The Impact of Natural Disasters on Education: Evidence from Standardized Testing

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Motivation: Natural disasters over time

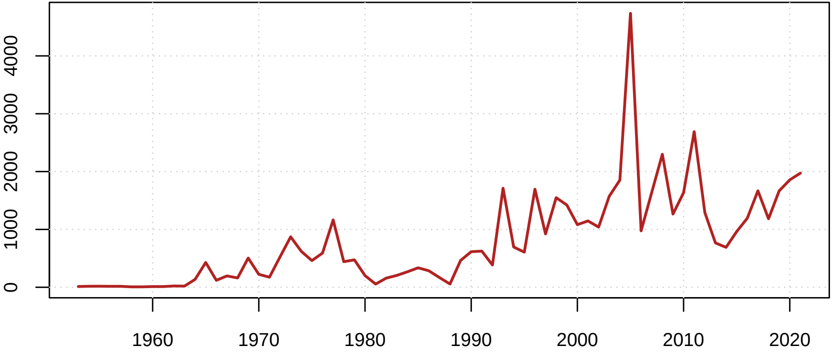

Figure: Number of county-level natural disasters by year

Motivation: Distribution of natural disasters

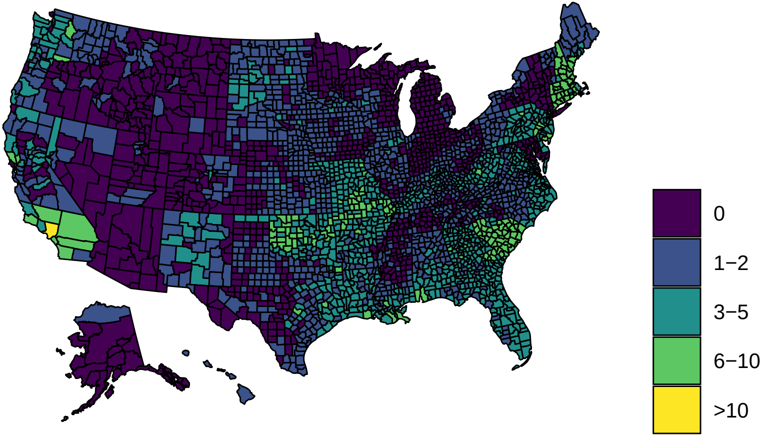

Figure: Number of declared natural disasters in school years 2008-09 through 2017-18

Research question

I exploit quasi-random variation in natural disaster exposure in the United States to answer two questions:

- **What is the causal effect of natural disasters on academic achievement as measured by standardized test scores?**
- What is the role of federal disaster assistance? Which counties apply for assistance?

Why is this important?

Negative effects in education affect earnings potential $\implies$ Inequality in disaster risk exposure could exacerbate economic inequality

Data

- **Natural disasters**:
  - Federal Emergency Management Agency (FEMA) declarations
  - Storms from the National Weather Service (NWS)
  - Daily temperature data from the Global Historical Climatology Network
- **Standardized testing outcomes** from the Stanford Education Data Archive (Reardon et al., 2021):
  - Cohort standardized average scores by county in Mathematics & Reading Language Arts (RLA)
  - Grades 3 through 8 for schoolyears 2008-09 to 2017-18
- **Public Assistance applications and payments** from FEMA

Distribution of mean test scores by subgroup

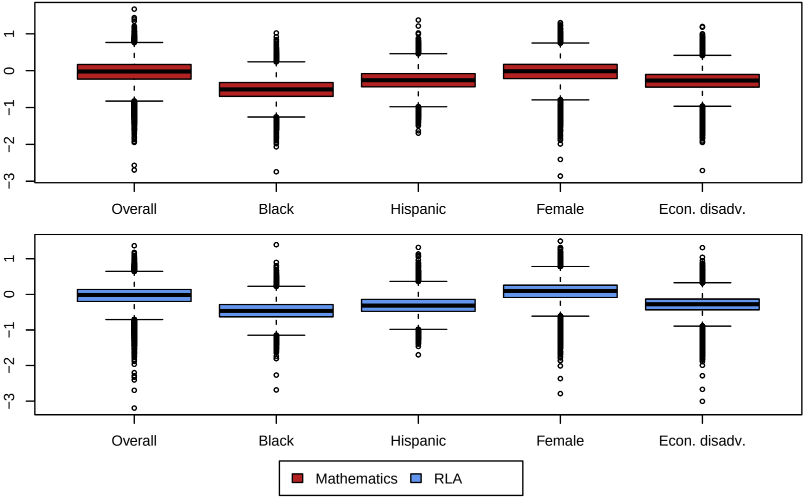

Figure: Boxplots of mean test scores by subgroup

When do counties apply for assistance?

Table: Share of counties that applied for federal assistance following a disaster by disaster type (schoolyears 2016-17 and 2017-18)

	Number of Cases	Applied for Assistance (in %)
Dam/Levee Break	3	0.00
Fire	106	10.38
Flood	85	9.41
Hurricane	1263	23.91
Mud/Landslide	1	0.00
Severe Ice Storm	20	0.00
Severe Storm(s)	154	30.52
Tornado	29	79.31
Total	1661	23.54

Which counties apply for assistance?

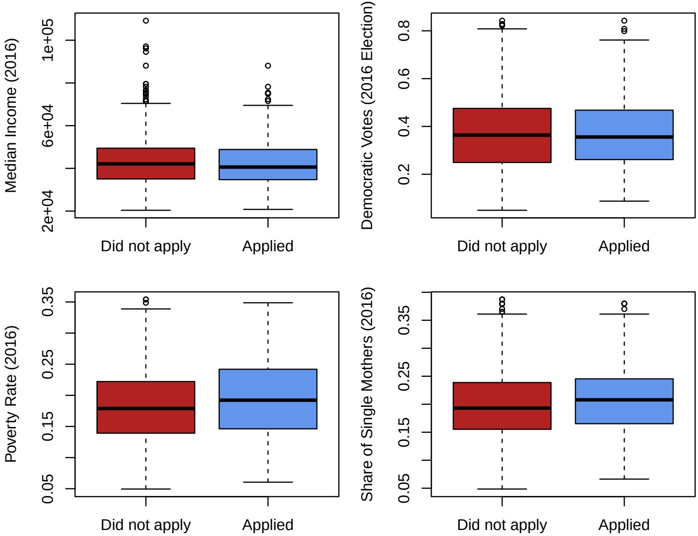

Figure: Boxplots by application status

Empirical Strategy

- Event-study design:

$$y_{i,t,g} = \beta_{-5}\mathbb{1}\{t - E_i \leq 5\} + \sum_{l=-4,\, l\neq -1}^{8} \beta_l \mathbb{1}\{t - E_i = l\}$$
$$+ \alpha_i + \lambda_t + \zeta_g + \varepsilon_{i,t,g}$$

- Treatment begins in the period of first disaster (E_i) and is absorbing (staggered adoption)
- But: Always-treated (i.e. disaster in the first year) counties are dropped
- Never-treated counties act as the baseline
- Standard-errors clustered at the cohort level (Abadie et al., 2017)

Empirical Strategy: Identification

- Natural disasters are plausibly independent of unobserved determinants of test scores conditional on location and year
- Heterogenous treatment effects $\implies$ simple TWFE is inadequate (de Chaisemartin and D'Haultfœuille, 2020; Sun and Abraham, 2021)
- Solution: Interaction-Weighted Estimator (IW) by Sun and Abraham (2021)
- Identifying Assumptions: Parallel Trends & No Anticipatory Behavior
- IW consistently estimates a weighted average of cohort average treatment effects on the treated (CATT)

Main Results: FEMA

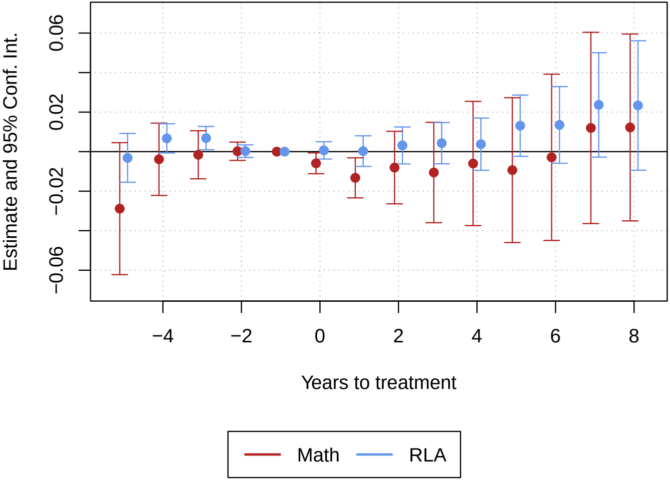

Figure: Dynamic Treatment effects in relative time: FEMA disaster data

Main Results: Subgroups, FEMA

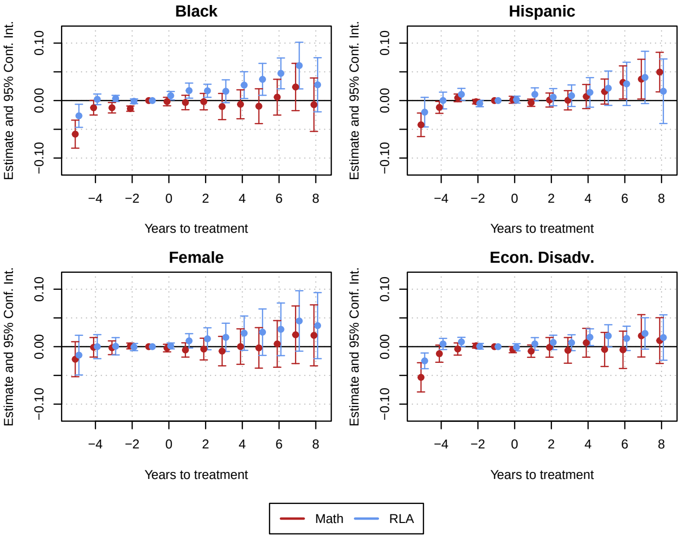

Figure: Dynamic Treatment effects in relative time: FEMA disaster data

Main Results: Storms

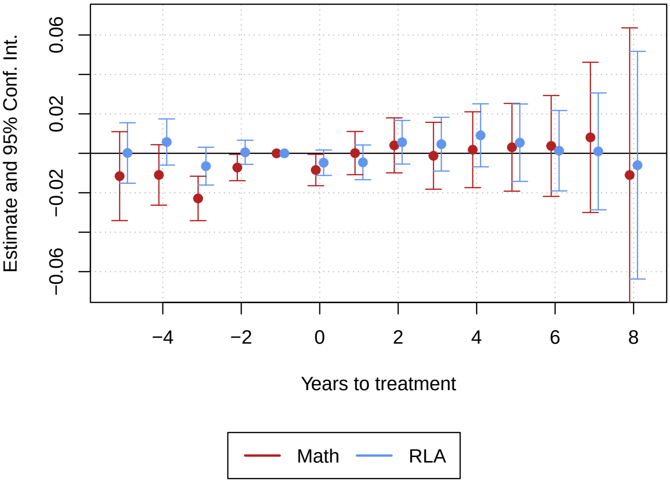

Figure: Dynamic Treatment effects in relative time: NWS storm data

Main Results: Subgroups, Storms

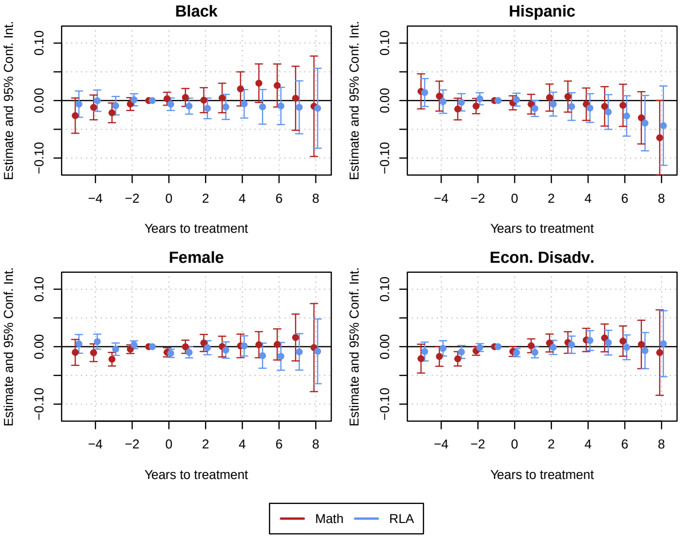

Figure: Dynamic Treatment effects in relative time: NWS storm data

Are these results driven by changes in county composition?

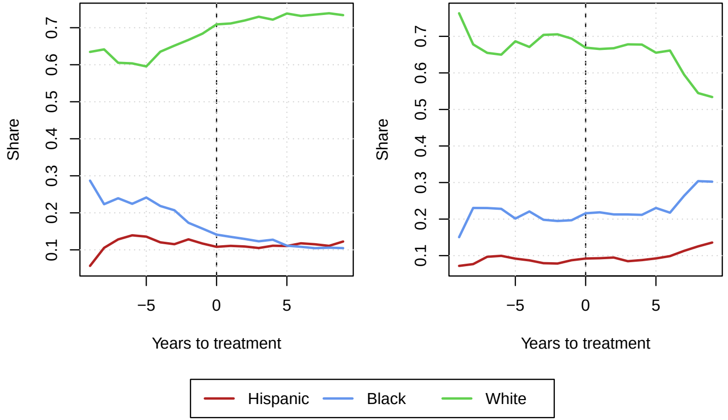

Figure: Aggregated ethnic shares by treatment timing based on FEMA disasters (left) and on NWS storms (right)

Empirical Strategy: Heat

- A binary treatment indicator is not well-suited to measure cumulative heat exposure. Following Park et al. (2020), I use two measures:
  - Average daily maximum temperature
  - Number of days above 30°C
- Linear model with county, year, and grade fixed effects:

$$y_{i,t,g} = \beta H_{i,t} + \alpha_i + \lambda_t + \zeta_g + \varepsilon_{i,t,g}$$

- Conditional on location and year, heat exposure is exogenous
- Interesting marginal interpretation of β: What is the effect of a 1°C hotter school year or of one additional day above 30°C on average test scores?

Heat Results

- No significant overall effect, but minorities seem to be more affected
- Possibly driven by unequal access to air-conditiong (Park et al., 2020)

Table: Estimated coefficients for heat models

	Overall	Black	Hispanic	Female	Econ. Disadv.
Max. Temp. (Math)	-0.0007 (0.0003)	-0.0006 (0.0008)	-0.0021^{***} (0.0006)	-0.001^{***} (0.0004)	-0.0011^{***} (0.0004)
Max. Temp. (RLA)	-0.0001 (0.0003)	-0.0015^{***} (0.0007)	-0.0011^{***} (0.0006)	-0.0002 (0.0003)	-0.0004 (0.0003)
Days ab. 30 (Math)	-0.000169 (0.000089)	0.000033 (0.000143)	-0.000196 (0.000136)	0.000003 (0.000095)	0.000003 (0.000096)
Days ab. 30 (RLA)	-0.000095 (0.000071)	-0.00014 (0.000122)	-0.000483^{***} (0.000117)	-0.000202^{***} (0.000079)	-0.000027 (0.000079)

Note: Standard errors in parentheses. Stars (***) indicate significance at a 5% level

Conclusion

- Negative short-term effect of disasters on achievement in mathematics
- Some positive long-term effects among subgroups (but not very robust)
- Socially vulnerable counties are more likely to need federal assistance following a disaster

References

Abadie, A., Athey, S., Imbens, G. W., and Wooldridge, J. (2017). When should you adjust standard errors for clustering? Technical report, National Bureau of Economic Research.

de Chaisemartin, C. and D'Haultfœuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9):2964–96.

Park, R. J., Behrer, A. P., and Goodman, J. (2020). Learning is inhibited by heat exposure, both internationally and within the united states. *Nature Human Behaviour*, 5(1):19–27.

Reardon, S., Kalogrides, D., Ho, A., Shear, B., Fahle, E., Jang, H., and Chavez, B. (2021). Stanford education data archive (version 4.1).

Sun, L. and Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2):175–199.