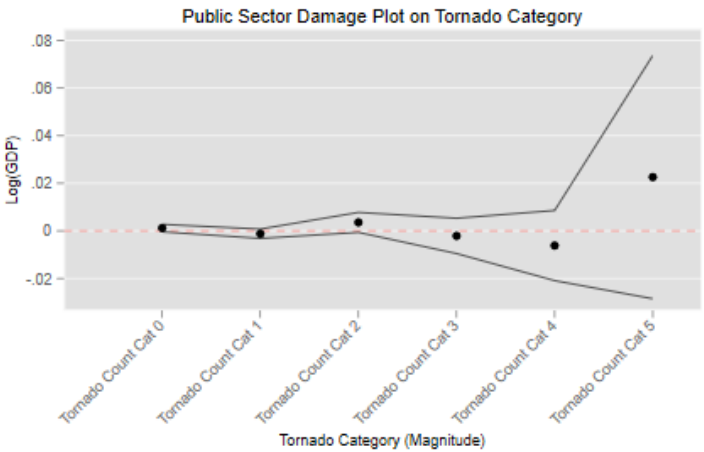




Contemporaneous Effect: GDP

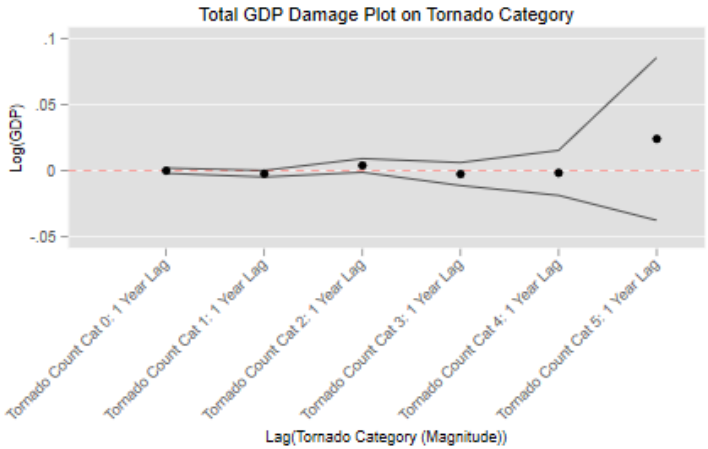


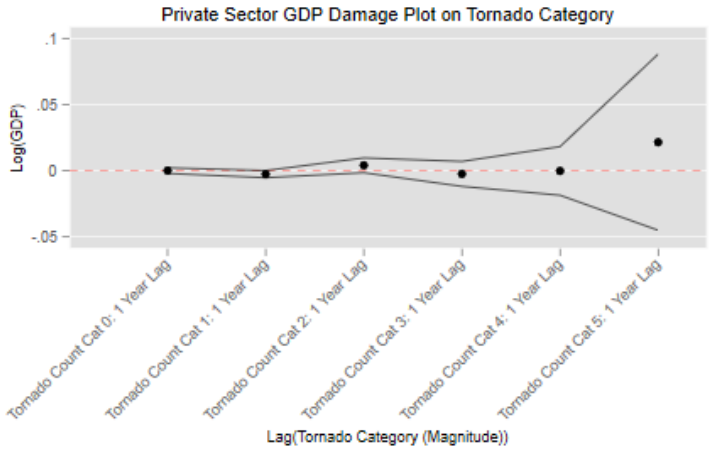


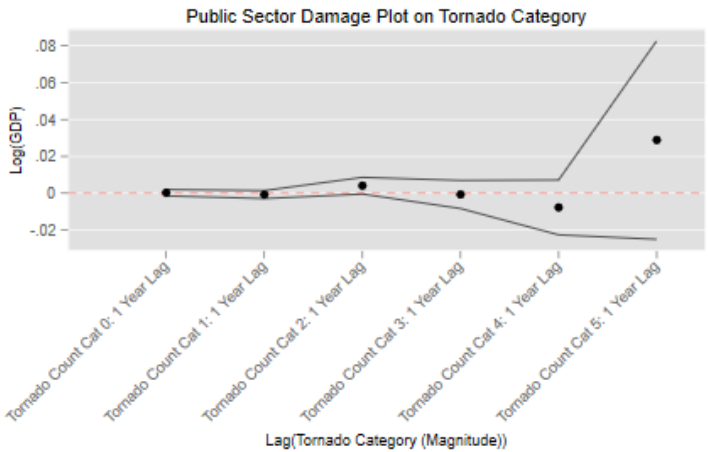


▸ Lagged GDP

Contemporaneous Effect: GDP Difference

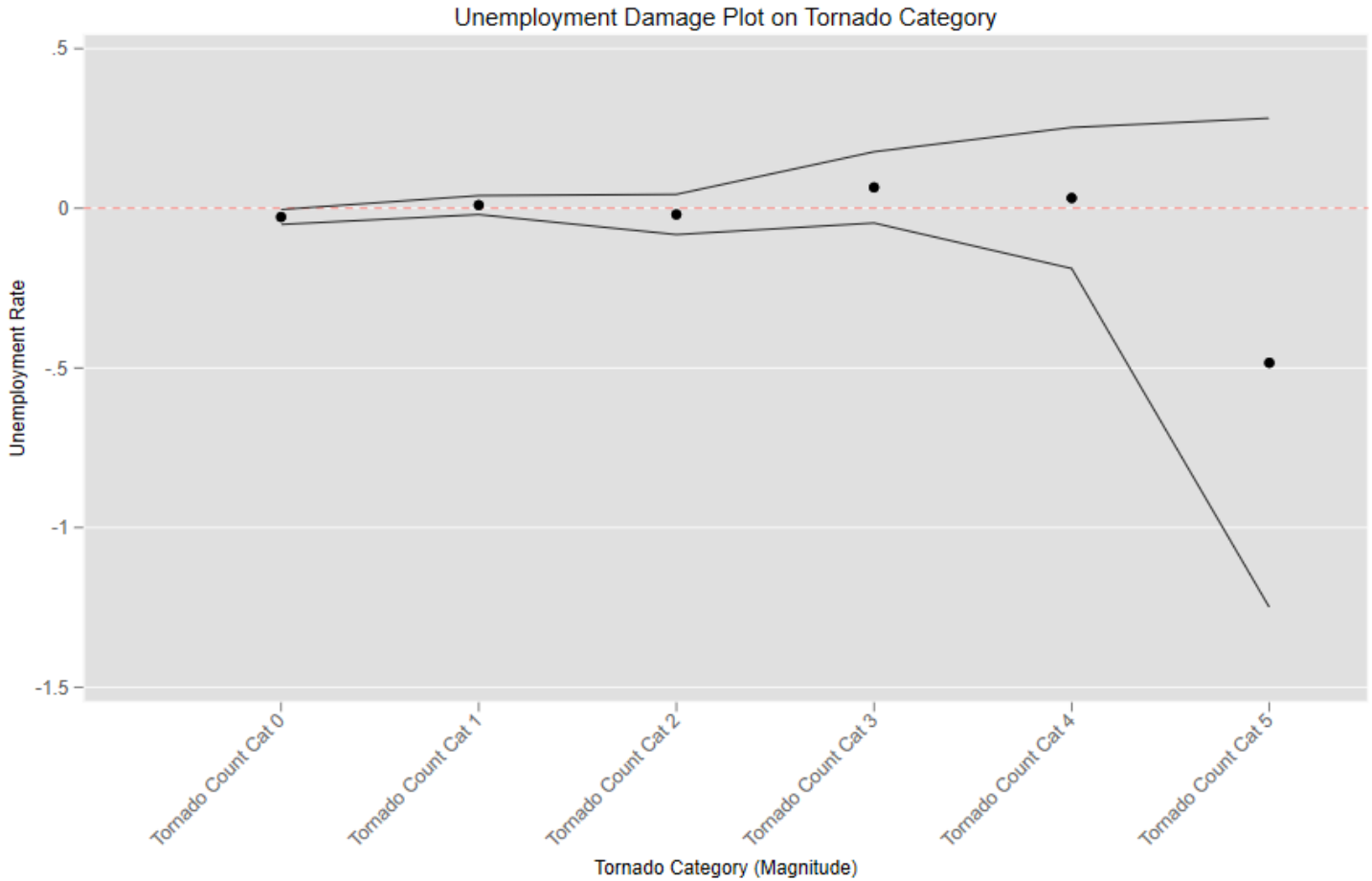






▸ Lagged GDP Difference

Contemporaneous Effect: Unemployment



▸ Lagged Unemployment

Discussion

1. Take Aways
   - 1.1 Tornadoes have no immediate impact on local production
   - 1.2 Robust across nearly all sectors (Not Shown: Available upon request)
2. Further Possible Work
   - 2.1 County-level analysis
   - 2.2 Humanitarian Preparedness (FEMA and Aid Relief)
   - 2.3 Explore other possible outcomes
     - Household Finances (Micro data)
     - Health Coverage (Insurance markets)
     - Poverty Measures

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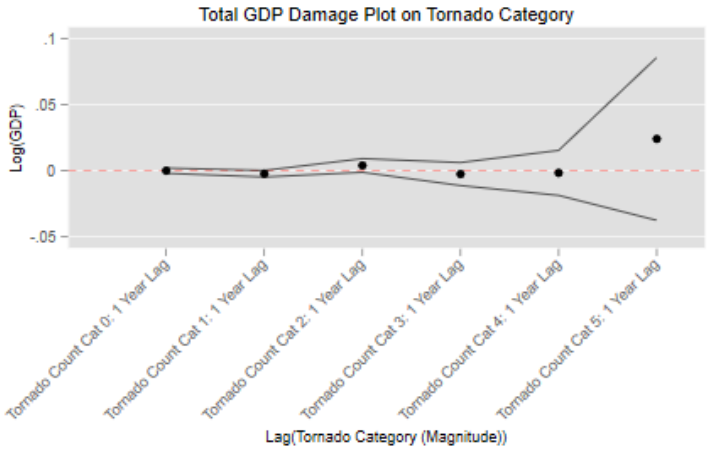
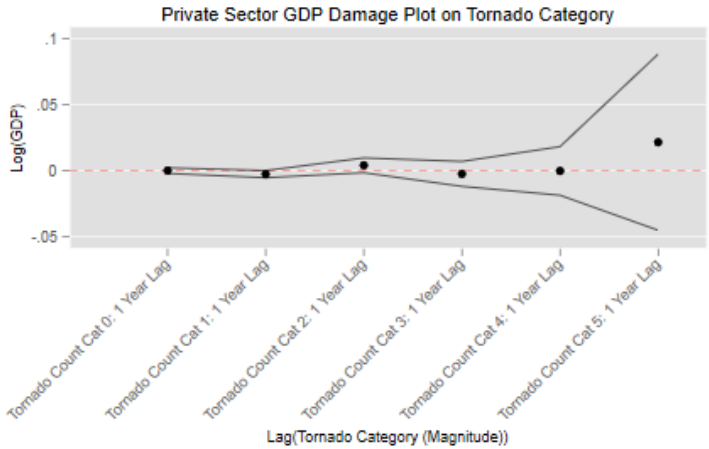
The End

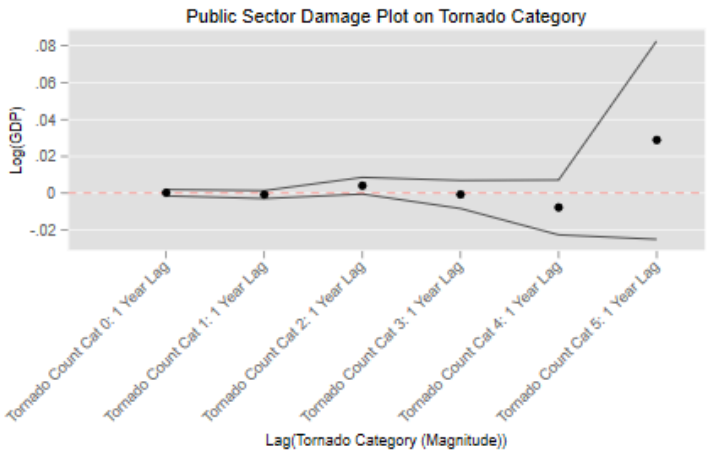
Thank You for Your Time!

@RyanMcWay

Lagged Effect: GDP

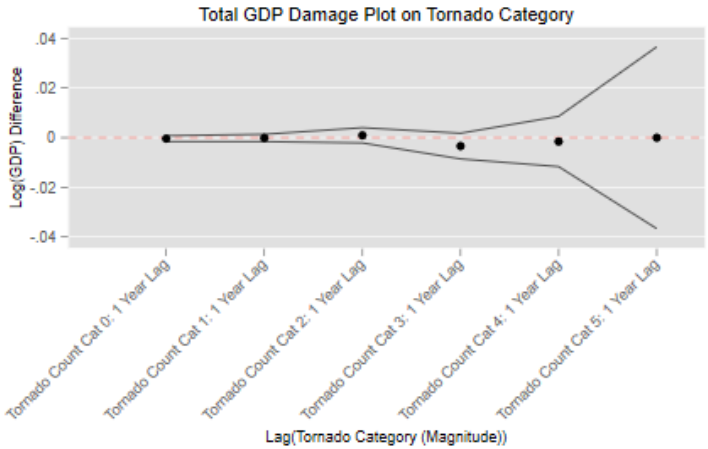


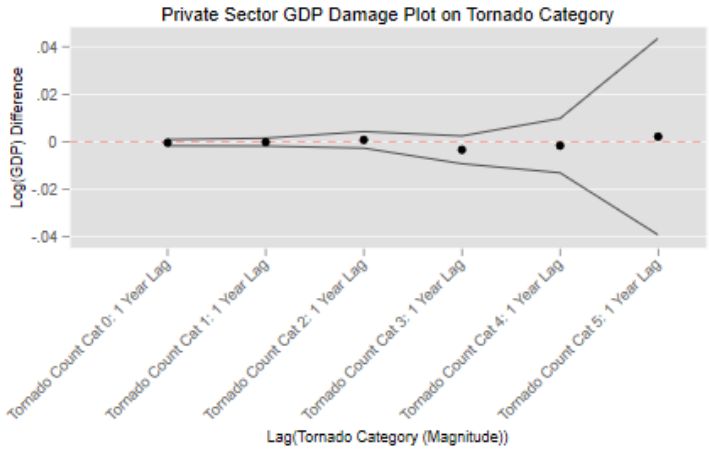


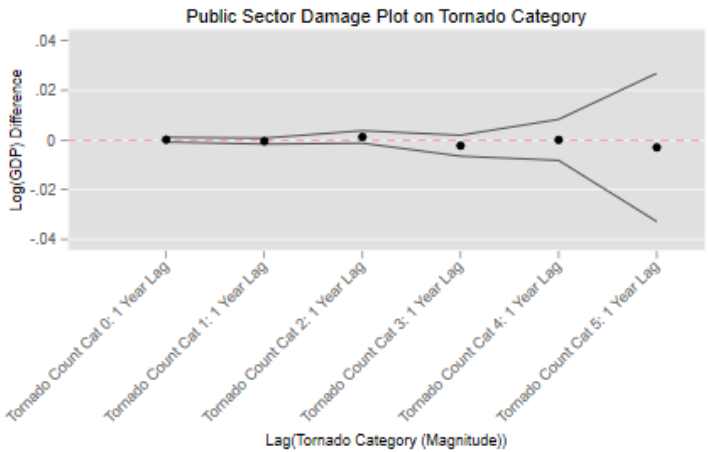


◂ Contemporaneous GDP

Lagged Effect: GDP Difference

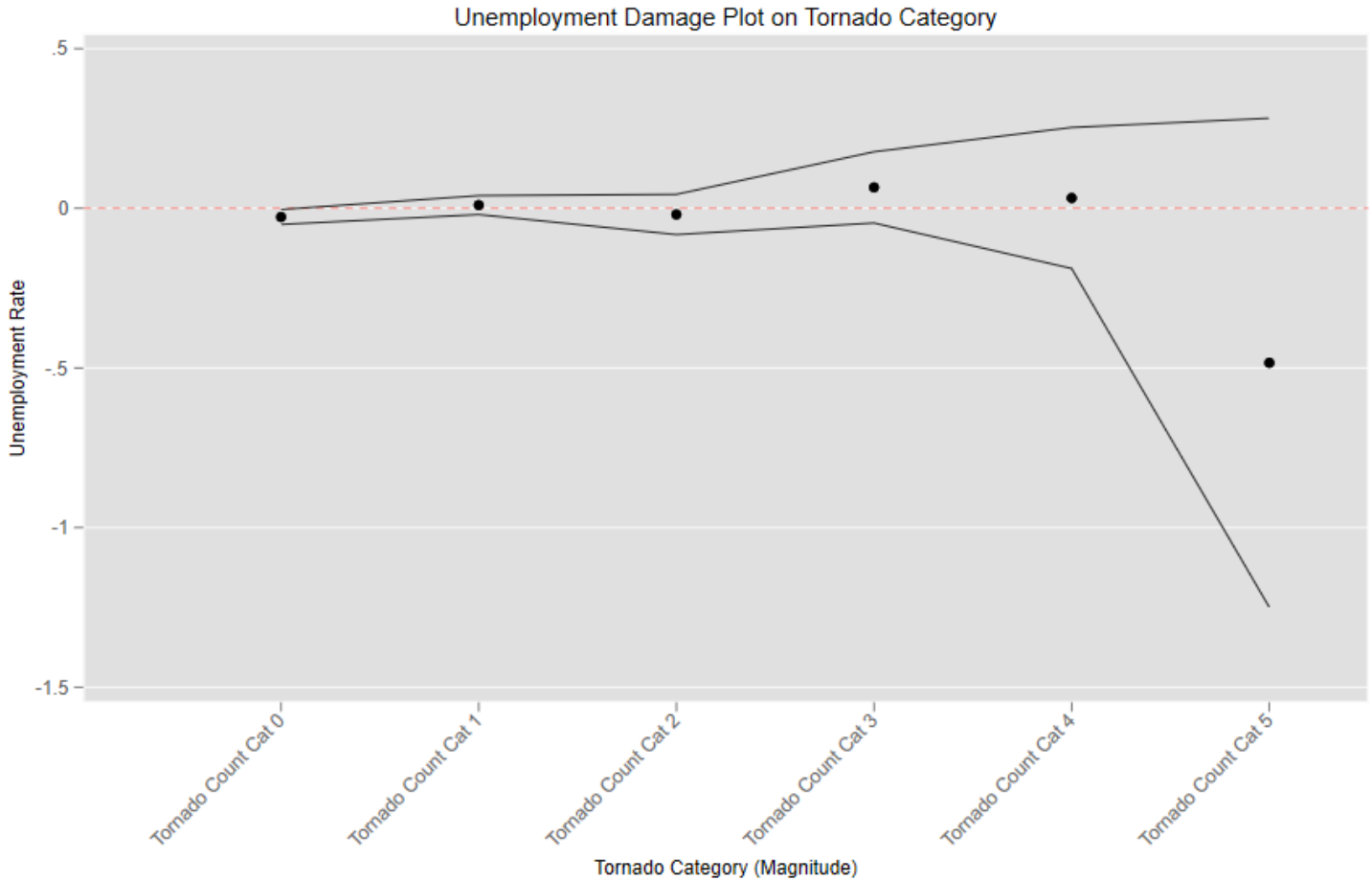






◂ Contemporaneous GDP Difference

Lagged Effect: Unemployment



◂ Contemporaneous Unemployment

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