

The Impact of Natural Disasters on Academic Performance: Evidence from Standardized Testing

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Abstract

1 Introduction

2 Data

2.1 Natural Disaster Data

Natural disasters are declared as such by the president, usually upon request by the affected state's governor. Once a disaster is federally declared, states or local governments can receive federal assistance. The Federal Emergency Management Agency (FEMA) provides data on all federally declared natural disasters, beginning in 1953. The data is easily accessible via their API ([Turner, 2022](#)).

Figure 1 shows the number of declared disasters since 1953 across the US. It seems that the variation in the number of declared disasters may be driven by the governor's proactiveness in requesting a declaration. Thus, it could be interesting to compare counties on different sides of state borders, whose actual disaster exposure is likely very similar in order to analyze the effect of a declaration.

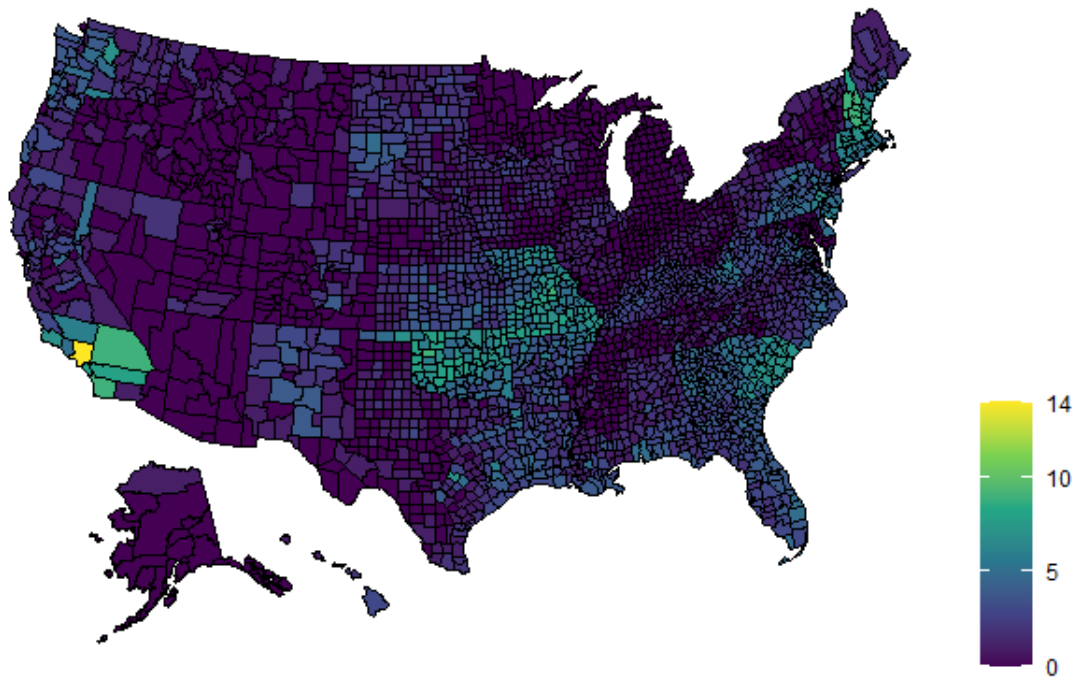


Figure 1: Number of declared natural disasters from 2008 to 2018

FEMA also provides federal disaster assistance data. This includes the amount of damage caused and amount of federal disaster assistance granted. Unfortunately, this data is only available since October 2016. Figure 2 shows the total federal assistance awarded to counties.

2.2 Standardized Testing Data

Data on academic achievement is available from the Stanford Education Data Archive ([Reardon et al., 2021](#)). They provide mean test results from standardized tests by county, year, grade and subject among all students and various subgroups (including race, gender, and economically disadvantaged). The most recent version 4.1 covers grades 3 through 8 in mathematics and Reading Language Arts (RLA) over the 2008-09 through 2017-18 school years.

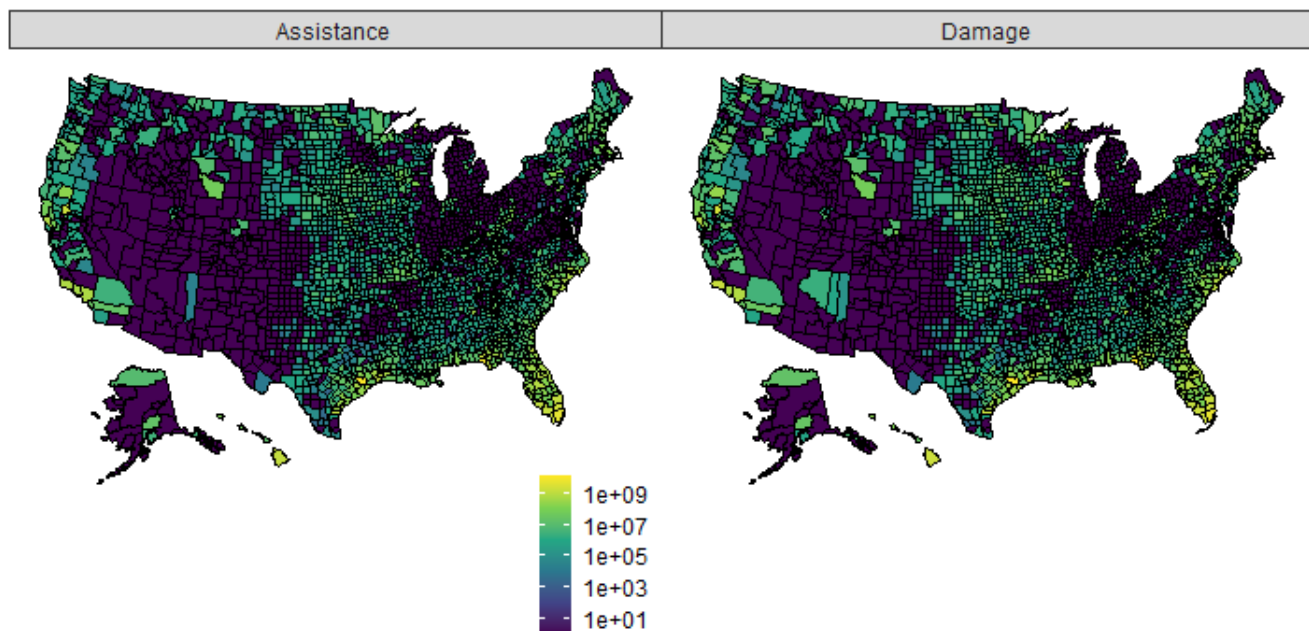


Figure 2: Amount of disaster damage and federal disaster assistance (in USD) awarded to counties since October 2016

Test scores are cohort-standardized, meaning they can be interpreted relatively to an average national reference cohort in the same grade. For instance, a county mean of 0.5 indicates that the average student in the county scored approximately one half of a standard deviation higher than the average national student in the same grade.

In addition to mean test scores, the data includes estimates of gap estimates for various subgroups, e.g. mean difference in test scores among white and black students. These are only reported if the subgroups' sample sizes are large enough. Thus, the number of observations for some of the gap statistics is substantially smaller.

Furthermore, the Stanford Education Data Archive maintains a large set of covariates for each county and year. They include variables like the county's median income, unemployment and ethnic proportions.

2.3 Combining disaster and testing data

Natural disasters should only have an effect on test scores if they occur before the test. Standardized tests are generally administered during spring. We will use March 1st as a cut-off point. Thus, any disaster happening within the same school year before the 1st of March will be considered. School years tend to start in late August or early September with some variation across states. We will use September 1st, meaning any disaster happening between September 1st and March 1st will be counted for a given school year.

Each disaster is assigned to a school year as described above. Then, disaster and test score data can be merged by school year and county. This yields a panel data set with six grades and two subjects for each county-year combination. Table 1 shows summary statistics for all relevant variables

Table 1: Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
Disasters	336415	0.221	0.566	0	0	0	6
Disaster Dummy	336415						
... 0	282581	84%					
... 1	53834	16%					
Cumulative Disasters	336415	1.245	1.631	0	0	2	14
Grade	338349						
... 3	58603	17.3%					
... 4	58501	17.3%					
... 5	57265	16.9%					
... 6	56992	16.8%					
... 7	54392	16.1%					
... 8	52596	15.5%					
Subject	338349						
... Mathematics	165352	48.9%					
... RLA	172997	51.1%					
Mean test score	327358	-0.042	0.294	-3.196	-0.214	0.152	1.669
White-Black gap	130595	0.618	0.257	-0.754	0.454	0.771	2.358
White-Hispanic gap	140326	0.451	0.258	-1.713	0.282	0.611	2.213
Male-Female gap	306055	-0.131	0.199	-1.612	-0.258	0.001	1.248
Disadvantaged gap	282423	0.543	0.211	-0.995	0.413	0.669	2.052
Total Damage	110901	1076549.238	21067263.821	0	0	0	1868575345.74
Federal Assistance	110901	817694.776	17101611.639	0	0	0	1628231852.72
Log Income	338088	10.693	0.253	9.305	10.546	10.834	11.727

3 Empirical Strategy

In order to identify a causal effect, unobservable determinants of a county's mean test score must be unrelated to natural disasters conditional on observable characteristics of that county. The occurrence of natural disasters is plausibly random conditional on location. Furthermore conditioning on the year should account for an increasing trend in natural disasters due to climate change. Thus, independence of mean test scores and natural disasters is plausible conditional on county and year fixed effects.

Consequently, the baseline specification is

$$y_{i,t,g} = \sum_{\tau=-9, \tau \neq -1}^9 \beta_{\tau} D_{i,t-\tau} + \alpha_i + \lambda_t + \zeta_g + X_{i,t} \gamma + \varepsilon_{i,t,g}, \quad (1)$$

where $y_{i,t,g}$ is the outcome of interest for county i , year t , and grade g . County, year, and grade fixed-effects are given by α_i , λ_t , and ζ_g respectively and $X_{i,t}$ is a row vector of additional control variables. $D_{i,t-\tau}$ is a treatment indicator for county i in year $t - \tau$. That is, $D_{i,t-\tau} = 1$ if the county experienced a disaster τ years ago at time t .

Note that treatment must be absorbing, meaning the sequence $(D_{i,t})_{t=1}^T$ must be a non-decreasing sequence of 0s and 1s. In other words, after being treated for the first time a county stays treated. In the present application this means treatment refers to having experienced a disaster rather than experiencing a disaster in that year. This is common practice and does not cause bias due to the conditionally random nature of natural disasters ([Deryugina, 2017](#), see). Thus, this captures the long term effects of having experienced a natural disaster.

It is implausible that the treatment effects are constant in our setting. The extent of disasters varies substantially, and also the level of preparation for such disasters likely displays high variance across counties.

4 Results

Table 2 and 3 show the results of the estimated models for mathematics and RLA respectively. Figure 3 shows the dynamic treatment effects.

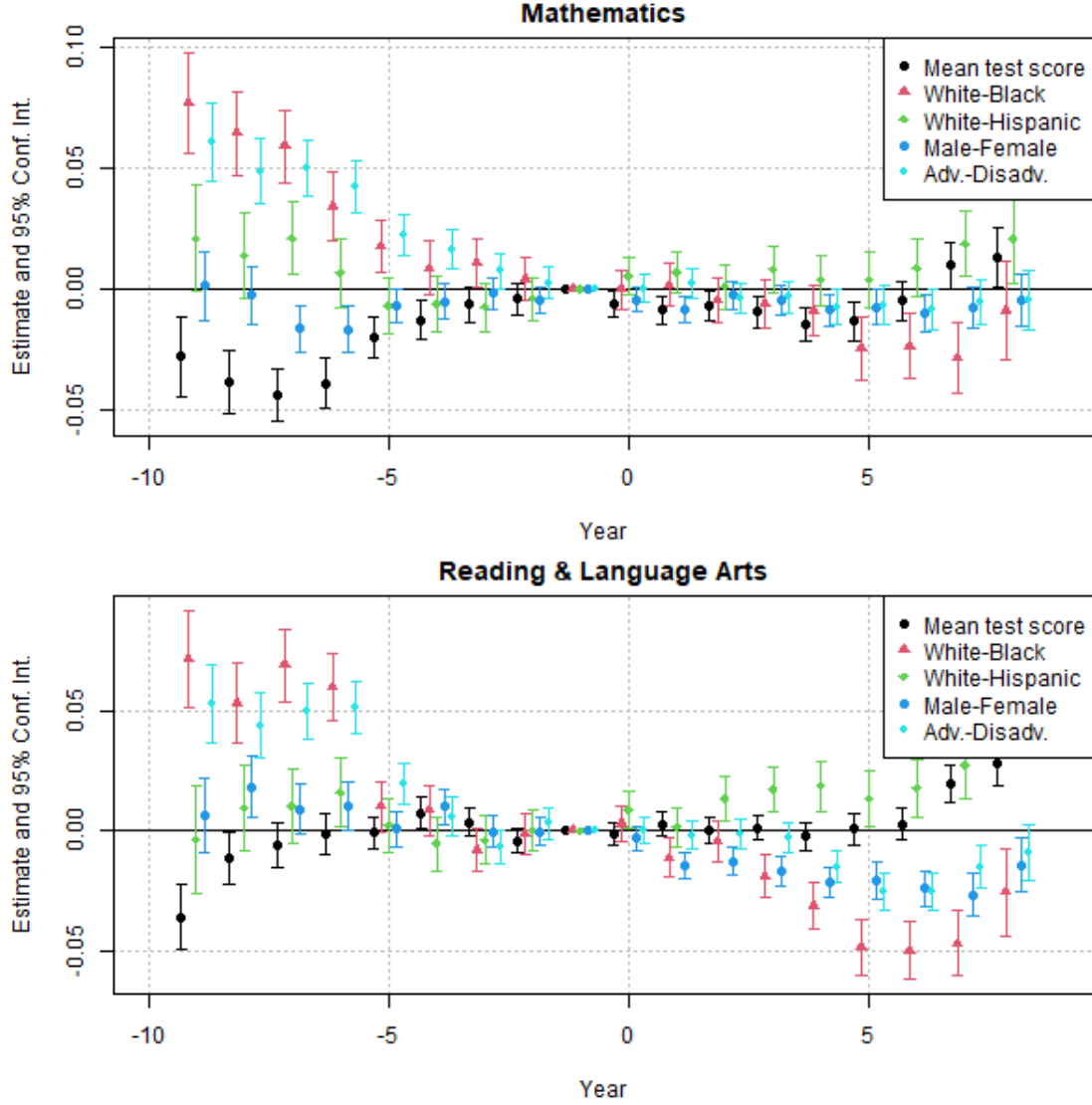


Figure 3: Dynamic Treatment effects by dependent variable and subject

Table 2: Results (Mathematics)

Dependent Variables: Model:	Mean test score (1)	White-Black (2)	White-Hispanic (3)	Male-Female (4)	Adv.-Disadv. (5)
<i>Variables</i>					
Year=-9	-0.0277*** (0.0083)	0.0767*** (0.0105)	0.0211* (0.0111)	0.0015 (0.0073)	0.0608*** (0.0083)
Year=-8	-0.0380*** (0.0066)	0.0644*** (0.0088)	0.0136 (0.0090)	-0.0024 (0.0060)	0.0487*** (0.0067)
Year=-7	-0.0434*** (0.0056)	0.0589*** (0.0077)	0.0211*** (0.0077)	-0.0162*** (0.0050)	0.0499*** (0.0057)
Year=-6	-0.0387*** (0.0053)	0.0343*** (0.0074)	0.0067 (0.0072)	-0.0164*** (0.0049)	0.0421*** (0.0055)
Year=-5	-0.0198*** (0.0041)	0.0176*** (0.0056)	-0.0069 (0.0057)	-0.0067* (0.0037)	0.0223*** (0.0042)
Year=-4	-0.0126*** (0.0041)	0.0088 (0.0056)	-0.0059 (0.0058)	-0.0049 (0.0037)	0.0164*** (0.0042)
Year=-3	-0.0063* (0.0037)	0.0109** (0.0050)	-0.0073 (0.0051)	-0.0017 (0.0032)	0.0075** (0.0037)
Year=-2	-0.0040 (0.0032)	0.0044 (0.0046)	-0.0041 (0.0045)	-0.0045 (0.0029)	0.0027 (0.0032)
Year=0	-0.0061** (0.0028)	-8.67×10^{-5} (0.0041)	0.0055 (0.0039)	-0.0042 (0.0025)	0.0004 (0.0028)
Year=1	-0.0086*** (0.0030)	0.0019 (0.0044)	0.0069 (0.0043)	-0.0084*** (0.0027)	0.0025 (0.0030)
Year=2	-0.0067** (0.0033)	-0.0044 (0.0048)	0.0011 (0.0046)	-0.0023 (0.0029)	-0.0036 (0.0032)
Year=3	-0.0093*** (0.0034)	-0.0061 (0.0050)	0.0083* (0.0048)	-0.0046 (0.0030)	-0.0032 (0.0033)
Year=4	-0.0145*** (0.0037)	-0.0087 (0.0055)	0.0036 (0.0052)	-0.0084*** (0.0033)	-0.0073** (0.0036)
Year=5	-0.0133*** (0.0042)	-0.0244*** (0.0065)	0.0038 (0.0059)	-0.0073** (0.0037)	-0.0066 (0.0041)
Year=6	-0.0049 (0.0042)	-0.0235*** (0.0068)	0.0088 (0.0061)	-0.0099*** (0.0038)	-0.0083** (0.0041)
Year=7	0.0098** (0.0048)	-0.0282*** (0.0075)	0.0189*** (0.0070)	-0.0074* (0.0043)	-0.0051 (0.0047)
Year=8	0.0134** (0.0063)	-0.0086 (0.0104)	0.0209** (0.0092)	-0.0044 (0.0056)	-0.0046 (0.0062)
<i>Fixed-effects</i>					
Year	Yes	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes	Yes
Grade	Yes	Yes	Yes	Yes	Yes
<i>Fit statistics</i>					
Observations	158,110	62,653	68,294	147,998	136,249
R ²	0.72285	0.61365	0.63448	0.21976	0.49781
Within R ²	0.00372	0.00510	0.00208	0.00151	0.00368

IID standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 3: Results (RLA)

Dependent Variables: Model:	Mean test score (1)	White-Black (2)	White-Hispanic (3)	Male-Female (4)	Adv.-Disadv. (5)
<i>Variables</i>					
Year=-9	-0.0359*** (0.0070)	0.0716*** (0.0102)	-0.0037 (0.0114)	0.0061 (0.0079)	0.0530*** (0.0085)
Year=-8	-0.0116** (0.0055)	0.0534*** (0.0086)	0.0094 (0.0092)	0.0183*** (0.0066)	0.0438*** (0.0069)
Year=-7	-0.0060 (0.0046)	0.0690*** (0.0076)	0.0104 (0.0079)	0.0090* (0.0055)	0.0498*** (0.0058)
Year=-6	-0.0013 (0.0044)	0.0598*** (0.0072)	0.0161** (0.0073)	0.0103* (0.0053)	0.0510*** (0.0056)
Year=-5	-0.0007 (0.0034)	0.0101* (0.0053)	0.0022 (0.0058)	0.0006 (0.0039)	0.0195*** (0.0042)
Year=-4	0.0073** (0.0033)	0.0086 (0.0053)	-0.0052 (0.0057)	0.0099*** (0.0038)	0.0058 (0.0041)
Year=-3	0.0036 (0.0029)	-0.0079* (0.0047)	-0.0040 (0.0051)	-0.0005 (0.0034)	-0.0068* (0.0036)
Year=-2	-0.0041 (0.0026)	-0.0014 (0.0043)	0.0001 (0.0045)	-0.0005 (0.0030)	0.0030 (0.0032)
Year=0	-0.0012 (0.0023)	0.0029 (0.0038)	0.0089** (0.0039)	-0.0033 (0.0026)	0.0003 (0.0028)
Year=1	0.0028 (0.0024)	-0.0112*** (0.0041)	0.0014 (0.0043)	-0.0143*** (0.0028)	-0.0018 (0.0030)
Year=2	0.0002 (0.0026)	-0.0045 (0.0044)	0.0134*** (0.0046)	-0.0128*** (0.0030)	-0.0011 (0.0032)
Year=3	0.0013 (0.0027)	-0.0191*** (0.0046)	0.0173*** (0.0048)	-0.0171*** (0.0031)	-0.0030 (0.0033)
Year=4	-0.0024 (0.0029)	-0.0312*** (0.0049)	0.0184*** (0.0052)	-0.0215*** (0.0033)	-0.0150*** (0.0035)
Year=5	0.0006 (0.0033)	-0.0486*** (0.0059)	0.0131** (0.0060)	-0.0207*** (0.0038)	-0.0257*** (0.0040)
Year=6	0.0028 (0.0034)	-0.0500*** (0.0060)	0.0178*** (0.0061)	-0.0242*** (0.0039)	-0.0253*** (0.0040)
Year=7	0.0195*** (0.0039)	-0.0470*** (0.0070)	0.0272*** (0.0070)	-0.0267*** (0.0045)	-0.0150*** (0.0047)
Year=8	0.0284*** (0.0050)	-0.0255*** (0.0092)	0.0513*** (0.0089)	-0.0143** (0.0057)	-0.0089 (0.0059)
<i>Fixed-effects</i>					
Year	Yes	Yes	Yes	Yes	Yes
County	Yes	Yes	Yes	Yes	Yes
Grade	Yes	Yes	Yes	Yes	Yes
<i>Fit statistics</i>					
Observations	169,246	67,940	72,032	158,055	146,172
R ²	0.74481	0.58872	0.61099	0.23741	0.46345
Within R ²	0.00242	0.00951	0.00262	0.00301	0.00506

5 Conclusion

References

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