Analysis of Education Expenditure and 8th Grade Average Math Scores in the United States from 2005-2015

DATS 6101 Introduction to Data Science

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Outline

- Introduction
- Original research question
- Refined research question
- Hypotheses
- Data
- Exploratory data analysis
- Model

Introduction

- Government education spending accounted for 4.989% of 2014 U.S. GDP[1]
- States have been implementing aggressive resource-based policies to improve public education[4]

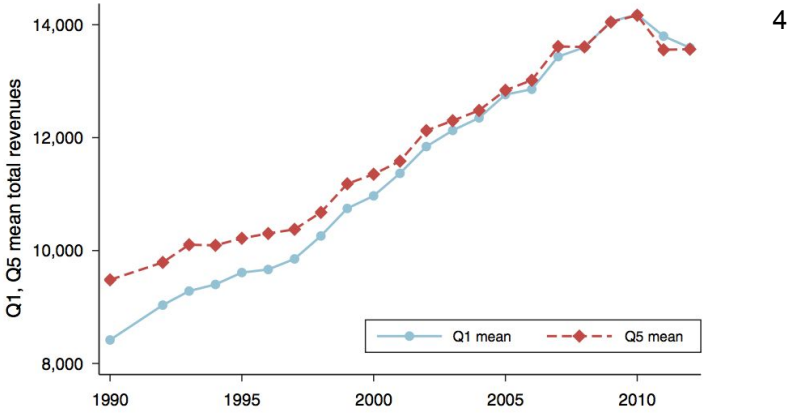

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FIGURE 1. MEAN REVENUES PER PUPIL FOR HIGHEST AND LOWEST INCOME SCHOOL DISTRICTS, 1990–2012

Notes: Highest (lowest) income districts are those in the top (bottom) 20 percent of their states' district-level distributions of mean household income in 1990, and are labeled as "Q5" and "Q1", respectively. See online Appendix for details of quintile classifications. Revenues are expressed in real 2013 dollars. Districts are averaged within states, weighting by log district enrollment; states are then averaged without weights. Hawaii and the District of Columbia are excluded.

Figure from References 4

Introduction

- U.S. behind in science, technology, engineering, and mathematics[2]

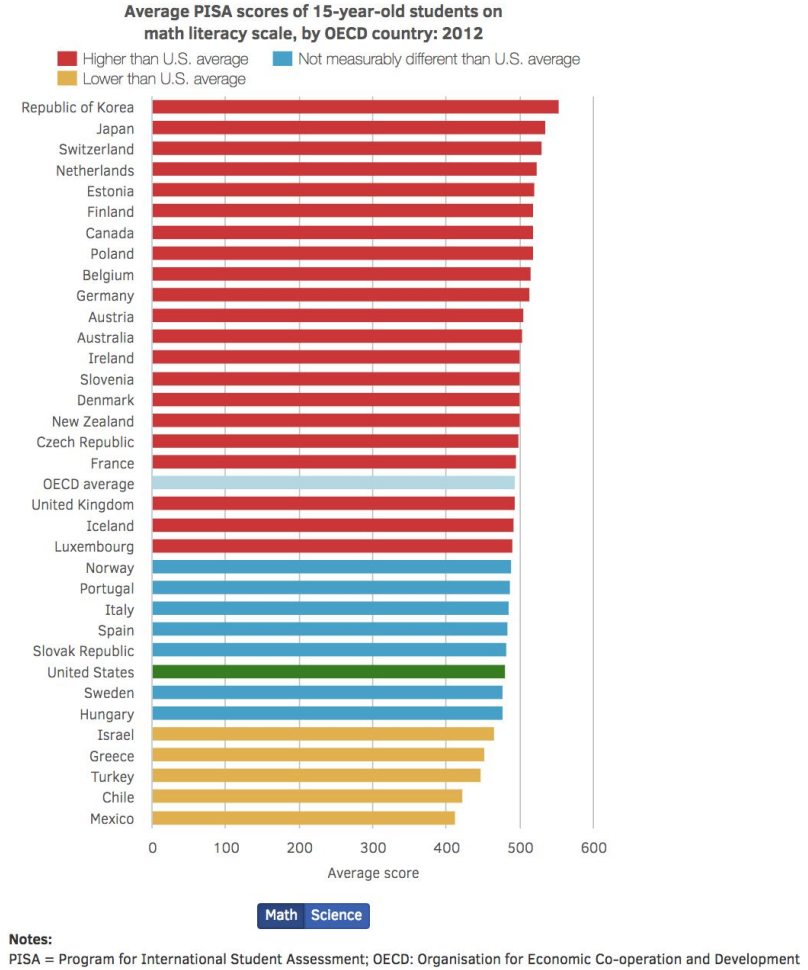


Figure from References 3

Original Research Question

Does education expenditure influence math scores?

Refined Research Question

Is there a statistically significant relationship between education expenditure and 8th grade average math scores in the U.S. from 2005 to 2015?

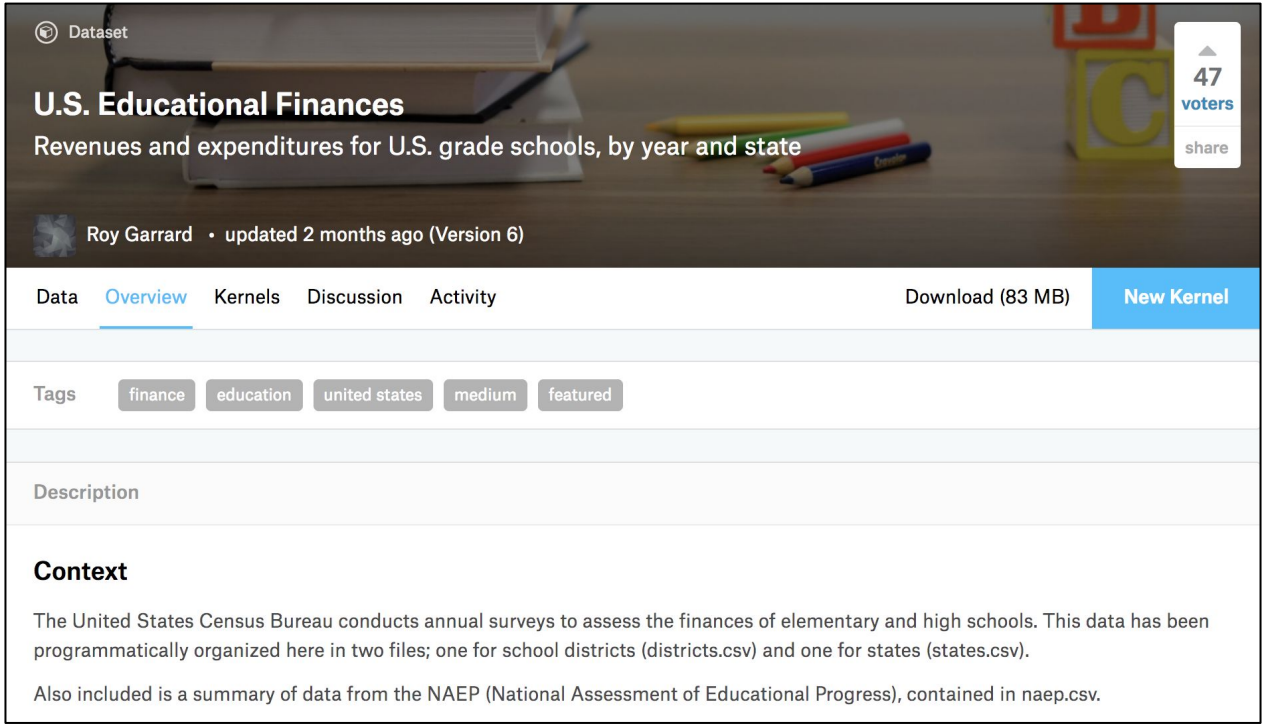
Hypotheses

H_0: There is no statistically significant relationship between education expenditure and 8th grade average math scores in the U.S. from 2005 to 2015. $\beta_1 = 0$.

H_A: There is a statistically significant relationship between education expenditure and 8th grade average math scores in the U.S. from 2005 to 2015. $\beta_1 \neq 0$.

Data Source

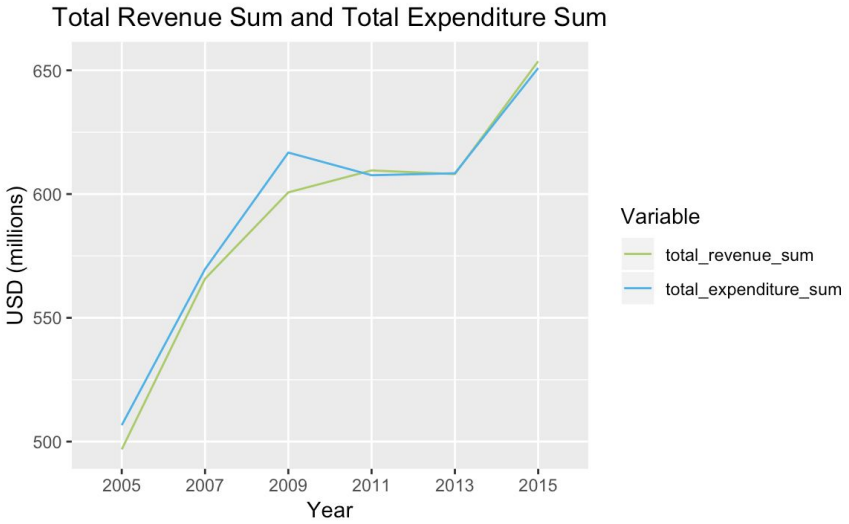
https://www.kaggle.com/noriuk/us-educational-finances/home

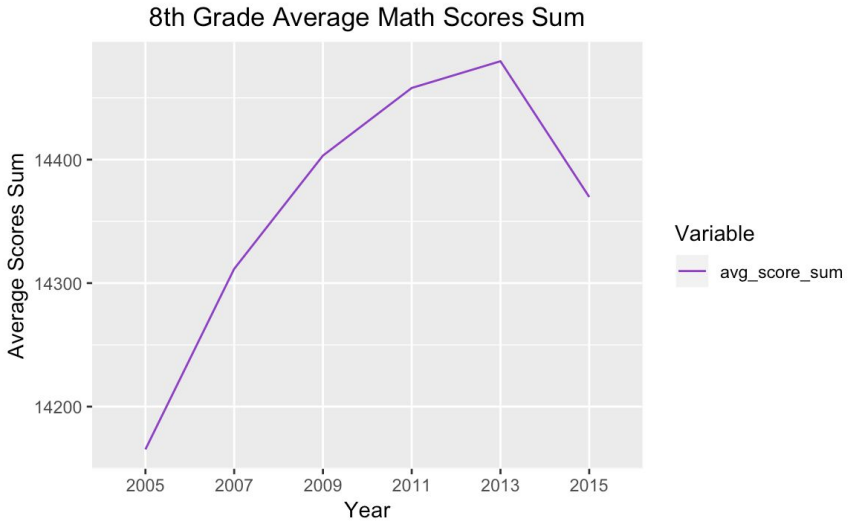


Data Variables

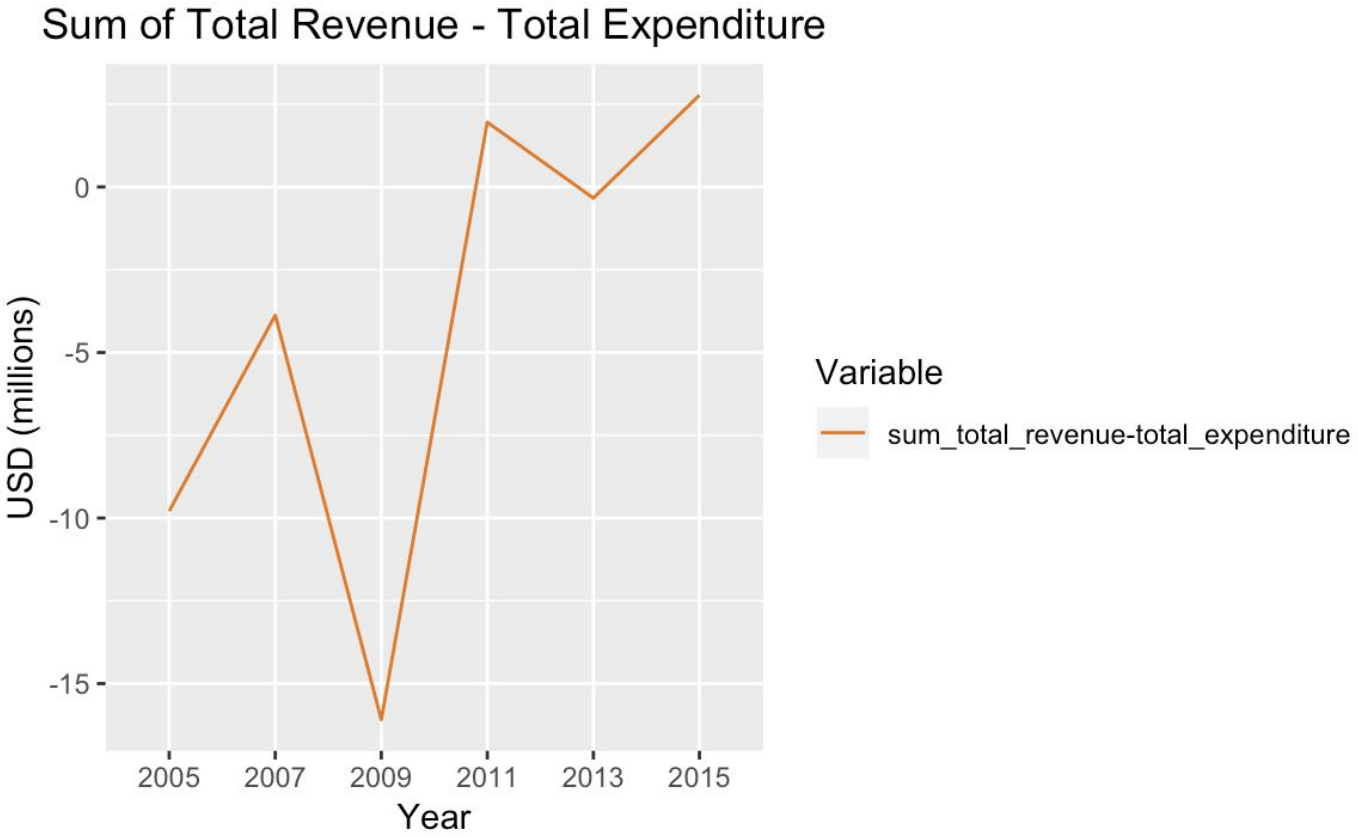
Variable	Data Type	Description
year	factor	2005-2015
state	factor	U.S. states and Washington D.C.
total_revenue	int	education revenue
total_expenditure	int	education expenditure
avg_score	num	average score on National Assessment of Education Progress (NAEP) exam
test_subject	chr	mathematics
test_year	chr	8

Exploratory Data Analysis





Exploratory Data Analysis



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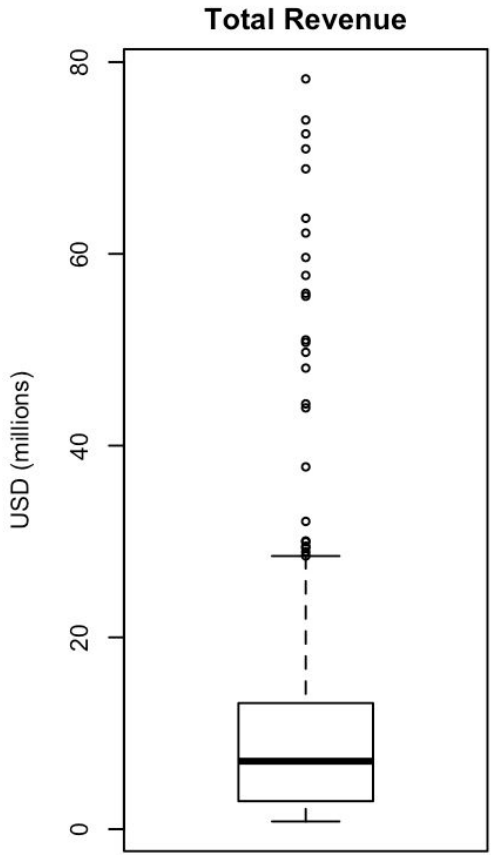

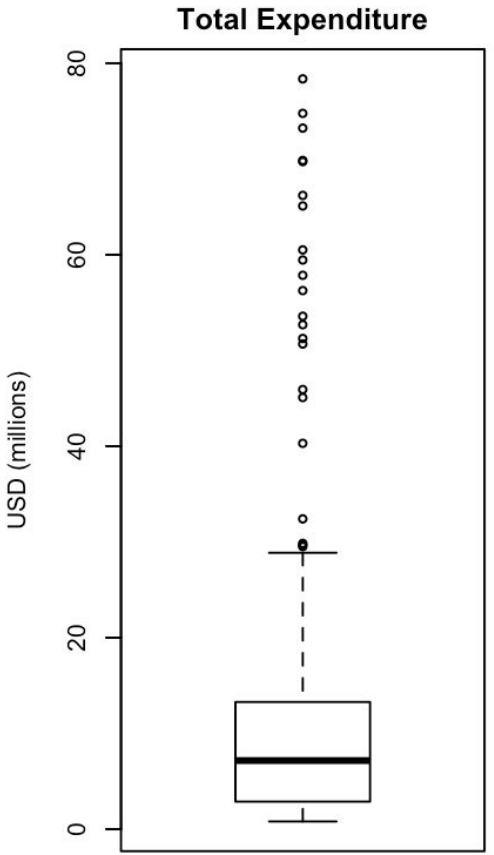

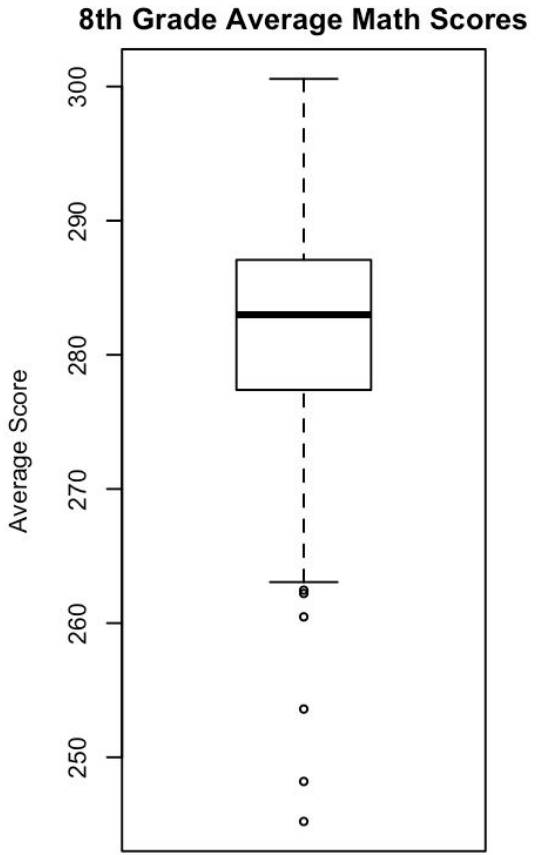

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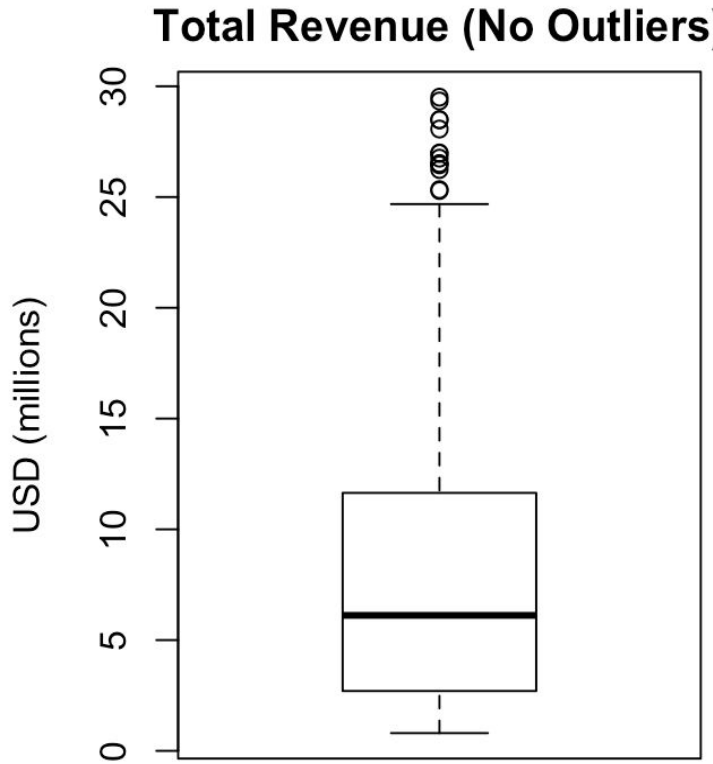

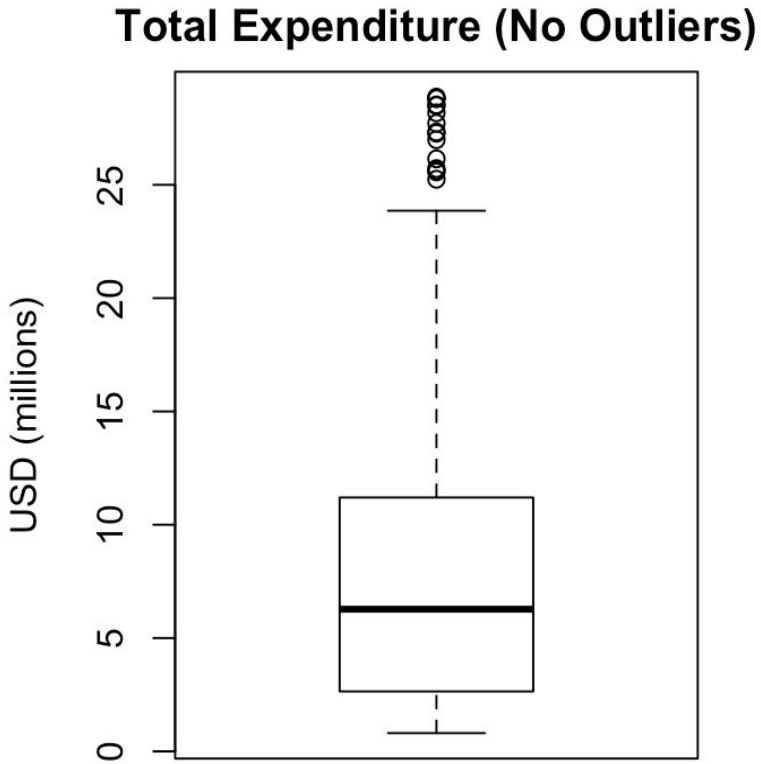

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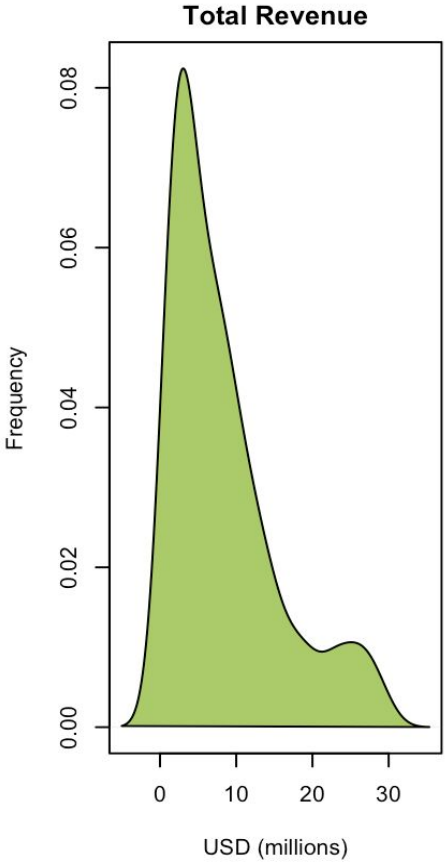
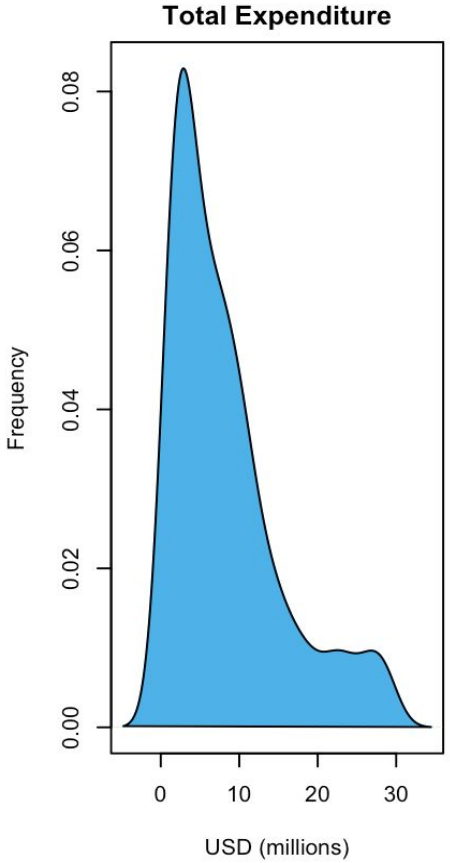
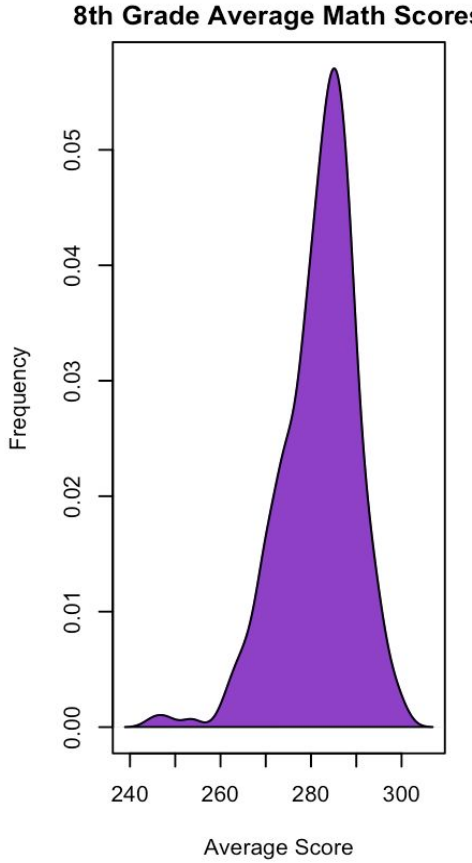


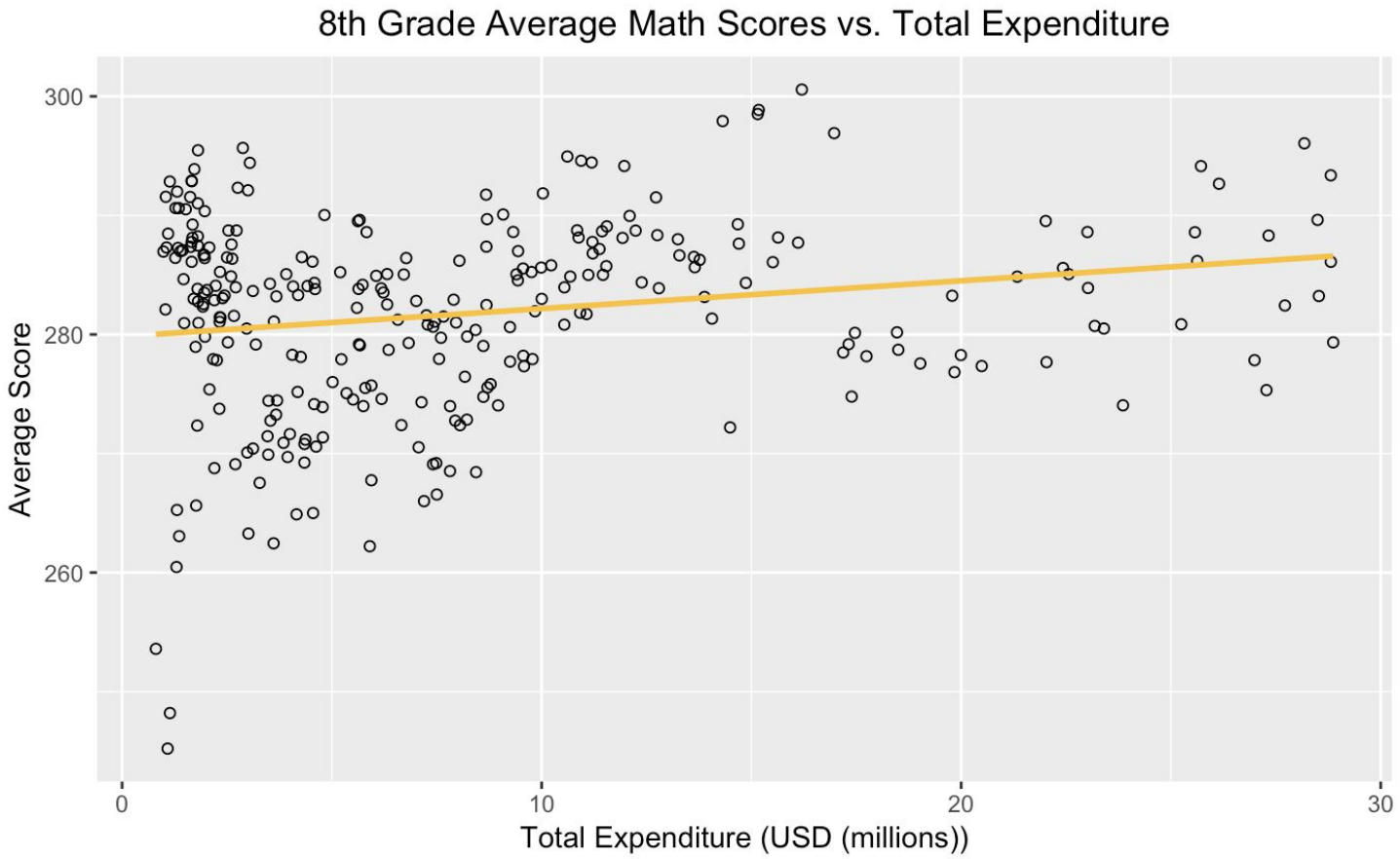




Exploratory Data Analysis

Shapiro-Wilk Normality Test	
Variable	**p-value**
total_revenue	9.49×10^{-16}
total_expenditure	8.94×10^{-16}
avg_score	4.56×10^{-7}

Exploratory Data Analysis

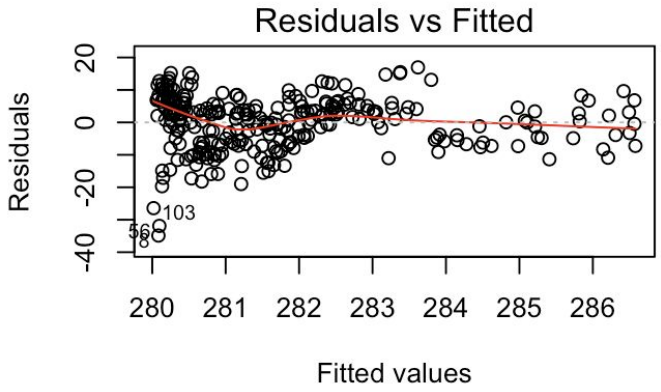


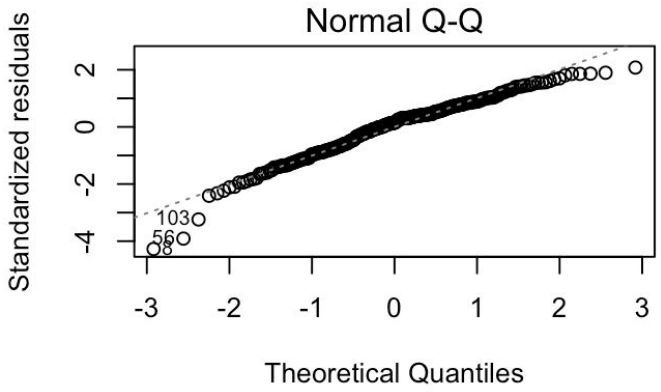
Exploratory Data Analysis

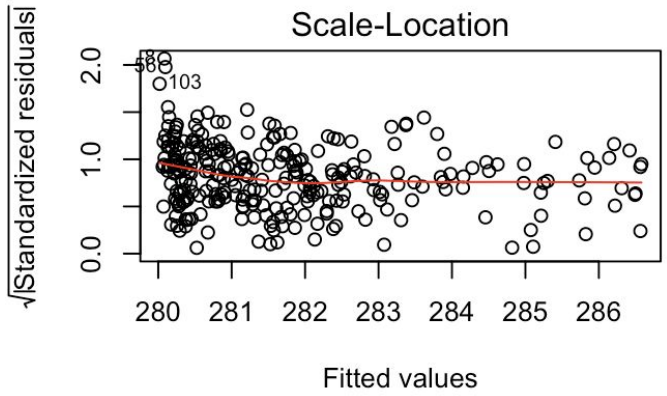
Model

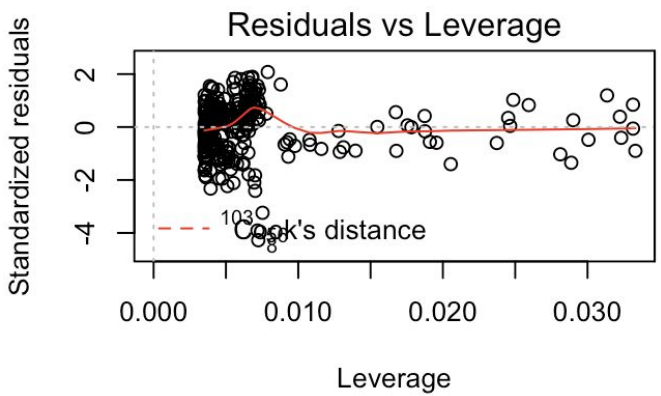
```
Call:
lm(formula = avg_score ~ total_expenditure, data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-34.869  -5.540   1.226   5.563  16.950

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)       279.83050    0.75191 372.161  < 2e-16 ***
total_expenditure   0.23380    0.06883   3.397 0.000781 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.188 on 282 degrees of freedom
Multiple R-squared:  0.0393,    Adjusted R-squared:  0.0359
F-statistic: 11.54 on 1 and 282 DF,  p-value: 0.0007805
```

Model


Residuals vs Fitted
Residuals
Fitted values
103
56
8

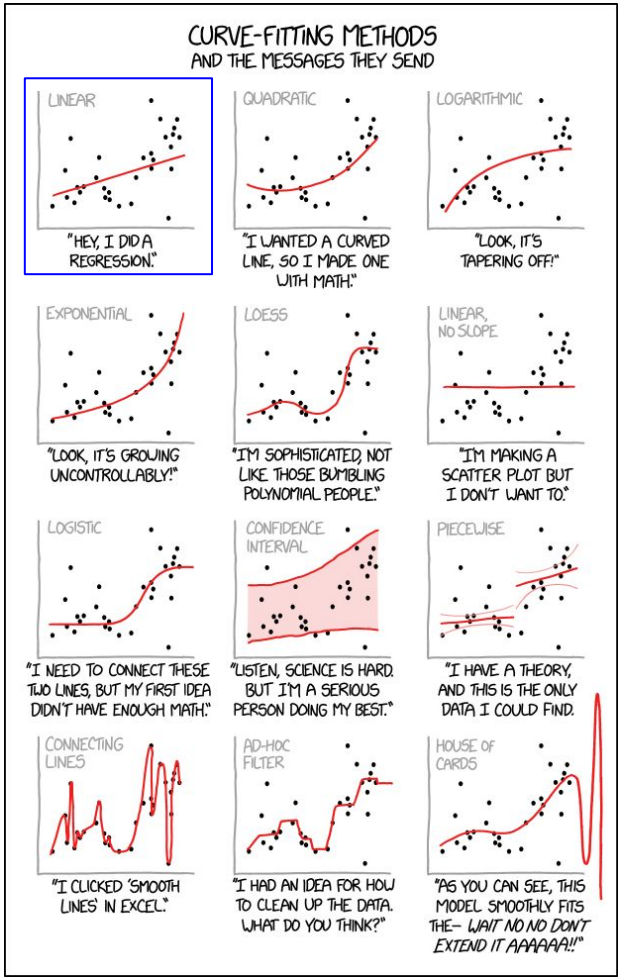

Normal Q-Q
Standardized residuals
Theoretical Quantiles
103
56
8


Scale-Location
√|Standardized residuals|
Fitted values
103
56


Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
103
8

Conclusions

- There is a statistically significant relationship between education expenditure and 8th grade average math scores in the U.S. from 2005 to 2015
- Poor model
- Limitations - entire U.S., one factor
- Improvement - school districts, socioeconomic factors



References

[1]Government Expenditure on Education, Total (% of GDP). (2014). Retrieved from https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?locations=US

[2]Han, S., & Buchmann, C. (2016). Aligning Science Achievement and STEM Expectations for College Success: A Comparative Study of Curricular Standardization. R*SF: The Russell Sage Foundation Journal of the Social Sciences,2*(1), 192-211. doi:10.1353/rus.2016.0001

[3]How do U.S. 15-year-olds Compare with Students from Other Countries in Math and Science? (2012). Retrieved from https://nsf.gov/nsb/sei/edTool/data/highschool-08.html

[4]Lafortune, J., Rothstein, J., & Schanzenbach, D. W. (2018). School Finance Reform and the Distribution of Student Achievement. *American Economic Journal: Applied Economics,10*(2), 1-26. doi:10.3386/w22011