Unequal Access: How Public Library Closures Affect Educational Performance

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Abstract

Educational disparities among children in the United States persist, and local public institutions, such as libraries, have been shown to mitigate these differences. However, in the U.S. over 700 public library branches closed between 2008 and 2019, potentially exacerbating inequalities. This paper analyzes the impact of public library closures on children's educational outcomes. Using geo-located data and an event study approach, we find that test scores declined in school districts that experienced closures. The effect is concentrated in suburban areas, where reading test scores decreased by 0.02 and math test scores by 0.04 standard deviations. The impact is especially pronounced for Black and Hispanic students, as well as students from economically disadvantaged backgrounds.

Keywords: Public libraries, education, event study, inequality

JEL Codes: I24, H52, C33

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1 Introduction

Educational inequality is still persistent in the U.S. school system leading to substantial gaps in educational outcomes for different groups of children (Blanden et al., 2023; Card & Rothstein, 2007; Reardon et al., 2019). These disparities not only contribute to heightened inequality in terms of higher education and lifetime income but also give rise to other negative consequences, such as higher crime rates and lower civic participation (Deming, 2011; Lochner, 2011, 2020; Rumberger, 2010). A potential measure to offset this development is the presence and support of local public and community institutions—social solutions (Saez, 2021). In the U.S., public libraries are particularly important given their focus on children's programs and collections. They are essential social infrastructure and offer one of the few free indoor spaces open to everyone and are, thus, potentially an important resource to mitigate inequalities (Klinenberg, 2019).

This paper studies the loss of these public spaces and the impact on their communities: specifically, we investigate how public library closures influence public library operations and students' educational performance in the United States. Our main outcomes of interest are public school test scores of students between the ages of 8 to 14—grades 3 to 8—from 2009 to 2018. For this, we combine the Public Library Survey (PLS) by the Institute of Museum and Library Services (IMLS) and the Educational Opportunity Project at Stanford University (SEDA) dataset with several other data sources. Using library closures within a two-mile radius of school districts as treatment shocks, we identify a causal connection between library closures and educational outcomes: a closure leads to a statistically and economically significant decline in average reading (math) test scores of around 0.01 (0.02) standard deviations overall. The effect is driven entirely by suburban regions, where a library closure leads to a reduction in reading (math) test scores of 0.02 (0.04) standard deviations.

A public library closure in a school district provides a promising setting to investigate the impact of public libraries on different communities in the United States. These closures, caused by a myriad of reasons, can be considered quasi-random events, allowing us to identify their effects, assuming that school districts would otherwise develop similarly. We show that school district and community characteristics are particularly stable in suburban regions. When a library closes, a school district experiences the loss of public space and its associated resources. Thus, these closures—occurring at different times—offer quasi-experimental variation in public library availability, which we use to identify a causal effect.

The effect of library closures in the U.S. exhibits notable geographic differences. Rural areas, where residents often travel longer distances to access public amenities, rarely experience closures, while urban and metropolitan areas see such events far more frequently. The geospatial impact of closures also varies; while closures in metropolitan regions may be less concerning due to low switching costs as the proximity to the next public library is quite small, urban areas are particularly impacted. Urban regions often lack reliable public transportation, making access to the remaining branches more difficult. Also, urban areas typically have fewer library branches per square mile, and the closure of one can disproportionately affect certain populations within these regions. Given the importance of accessibility, these closures can profoundly impact local communities, exacerbating inequalities in educational resources and opportunities.

These impacts are particularly salient for children. The average children's collection stock of a library is 31 percent (IMLS, 2024). A public library closure not only causes the loss of access to books, but also the loss of study space, the opportunity to interact with librarians, access to the internet, computers, and library programs such as homework help. Out of all library programming, 67 percent are geared toward children.

We explore heterogeneous effects for different students, school districts, and libraries. Black and Hispanic students suffer the most from library closures, as their test scores drop two- and threefold, respectively, compared to their White peers. Economically disadvantaged students experience a large drop in math test scores, while there are no effects for those who are not disadvantaged. The results are similar, splitting the sample by neighborhood poverty. Juxtaposing economic status and neighborhood poverty, it becomes apparent that those who use libraries more frequently—high-income families—and those who benefit most from library resources—low-income families—are impacted the most. The effect is driven by closures of physical libraries in school district with a small number of library branches.

This paper contributes to the existing economics literature on libraries. It is most closely related to Gilpin et al. (2024), who find that an additional $200 per child investment in public libraries increases reading test scores by 0.02 standard deviations. The effects are mainly driven by White and Asian students' improved test scores. We expand on the existing literature in two ways: looking at the nationwide effects of library closures allows us (i) to study the loss of public resources, potentially leading to larger effects than expansions, and offers (ii) a clean identification strategy increasing the internal validity of existing research. These points enables us to provide a deeper understanding of the multifaceted nature of educational disparities, emphasizing the role of accessible public resources such as libraries.

The remainder of this paper is structured as follows: In section 2, we describe the U.S. public library system. Section 3 introduces the data on public libraries in the U.S. and educational outcomes. Next, we discuss our empirical strategy and argue why library closures identify the effect in section 4. Section 5 presents the overall results, followed by closer insights into effects on urban areas in section 6. Here we discuss different robustness checks and provide insights into various heterogeneities. Finally, section 7 concludes and offers some policy recommendations.

2 Background and Literature: Public Libraries in the U.S.

The public library system in the United States plays a crucial role in providing free access to information, resources, and services to communities across the nation. Established in the mid-19th century, public libraries have evolved to become vital centers for education, technology access, community engagement, and lifelong learning (Klinenberg, 2019). In 1854, public libraries made their debut in Boston, aiming to provide free access to books and educational resources to the public. The movement gained momentum with philanthropists like Andrew Carnegie, who funded the construction of over

1,600 public libraries across the country in the late 19th and early 20th century (Berkes & Nencka, 2024). These libraries formed the foundation for the expansive network of public libraries seen today.

Public libraries are typically funded through a combination of local government allocations, state funds, federal grants, and private donations (American Library Association, 2019). However, most of their funding comes from local taxes, specifically through property taxes. Libraries are governed by library boards or commissions, which ensure that libraries meet the needs of their communities. On the national level, the American Library Association and Public Library Association play significant roles in advocating for libraries, providing guidelines, and supporting library professionals.

Modern public libraries offer a wide array of services beyond book lending. They provide internet access, digital literacy training, and access to e-books and online databases. Libraries host programs for all ages, including storytimes for children, homework help for students, and continuing education classes for adults. Additionally, libraries often serve as community centers, offering meeting spaces, cultural events, and resources for job seekers and business owners.

Library closures, often due to budget cuts, natural disasters, or reasons that we discuss in section 4, profoundly affect the communities they service. They limit access to essential resources, particularly for underserved populations who rely on libraries for internet access, educational support, and safe communal spaces. A survey by the Pew Research Center reveals that Hispanics, parents, and women are specifically worried about public library closures (Horrigan, 2015).

Public library closures are particularly concerning in urban areas as there are significant differences in accessibility and transportation costs across metropolitan, (sub)urban, and rural areas. Public library branch density is highest in metro areas at 0.27 branches per square mile, compared to 0.07 in suburban and 0.01 in rural areas; this equates to a travel distance of 1-2 miles between branches in metropolitan areas, 4-5 miles in suburban areas, and 10-20 miles in rural areas (Donnelly, 2015). These disparities suggest that branch closures would impact suburban and rural areas more, where distances are greater and transportation costs are higher. However, rural libraries often mitigate these challenges with bookmobiles and shared services, potentially reducing the impact of closures (IMLS, 2024). In metropolitan areas, 83 percent of residents have access to public transportation, compared to 60 to 70 percent in suburban areas and 10 to 20 percent in rural areas (Bureau of Transportation Statistics, 2023). The frequency of service and routes is especially limited in suburban and rural regions (Puentes & Roberto, 2008).

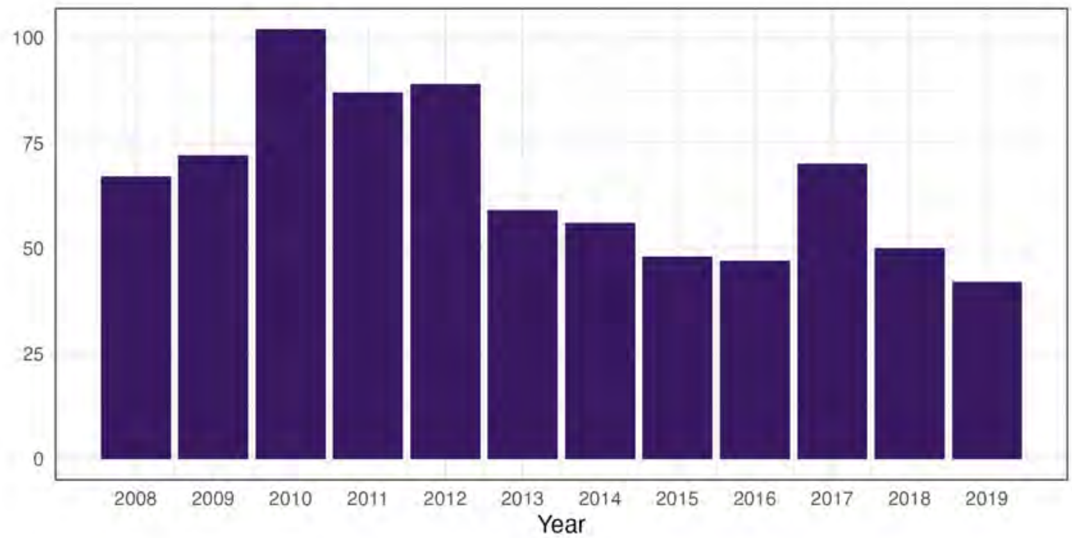
Gilpin and Bekkerman (2020) show that increased distance from a library reduces students' library usage. Bhatt (2010) also finds that libraries increase the amount of time children spend reading, reduce children's television consumption, and increase homework completion rates. Though, libraries are not only important for children but also for communities as a whole: their programming for adults increases labor force participation (Ferreira Neto, 2023). Porter (2015) finds that public libraries' extended opening hours in Los Angeles reduced crime rates. Economic historians find that the expansion of public libraries in the U.S. was largely driven by urbanization and a diverse migrant population and highlight these public spaces' importance for non-white communities (Kevane & Sundstrom, 2014). Aside from economics, there is a large literature on libraries and social capital in the information and library sciences (Aabø, 2005; Ferguson, 2012; Johnson, 2010; Vårheim et al., 2008; Wojciechowska, 2020). A systematic literature review by Stenstrom et al. (2019) stresses the public libraries' significance for vulnerable populations and community development.

3 Data on Public Libraries and Education

We combine multiple data sources in this project. Information on libraries comes from the Institute of Museum and Library Services' Public Libraries Survey (PLS, Pelczar et al., 2023), for the educational outcomes we use the Educational Opportunity Project at Stanford University (SEDA, Reardon et al., 2023) which includes control variables from the American Community Survey (ACS). To control for public school funding, we use data from the National Center for Education Statistics (NCES, Common Core of Data, 2019). We also use school district shapefiles from the NCES to define the treatment status (Geverdt, 2019). Data from the U.S. Department for Agriculture (USDA, Economic Research Service, 2013) allows us to differentiate between metro, urban, and rural areas.

The Public Libraries Survey (PLS, Pelczar et al., 2023) offers data on the near-universe of public libraries in the United States with a response rate of around 97 percent. It contains rich information on finances and usage, as well as openings and closures of libraries and their branches. Our library sample covers the years 2008 to 2019, including on average 8,972 public libraries per year in 49 states[1], reporting 765 library closures, which we discuss in more detail below. Figure 1 shows yearly closures from 2008 to 2019.

Figure 1: Library Branch Openings and Closures between 2008 and 2019



Notes: Figure 1 shows the number of library branch openings and closures between 2008 and 2019. *Source*: own calculations, data: Public Library Survey (PLS).

The PLS comprises all kinds of library outlets—allowing us to differentiate physical library outlets, that provide public space and other library services, and non-physical library outlets, like bookmobile or books-by-mail, that solely give access to books. Table

[1] We include all states except Alaska and Hawaii, Puerto Rico, and other U.S. territories.

1 shows the different kinds of library outlets and their number of closures by urbanicity as defined by the USDA (Economic Research Service, 2013). We will also use variables on library outcomes such as library visits, circulation, programming, and finances to illustrate how closures affect public libraries themselves as well as to explore some heterogeneities in the impact on childrens' test scores.

Table 1: Library Closures between 2008 and 2019 by Urbanicity

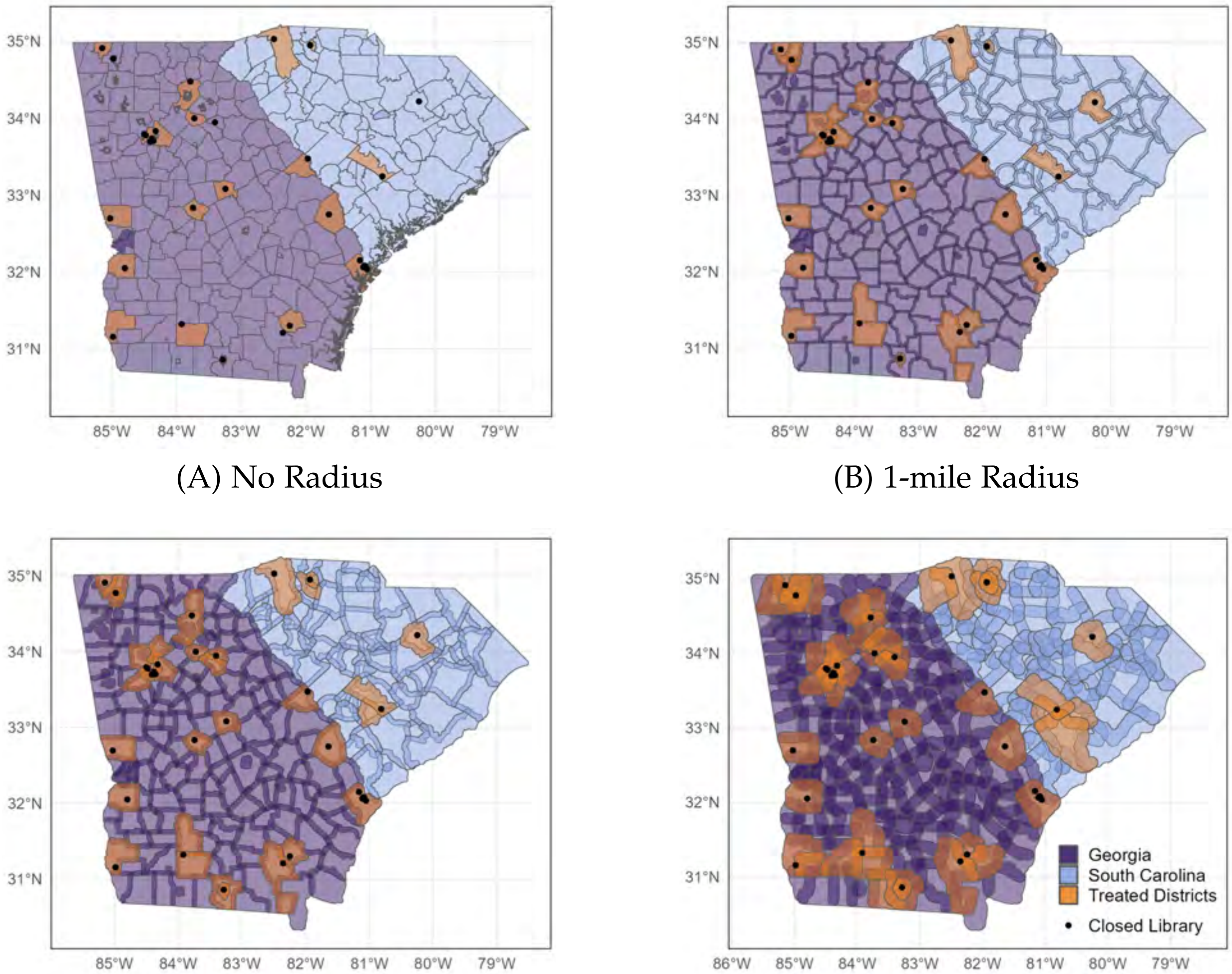
	Total Number of Closures			
Library Outlet	All	Metro	Urban	Rural
Physical Library Branch	539	339	138	62
Non-Physical Library Branch	226	149	65	12
All Closures	765	488	203	74

Notes: Table 1 shows the number of closures between 2008 and 2019 by urbanicity and kind of library outlet. *Source*: own calculations, data: Public Library Survey (PLS) and U.S. Department of Agriculture (USDA).

We use school district shapefiles from the NCES (Geverdt, 2019) to identify treated districts. Since the PLS offers the exact geo-location of each library unit, we link closed library branches to school districts. Individuals might not necessarily live in the school district where they attend school, and they can move freely between school districts. Therefore, we consider the first library closure within two miles of the school district as the treatment in our preferred specification. Most school districts only experience one closure, which makes multiple treatments less worrisome. A histogram of closures can be found in Figure B1 in the Appendix. We vary this definition of treatment to illustrate the robustness of our results.

Figure 2 shows a map of South Carolina and Georgia indicating library closures and the school districts' treatment status using a radius from zero to 5 five miles. By definition, if we expand the radius, more districts count as treated. This will allow us to show the role of distance and accessibility for our results. We do not allow this radius to cross state borders, since out-of-state library visits might be expensive, with a library card from another state costing between 50 and 100 dollars.

Figure 2: Treatment Definition in South Carolina and Georgia



(A) No Radius (B) 1-mile Radius

(C) 2-mile Radius (D) 5-mile Radius

Notes: Figure 2 shows the treatment definition considering closures between 0 and 5 miles from the school district. Closures in other states are not considered. *Source*: own calculations, data: Public Library Survey (PLS) and National Center for Education Statistics (NCES).

We then connect the information on public libraries with the educational outcome data, which are provided by the Educational Opportunity Project at Stanford University (SEDA, Reardon et al., 2023). Federal law in the U.S. requires schools to perform yearly, standardized tests for math and Reading Language and Arts (RLA or reading from here on) from grades 3 through 8. U.S. states can design these tests following their own standards. The U.S. Department of Education collects these data and SEDA makes them comparable across states and years.[2] The standardized test scores are cen-

[2]For more details see the documentation of the SEDA 4.1 data.

tered around 0 with a standard deviation of one, so our results will be interpreted as changes of a standard deviation. The data are available for the school years 2008/09 to 2017/18. These cohort-standardized test scores for each school district and each grade, respectively for math and reading, are our main outcome variables.

Table 2: Summary Statistics for Balanced Panel

	Mean	Median	Min	Max	S.D.
SEDA Test Scores					
Math Score	0.02	0.02	-3.74	2.32	0.10
Reading Score	0.01	0.02	-1.83	2.56	0.10
Public Libraries					
Number of Libraries	1.90	1.00	1.00	60.00	2.50
Library Visits (per 1,000)	186.53	56.23	0.00	10,894.77	519.88
Circulation (per 1,000)	300.76	69.23	0.00	18,357.62	992.50
Kids' Circulation (per 1,000)	106.49	22.19	0.00	7,480.70	362.92
Library Programs	583.87	231.00	0.00	36,133.00	1530.38
Kids' Library Programs	338.97	140.00	0.00	19,883.00	794.19
Kids' Program Attendance	9.38	3.00	0.00	597.22	24.53
Total Staff	18.56	6.00	0.00	900.06	48.03
Librarians	6.60	2.75	0.00	486.60	16.07
Total Op. Expenditure	1,356.00	330.49	0.00	99,110.83	4,254.26
School District Characteristics					
Number of Students	1,786	609	1	161,307	5,278
Log School Funding per Student	10.41	10.29	7.48	15.31	0.48
Share Black Students (in %)	10.69	2.23	0.00	100.00	19.14
Share Hispanic Students (in %)	12.23	4.51	0.00	100.00	19.02
Share ECD Students (in %)	51.86	51.99	0.18	100.00	21.30
Community Characteristics					
Unemployment Rate (in %)	7.36	7.06	0.05	29.30	2.71
Share Single Mothers (in %)	15.97	14.87	0.32	61.55	6.30
Share SNAP Recipients (in %)	11.77	10.95	0.06	51.16	6.37
Share BA or Higher (in %)	20.99	17.75	0.09	88.88	11.43

Notes: Table 2 shows a 5-number summary for the balanced panel between 2009 and 2018. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

SEDA includes a wide range of control variables from the racial composition of each grade to socio-demographic information on the school district-level. In 2018, there were 18,274 school districts on the United States mainland. SEDA offers data for 12,838 school districts, which we restrict in our main specification to a balanced panel between

2009 and 2018, meaning we only consider school districts where we have either reading or math test scores for all ten years. The final sample has 563,070 school district-grade-year observations in 5,919 school districts. Summary statistics for our main variables are in Table 2. Table A1 in the Appendix displays the sample means for the same variables by metro, urban, and rural areas.

4 Methodology and Identification

We use public library closures as treatment shocks to identify the effect of library access on test scores. Libraries are closed at different points in time across different school districts. To account for this staggered treatment, we estimate an event study model using Sun and Abraham (2021):

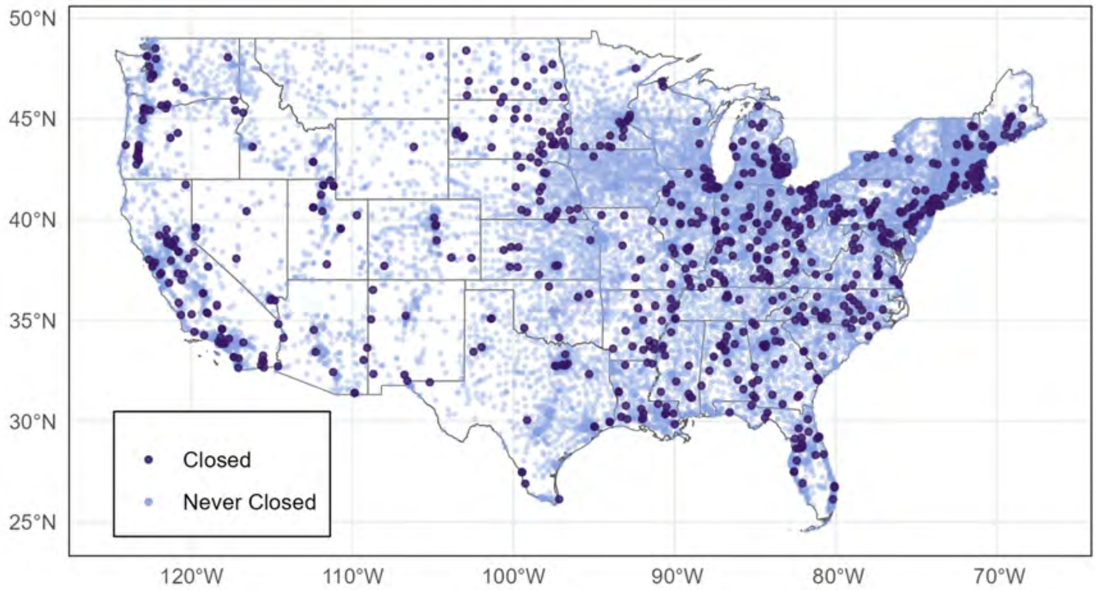
$$y_{dgt} = \sum_{j \in -5 \ldots 0 \ldots 6} \gamma_j \times (Closure)_{d,t-j} + \alpha_{dg} + \delta_{st} + \epsilon_{dgt}, \tag{1}$$

where y_{dgt} is the cohort-standardized test score in school district d, for grade g in the year t for either reading or math. $(Closure)_{d,t-j}$ indicates the distance from the year in which a library unit was closed within the school district d. We include school district-grade fixed-effects α_{dg} and state-year fixed-effects δ_{st}. The standard errors are clustered at the school district level, as this is the level at which the treatment occurs. We bin the last three post-periods, since the number of observations is very small.

Identification. The PLS states the reason why a library unit drops out of the panel—aside from closures, it documents temporary closures, mergers with another library, or other administrative changes.[3] Figure 3 shows that library closures in the U.S. were evenly distributed geographically between 2008 and 2019. There also do not seem to be any time trends in closures, aside from an uptick after the 2007/08 financial crisis (see Figure 1). We will control for this in a robustness check later on.

[3]For more details see the documentation of the 2021 PLS data.

Figure 3: Public Library Closures in the United States and their Closures between 2008 and 2019

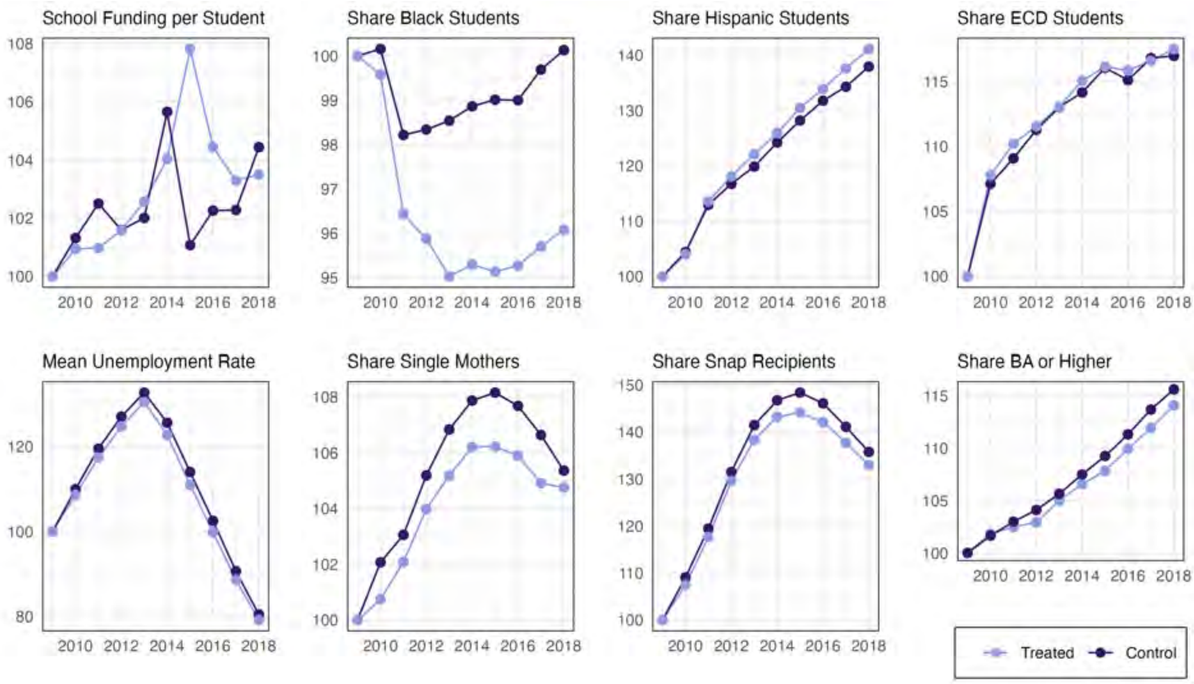


Notes: Figure 3 shows the location of all public libraries in the United States between 2008 and 2019, and indicated closures. *Source*: Own calculations, data: Public Library Survey (PLS) and U.S. Census Bureau.

Another threat to our identification might be relocations; these are not provided in the PLS dataset. To control for this, we exclude closures if another library was opened in the same library system within two years after the closure. The number of openings is similar to the number of closures in our sample, however, these two events are only very weakly correlated ($\rho = 0.04$). Funding of public schools and public libraries is an additional major concern regarding identification. Since both are primarily funded by local and state sources, with only a small amount of federal funding, this could pose a problem to identification. If closures take place because of reduced funding for both, public libraries and public schools, this could lead to worse test scores due to reduced school funding rather than the closure of the library itself. To show that this is not the case, we use public school funding as an outcome and show that it does not change around a closure, and we include it as a control variable in another specification.

Our main identifying assumption is that treated and untreated school districts' characteristics are comparable in trend, meaning treated districts would have developed similarly without the occurrence of a library closure. In section 6 we show that—especially within urban areas—school district as well as community characteristics remain stable around a closure event.

Figure 4: Descriptives Statistics of School Districts between 2009 and 2018



Notes: Figure 4 shows control variables describing characteristics of school districts normalized in 2009—mean public school funding per student, the logarithm of median household income, mean poverty rate, mean share of White students, mean unemployment rate, mean share of single mothers, mean share of SNAP recipients, mean share of adults with education higher than BA—over time between 2009 and 2018. *Source*: Own calculations, data: Public Library Survey (PLS) and U.S. Census Bureau.

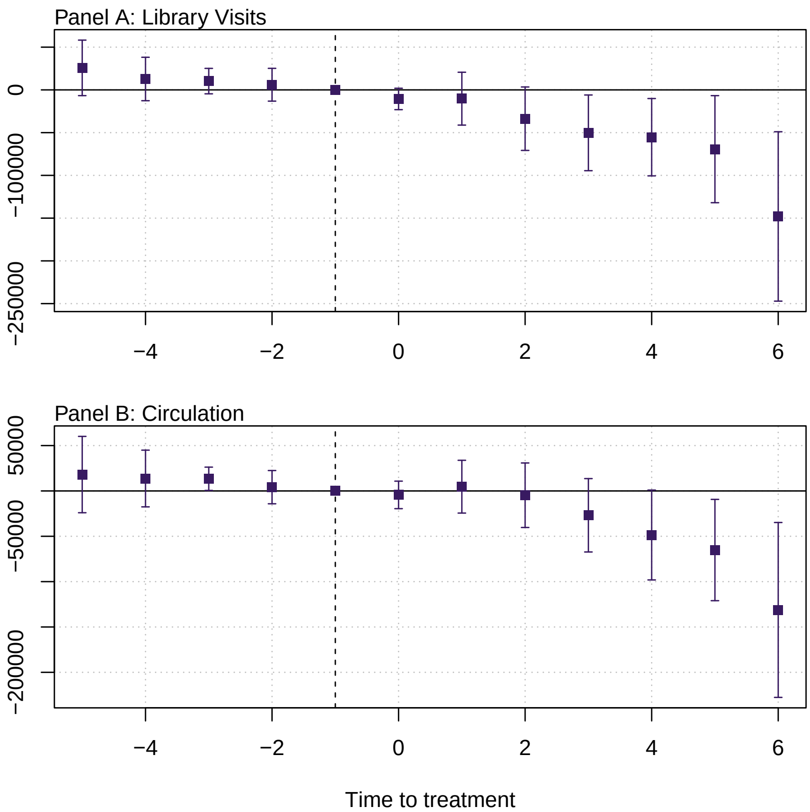
Figure 4 shows the school district and community characteristics between 2009 and 2018 normalized in 2009 and separated by whether the district experienced a library closure (treated) or not. Most of these characteristics developed similarly over time. We will later show balancing tests, indicating that there are no changes in all of these characteristics around a closure. Additionally to this evidence, the pre-trends of our analysis in Figure 6 are statistically insignificant and jointly zero. These facts support our main identifying assumption, and we can therefore identify the causal effect of a library closure on children's educational outcomes.

5 Overall Results

5.1 Effects on Public Library Outcomes

Before presenting evidence on the effect of public library closures on students' test scores, we discuss the impact on library outcomes. Figure 5 shows that after a closure, library visits and circulation decrease in the treated school district.[4]

Figure 5: Effect of Library Closures on Library Visits and Circulation



Notes: Figure 5 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for library visits and circulation. Pre-trends are jointly zero. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Public Library Survey (PLS) and National Center for Education Statistics (NCES).

Thus, rather than visiting another library within the district, individuals reduce their overall library usage. Since the effect takes some time to fully set in, we assume that individuals change habits in the short-run, meaning they travel longer distances

[4]An alternative specification with logged outcomes can be found in Figure B2 in the Appendix.

to visit another library. However, this behavior diminishes over time—likely due to the unsustainable costs of increased travel distances—leading to a long-term reduction in visits and circulation.

Table 3 shows the impact on different library outcomes. Beyond library visits and circulation, the number of total staff and the amount of operational expenditures decrease. Notably, there is a statistically significant increase in library programming for children, and an increase in children's program attendance, albeit not significant. This could indicate that the remaining libraries in the school districts increase services to offset negative effects for their communities. The following results for test scores might therefore be lower-bound effects.

Table 3: Impact of Library Closures on Library Outcomes

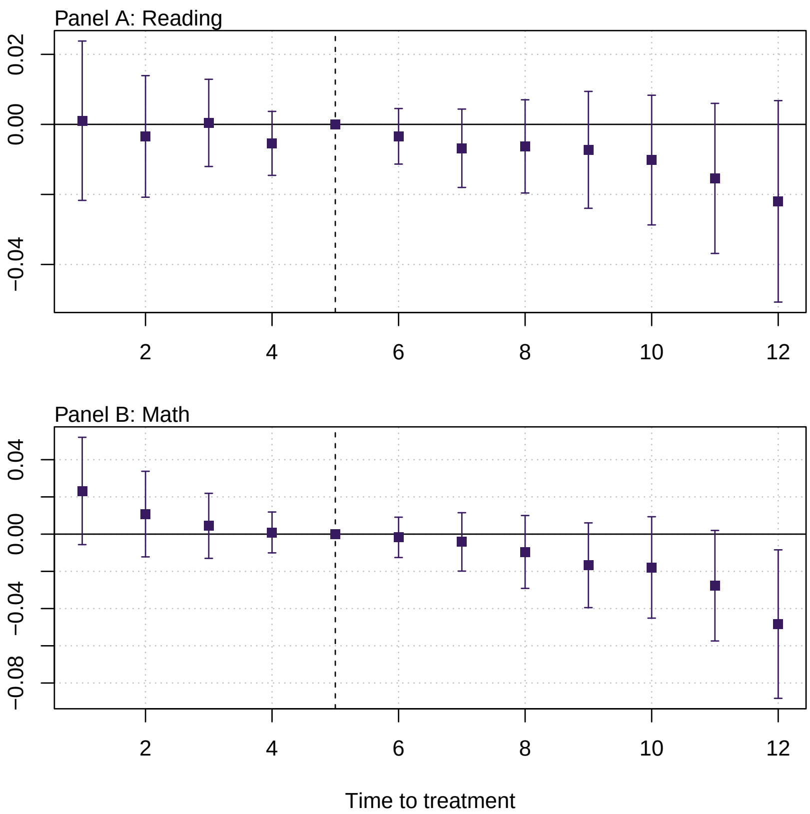
Dependent Variables:	Visits	Circulation	Total Staff	Librarians
Model:	(1)	(2)	(3)	(4)
Library Closure (ATT)	-53,463.8**	-38,515.6**	-4.475**	-0.6567
	(21,583.9)	(17,453.1)	(1.984)	(0.5144)
Dep. var. mean	185,350.1	298,864.4	17.973	6.410
Observations	36,398	36,283	345,470	345,470
Dependent Variables:	**Op. Expend.**	**Kid's Circ.**	**Kid's Prog.**	**Kid's Prog. Att.**
Model:	(5)	(6)	(7)	(8)
Library Closure (ATT)	-0.0533***	-9,799.7	84.62**	56.68
	(0.0182)	(6,232.4)	(41.09)	(912.3)
Dep. var. mean	12.886	104,467.8	334.68	9,280.5
Observations	345,454	345,470	345,458	345,470
School dist.-Grade-Subject	✓	✓	✓	✓
State-Year	✓	✓	✓	✓

Notes: Table 3 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for different library outcomes. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS) and National Center for Education Statistics (NCES).

5.2 Effects on Children's Test Scores

Turning to the effects of library closures on children's test scores, Figure 6 shows the event study plot for our main specification. Here we estimate the effect of a library closure within two miles of a school district on the average reading or math test scores of students aged between 8 and 14. There are small and statistically insignificant pre-trends, which are jointly zero in both specifications. The event study plots clearly show that library closures have a lasting negative effect on students' test scores, this is especially pronounced for math outcomes. The effect does not set in immediately, consistent with our findings in Figure 5 showing that individuals switch habits in the short-run.

Figure 6: Impact of Library Closures on Math and Reading Test Scores



Notes: Figure 6 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

Table 4 column (1) depicts the ATTs for math and reading test scores in all school districts, regardless of urbanicity. A public library closure reduces reading test scores on average by 0.01 and math test scores by 0.02 standard deviations. While both effects are negative, only the one for math is statistically significant. Throughout this paper, we find that math test scores are impacted more strongly than reading test scores. This is in line with previous literature, showing larger effects of educational interventions for math than for reading (Jackson et al., 2014). This could also be a first indication of the importance of a library's public space beyond books since math might be a more study-intensive subject.

Table 4: Impact of Library Closures on Test Scores by Urbanicity

Test Scores: Model:	All (1)	Metro (2)	Urban (3)	Rural (4)
Reading				
Library Closure (ATT)	-0.0100	-0.0086	-0.0220**	-0.0154
	(0.0063)	(0.0077)	(0.0107)	(0.0266)
Dep. var. mean	0.01024	0.06008	-0.04658	-0.06015
Observations	296,002	160,464	113,617	21,919
Math				
Library Closure (ATT)	-0.0174*	-0.0117	-0.0408**	-0.0327
	(0.0092)	(0.0105)	(0.0180)	(0.0515)
Dep. var. mean	0.02075	0.07212	-0.03508	-0.06302
Observations	263,642	142,286	102,289	19,065
School district-Grade	✓	✓	✓	✓
State-Year	✓	✓	✓	✓

Notes: Table 4 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator separately for school districts in metro, urban, and rural counties. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

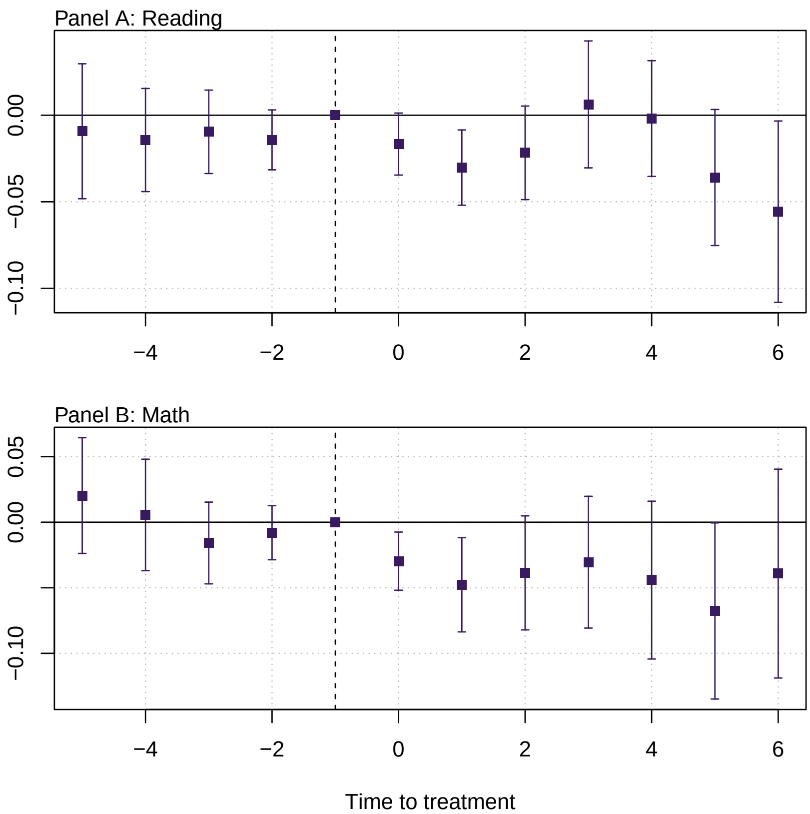
Columns (2) to (4) show that urban areas predominantly drive the observed effect. As previously discussed, (sub)urban regions are particularly vulnerable to the loss of public libraries due to lower branch density and limited access to public transportation. Our results corroborate this vulnerability. In urban school districts, effects are strong and statistically significant with a reduction of 0.02 standard deviations for reading and

0.04 for math test scores. For school districts in metro and urban counties we see no significant changes in children's educational performance. Since urban districts play a central role in this effect, the remainder of this paper will focus on school districts in urban counties.

6 Library Closures in (Sub)Urban Regions

The corresponding event study for the impact of a library closure on students' test scores in urban school districts in Table 4 can be seen in Figure 7, in Panel A for reading and Panel B for math test scores. There are no clear pre-trends and they are also zero jointly tested.

Figure 7: Impact of Library Closures on Test Scores in Urban Areas

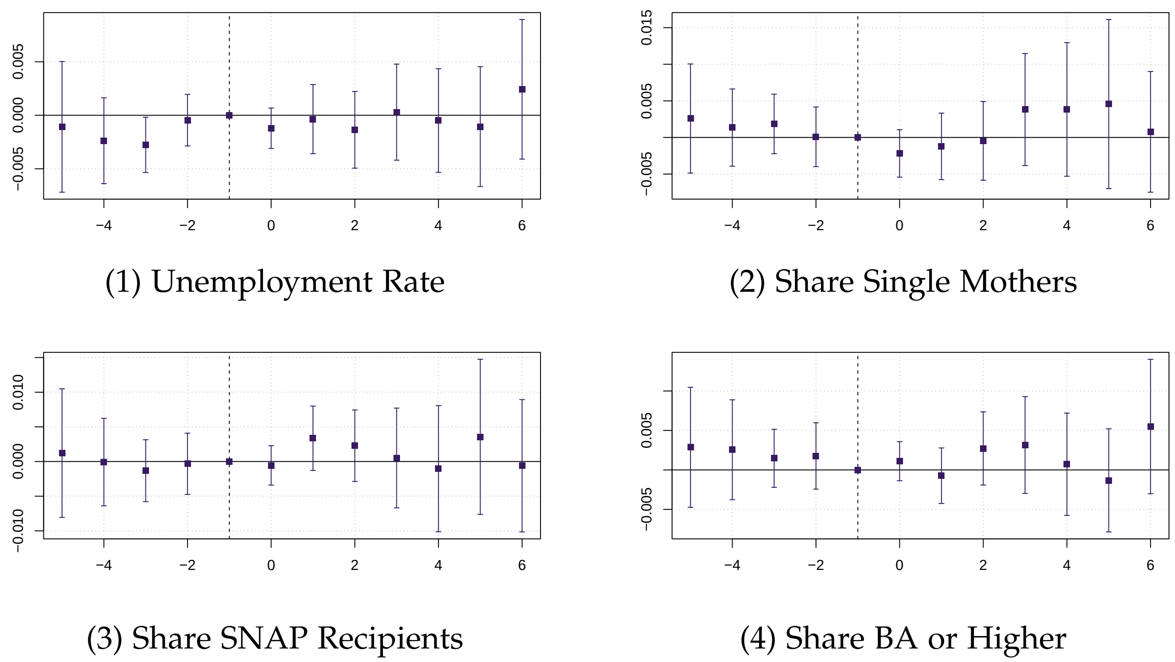


Notes: Figure 7 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for urban areas. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture, Economic Research Service (ERC), and Public Library Survey (PLS).

A closer look at the effects for urban school districts reveals that the negative effect of a closure sets in immediately after the event. Though children's performance seems to recover in year 3 and 4 after the closure, there are long-lasting consequences.

Robustness. The main identifying assumption for our empirical design is that we have parallel trends, which means that other community and school district characteristics are not affected by a library closure. Figure 8 shows event study plots using community characteristics as outcomes. Neither the unemployment rate, the share of single mothers, the share of Supplemental Nutrition Assistance Program (SNAP) recipients nor the share of highly educated adults, changes with a library closure. This also holds for school district characteristics such as public school funding, the share of Black, Hispanic, and economically disadvantaged students (see Figure B3 in the Appendix). Thus, observable community and school district student body characteristics remain stable around a closure.[5]

Figure 8: Balancing Tests for Community Characteristics (Urban Sample)



(1) Unemployment Rate

(2) Share Single Mothers

(3) Share SNAP Recipients

(4) Share BA or Higher

Notes: Figure 8 shows balance tests for different community characteristics using solely the sample of school districts in urban counties. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture (USDA), and Public Library Survey (PLS).

[5]The balancing tests for the full sample can be found in Figures B4 and B5 in the Appendix.

We perform several additional robustness checks for this main specification in Table 5. Including grade-year δ_{gt} and subject-year δ_{st} fixed-effects in column (2) to capture even more variation does not change the results significantly. In column (3), we add a battery of controls, namely public school funding, the unemployment rate, the share of single mothers, the share of SNAP recipients, and the share of adults with education higher than BA, which vary on the yearly school district-level. Control variables varying on the school district-grade-year level are the share of Black and Hispanic students. In column (4), we include the more restrictive fixed effects as well as the controls, and our results still hold.

Table 5: Impact of Library Closures on Test Scores in Urban Areas

Dependent Variable:	Test Scores			
	(1)	(2)	(3)	(4)
Reading				
Library Closure (ATT)	-0.0220**	-0.0218**	-0.0231**	-0.0229**
	(0.0107)	(0.0106)	(0.0112)	(0.0111)
Dep. var. mean	-0.04658	-0.04658	-0.04586	-0.04586
Observations	113,617	113,617	112,788	112,788
Math				
Library Closure (ATT)	-0.0408**	-0.0416**	-0.0403**	-0.0411**
	(0.0180)	(0.0180)	(0.0190)	(0.0190)
Dep. var. mean	-0.03508	-0.03508	-0.03407	-0.03407
Observations	102,289	102,289	101,518	101,518
School District-Grade	✓	✓	✓	✓
State-Year	✓	✓	✓	✓
Subject-Year		✓		✓
Grade-Year		✓		✓
Controls			✓	✓

Notes: Table 5 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for school districts in urban counties. Controls are on the annual school district-level public school funding, annual unemployment rate, share of single mothers, share of SNAP receivers, and share of adults with education higher than BA. On the Grade-Year level controls are share of Black and Hispanic students. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Next, we re-estimate our main specification using an alternative estimator by Gardner (2022) and a two-way fixed effects estimator to verify our results, which can be seen in Figure B7 in the Appendix. We additionally re-estimate our main specifications using student population weights (see Figure B8 in the Appendix). Our results are robust to both specifications. To see if our results are driven by closures following to the financial crisis 2007/08, we exclude the years 2009 and 2010 and then re-estimate our main specification. The results do not change and can be seen in Figure B9 in the Appendix. Finally, we re-estimate our model using different values for the treatment radius in Table 6. These results indicate that the closer a closure takes place to the school district, the larger the effect. At 5 miles, the effect becomes statistically insignificant and almost zero. This highlights the importance of the accessibility of library branches. Figure B10 in the Appendix shows the event study graphs for these estimations, which again clearly illustrate the weakening of the impact with increasing the distance.

Table 6: Varying the Radius for Treatment Definition

Dependent Variable:	Test Scores				
Radius:	None	1 mile	2 miles	4 miles	5 miles
Reading					
Library Closure (ATT)	-0.0351**	-0.0227*	-0.0220**	-0.0219**	-0.0071
	(0.0141)	(0.0118)	(0.0107)	(0.0092)	(0.0094)
Dep. var. mean	-0.04696	-0.04663	-0.04658	-0.04655	-0.04652
Observations	113,663	113,700	113,617	113,394	113,256
Math					
Library Closure (ATT)	-0.0682***	-0.0527***	-0.0408**	-0.0355**	-0.0081
	(0.0220)	(0.0185)	(0.0180)	(0.0151)	(0.0144)
Dep. var. mean	-0.03561	-0.03529	-0.03508	-0.03525	-0.03513
Observations	102,307	102,369	102,289	102,054	101,936
School district-Grade	✓	✓	✓	✓	✓
State-Year	✓	✓	✓	✓	✓

Notes: Table 6 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator varying the treatment radius from 0 to 5 miles for school districts in urban counties. School district-Grade fixed effects and state-year fixed effects are included. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

6.1 Heterogeneity

To investigate the effect of library closures for different subgroups, we conduct heterogeneity analyses first by students' characteristics—such as race, grade level, and economic disadvantage—and then by school district and library characteristics—such as the kind of outlet that closed, public library funding, and public school funding.

We re-estimate all heterogeneity analyses including a battery of control variables for student and community characteristics and public school funding. The analysis can be found in the Appendix in Tables A2 to A6. Indeed, none of our findings change if we include these controls. We thus conclude that these heterogeneities are driven by different effects for different groups rather than any of the characteristics in our controls.

6.1.1 Students' Characteristics

Race. The heterogeneity analysis by race reveals that all groups experience significant negative effects on test scores, however, there are stark differences in magnitude for White, Black, and Hispanic students. A look at the different ATTs in Table 7 reveals that—as in our main specification—math test scores are more strongly affected across all groups than those for reading. For math, the effect size for Black students is almost twice as large as for White students and three times as large for Hispanic students. We show the event study plots in Figure B11 in the Appendix.

While we know from Gilpin et al. (2024) that openings do not positively affect Black and Hispanic students, our results show that closures affect them heavily. This could have multiple reasons. For one, we know that in the South—where most of the U.S. Black population lives—residents live further away from library outlets than in the North (Donnelly, 2015). So, if one outlet closes the next is even further away, making alternative options unfeasible. Furthermore, a survey on public libraries by the Pew Research Center (Horrigan, 2015) reveals that almost 80 percent of Hispanics state that a library closure would considerably impact their community. Hispanics are also the racial group that values library services the most (Horrigan, 2015). These facts might explain the large effect we see on Hispanic students' test scores. Since the PLS does not offer data distinguished by race, we cannot provide details for library use for the different groups.

Table 7: Impact of Library Closures on Test Scores by Race

Test Scores:	White	Black	Hispanic
Model:	(1)	(2)	(3)
Reading			
Library Closure (ATT)	-0.0193*	-0.0405**	-0.0305
	(0.0105)	(0.0186)	(0.0215)
Dep. var. mean	0.06740	-0.54629	-0.37548
Observations	103,354	19,965	21,625
Math			
Library Closure (ATT)	-0.0392**	-0.0745***	-0.1281***
	(0.0183)	(0.0235)	(0.0411)
Dep. var. mean	0.06858	-0.57997	-0.26510
Observations	93,615	17,574	19,100
School district-Grade	✓	✓	✓
State-Year	✓	✓	✓

Notes: Table 7 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by race. Column (1) shows test scores for White students, column (2) shows test scores for Black students, and column (3) shows test scores for Hispanic students. School district-grade fixed effects and state-year fixed effects are included. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Grade Level. Library closures might affect children of different ages differently as the types of books and programming offered by libraries for them differ. In Table 8 we see similar results for elementary (grade 3 to 5) and middle school (grade 6 to 8) children. Math scores decrease by 3.5 to 4.5 percentage points of a standard deviation. Reading scores are only significant for elementary school children. This might be due to several reasons. First, if a closure happens during their time in elementary school, children experience more school years without access to a public library, leading to a stronger decline in their educational outcomes over time. Second, books for younger children tend to be shorter, increasing their demand for library books. Third, libraries provide essential resources beyond books, such as early literacy programs, which are particularly important for younger students. Additionally, Horrigan (2015) reports that 70 percent of parents of minors are concerned about the impact of library closures, underscoring the significance of these spaces for children's development and education. The event study plots can be found in Figure B12 in the Appendix.

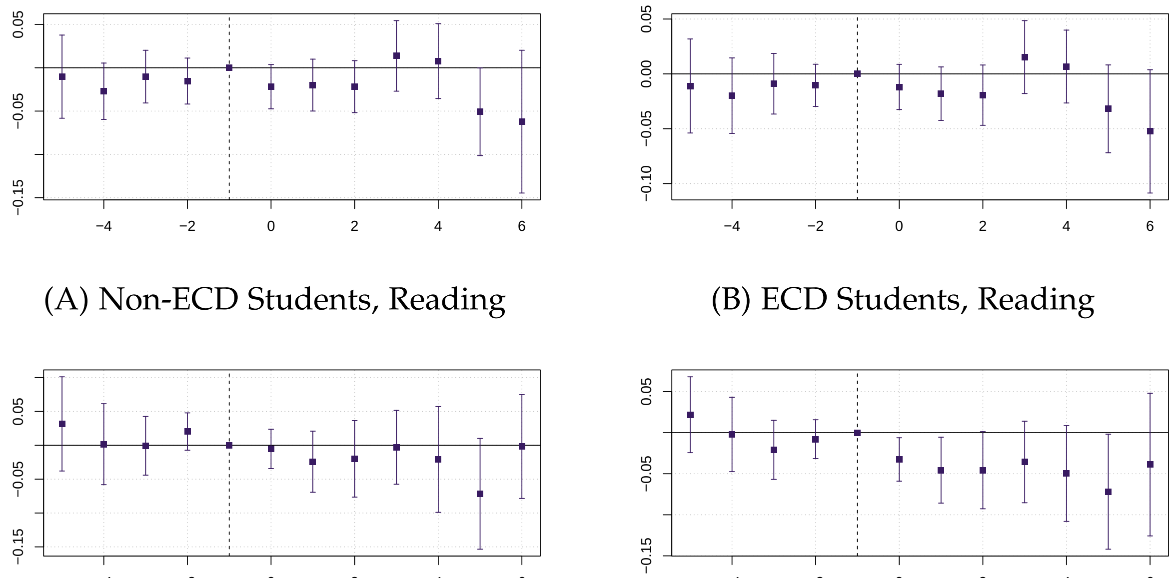
Table 8: Impact of Library Closures on Test Scores by School Grade

Dependent Variable:	Test Scores	
	Elementary School	Middle School
Reading		
Library Closure (ATT)	-0.0237*	-0.0181
	(0.0123)	(0.0131)
Dep. var. mean	-0.03296	-0.06143
Observations	59,274	54,342
Math		
Library Closure (ATT)	-0.0454***	-0.0347**
	(0.0159)	(0.0168)
Dep. var. mean	-0.03060	-0.04109
Observations	58,622	43,666
School-Grade-Subject	✓	✓
State-Year	✓	✓

Notes: Table 8 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by grade. Column (1) shows grades 3 to 5, and column (2) shows grades 6 to 8. School district-grade fixed effects and state-year fixed effects are included. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Economic Status. The SEDA data offers test scores differentiated by economic status. While higher-income families are more likely to use public libraries, the resources that libraries offer may have a higher value-added for poorer families (Horrigan, 2015). Hence, the loss of these resources could lead to greater impacts for both, students from high and low-income households. We investigate this by differentiating between the test scores of economically disadvantaged students (ECD) and those who are not (Non-ECD) in Figure 9. Reading scores (panels A and B) follow a similar pattern for both groups. While there is almost no change in math test scores for non-ECD students (panel C), there is a clear negative effect for ECD students (panel D).

Figure 9: Impact of Library Closures on Test Scores by Economic Disadvantage



(A) Non-ECD Students, Reading

(B) ECD Students, Reading

(C) Non-ECD Students, Math

(D) ECD Students, Math

Notes: Figure 9 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results are estimated separately for economically disadvantaged and non-disadvantaged students. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

The ATTs in Table 9 confirm that only ECD students' math test scores decline while reading scores are only impacted for non-ECD students. We will delve deeper into this differential impact when looking at the intersection of students' economic status and the neighborhoods in which their schools are located.

Table 9: Impact of Library Closures on Test Scores by Economic Disadvantage

Dependent Variable:	Test Scores	
	Non-ECD Students	ECD Students
Reading		
Library Closure (ATT)	-0.0217*	-0.0156
	(0.0126)	(0.0105)
Dep. var. mean	0.25858	-0.26542
Observations	87,342	96,442
Math		
Library Closure (ATT)	-0.0182	-0.0438**
	(0.0214)	(0.0189)
Dep. var. mean	0.26260	-0.25045
Observations	78,216	86,646
School-Grade-Subject	✓	✓
State-Year	✓	✓

Notes: Table 9 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by economic status. Column (1) shows non-economically disadvantaged students, and column (2) shows economically disadvantaged students. School district-grade fixed effects and state-year fixed effects are included. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

6.1.2 School District and Library Characteristics

Neighborhood. To capture not only the difference between economically disadvantaged and non-disadvantaged students but also differences between high and low-poverty neighborhoods, we estimate the main specification separately for poor and non-poor school districts, using the district's poverty rate. We define a school district as poor if the poverty rate is higher than the median of all school districts in a given year. The results can be seen in Table 10. Reading test scores are similarly affected in the two groups with a reduction of 0.02 standard deviations. There is a statistically significant reduction of 0.05 standard deviations in math test scores in school districts with high poverty levels while for the low-poverty districts, the effect is zero. The event study graphs can be found in Figure B13 in the Appendix.

Table 10: Impact of Library Closures on Test Scores by the Poverty Rate

Dependent Variable:	Test Scores	
	Non-Poor Neighborhoods	Poor Neighborhoods
Reading		
Library Closure (ATT)	-0.0262*	-0.0236*
	(0.0153)	(0.0134)
Dep. var. mean	0.05130	-0.14427
Observations	56,781	56,562
Math		
Library Closure (ATT)	0.0008	-0.0575***
	(0.0233)	(0.0207)
Dep. var. mean	0.08850	-0.15824
Observations	51,117	50,944
School-Grade-Subject	✓	✓
State-Year	✓	✓

Notes: Table 10 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by the school district's poverty rate. Column (1) shows school districts with a poverty rate below the median and column (2) shows school districts with a poverty rate above the median. School district-grade fixed effects and state-year fixed effects are included. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

To allow for a more intersectional analysis, we differentiate, first, by the poverty level of the school district and, second, by students' economic status. The event study graphs can be found in the Appendix in Figure B14 for reading and Figure B15 for reading. Table 11 shows that library closures reduce math test scores by 0.07 standard deviations for ECD students in poor districts. All other students do not experience statistically significant changes to their math test scores. For reading test scores, a different picture emerges: in low-poverty neighborhoods only students who are not economically disadvantaged experience a reduction in test scores, while in high-poverty neighborhoods this only holds for those who are economically disadvantaged. As discussed above, a library closure seems to affect these two groups: higher-income families in rich neighborhoods who use libraries more often and less well-off families in poor school districts for whom the marginal benefit of library resources is higher.

Table 11: Impact of Library Closures on Test Scores by Neighborhood and Economic Status

Dependent Variable:	Test Scores			
	Non-Poor Neighborhoods		Poor Neighborhoods	
	Non-ECD Students	ECD Students	Non-ECD Students	ECD Students
Reading				
Library Closure (ATT)	-0.0316**	-0.0173	-0.0159	-0.0236*
	(0.0131)	(0.0215)	(0.0178)	(0.0132)
Dep. var. mean	0.27636	-0.16642	0.23845	-0.31901
Observations	46,538	24,534	40,721	53,342
Math				
Library Closure (ATT)	-0.0165	0.0170	-0.0087	-0.0672***
	(0.0254)	(0.0269)	(0.0202)	(0.0211)
Dep. var. mean	0.31071	-0.16209	0.20668	-0.32015
Observations	42,140	38,257	36,000	48,181
School-Grade-Subject	✓	✓	✓	✓
State-Year	✓	✓	✓	✓

Notes: Table 11 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by economic status and a school district's poverty rate. Columns (1) and (2) show students in school districts with a poverty rate below the median. Column (1) shows non-ECD students and column (2) shows ECD students. Columns (3) and (4) show students in school districts with a poverty rate above the median. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Public School Funding. After having established the importance of neighborhood characteristics, we will now turn to the role of public school funding. This might also be a key factor that could offset the negative impact of closing a public library. If that is the case, we would expect well-funded school districts to show small or non-negative effects of a library closure on math and reading test scores. To examine this, we divide school districts into terciles based on the annual school funding per student.

Our assumption that well-funded school districts counterbalance negative effects of library closures holds for reading and math: Table 12 shows that school districts with the highest amount of annual funding experience no statistically significant change in test scores. Districts with a low to medium amount of school funding show similar effects to our main specification with a reduction of 0.02 to 0.04 standard deviation in reading and 0.07 standard deviations for math test scores. The event study graphs for the school funding terciles can be found in Figure B16 in the Appendix.

Table 12: Impact of Library Closures on Test Scores by Public School Funding Terciles

Dependent Variable:		Test Scores	
Public School Funding:	1st Tercile	2nd Tercile	3rd Tercile
Reading			
Library Closure (ATT)	-0.0224*	-0.0393**	-0.0198
	(0.0135)	(0.0162)	(0.0220)
Dep. var. mean	-0.04043	-0.03939	-0.05816
Observations	37,003	37,517	38,526
Math			
Library Closure (ATT)	-0.0671***	-0.0655***	0.0460
	(0.0204)	(0.0247)	(0.0391)
Dep. var. mean	-0.06641	0.00375	-0.04072
Observations	34,496	34,277	32,956
School district-Grade	✓	✓	✓
State-Year	✓	✓	✓

Notes: Table 12 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by annual public school funding per school district. Column (1) shows school districts with less than $12,793.43 per student per year, column (2) with between $12,793.43 and $16,301.69 funding per student per year, column (3) with over $16,301.69 funding per student per year. School district-grade fixed effects and state-year fixed effects are included. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Number of Library Branches. The impact of a library closure on test scores might also depend on the number of available alternatives. We would expect that a closure in a school district with only one or two libraries has more detrimental effects than a closure in a district with many libraries. Therefore, we split our sample by the number of libraries in 2008, differentiating by a fixed pre-treatment variable. We then group districts with one or two libraries, which are the majority, and districts with three or more libraries.

Table 13 shows the ATTs for the two groups. In districts with only one or two libraries, the effect is large—a reduction of 0.09 standard deviations in math test scores—and highly statistically significant. As expected, for the math test scores we see no effect if a library closes in a district with many alternatives. For reading test scores, the picture is more ambiguous. Though the impact is larger in districts with few libraries, there is also an effect in the second group. This highlights the importance of library accessibility, as alternatives counteract the negative impact of the loss of a library.

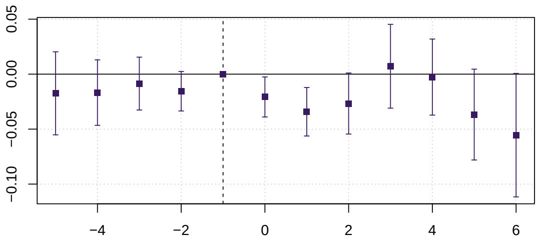
Table 13: Impact of Library Closures on Test Scores by Number of Library Branches

Dependent Variable:	Test Scores	
	Less than 3 Branches	3 or more Branches
Reading		
Library Closure (ATT)	-0.0329**	-0.0251*
	(0.0128)	(0.0147)
Dep. var. mean	-0.05396	-0.01878
Observations	86,178	23,308
Math		
Library Closure (ATT)	-0.0892***	-0.0028
	(0.0230)	(0.0207)
Dep. var. mean	-0.03922	-0.01632
Observations	77,534	20,904
School-Grade-Subject	✓	✓
State-Year	✓	✓

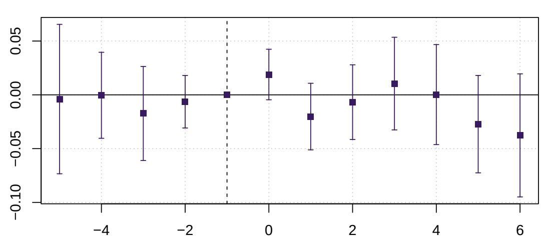
Notes: Table 13 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results are estimated separately for school districts with one or two library branches and those with three or more branches. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

Type of Closure. Lastly, we re-estimate our main specification separately for the kind of library outlet—physical library outlets such as branch libraries and non-physical outlets like bookmobiles. A central library is the main building of an administrative library entity. A branch library is a unit in a separate building with paid staff and/or regularly scheduled opening hours, whereas a bookmobile is a "truck or van that carries an organized collection of library materials" (Pelczar et al., 2023, p.F-7).

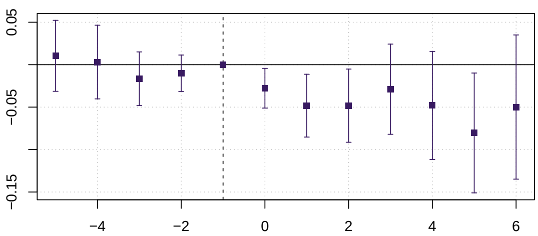
Figure 10: Impact of Library Closures on Test Scores by Kind of Outlet



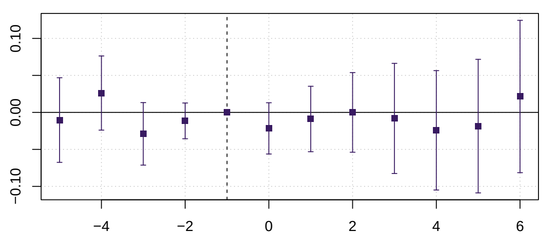
(A) Physical Branch, Reading



(B) Non-Physical Branch, Reading



(C) Physical Branch, Math



(D) Non-Physical Branch Students, Math

Notes: Figure 10 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results are estimated separately for closures of physical and non-physical library outlets. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

Figure 10 panels A and C show the development of test scores following the closure of a physical library outlet. The patterns we observe are similar to those of the overall effect. Non-physical library outlets (panels B and D), which solely provide access to books or additional reading material, show no change following a closure. Table 14 presents the ATTs, where, again, there is an impact of similar magnitude to the baseline findings for physical outlets. For non-physical outlets, we observe a statistically non-significant zero effect. Importantly, the mean of the dependent variable for the two types of closures is very similar, suggesting that physical and non-physical outlets are not closed in different regions, which otherwise could explain the effect. Rather this highlights the role that public space plays in the negative impact on test scores. It also emphasizes the importance of library resources such as programs for children or access to the internet and computers.

Table 14: Impact of Library Closures on Test Scores by Kind of Library Outlet Closed

Dependent Variable:	Test Scores	
Model:	Physical Outlet	Non-Physical Outlet
Reading		
Library Closure (ATT)	-0.0241**	-0.0073
	(0.0110)	(0.0139)
Dep. var. mean	-0.04654	-0.04421
Observations	113,384	110,618
Math		
Library Closure (ATT)	-0.0446**	-0.0089
	(0.0190)	(0.0264)
Dep. var. mean	-0.03489	-0.03229
Observations	102,066	99,666
School district-Grade	✓	✓
State-Year	✓	✓

Notes: Table 14 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator separately for physical and non-physical library outlets. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS) and National Center for Education Statistics (NCES).

7 Conclusion

This study underscores the critical role of public library accessibility by investigating the impact of library closures on children's test scores. We demonstrate a causal and significant effect of library closures in urban areas, with a reduction of 0.02 standard deviations for reading test scores and 0.04 standard deviations for math. Consistent with Jackson et al. (2014), we find that math scores are affected more strongly than reading scores in all our specifications.

The effects of library closures are particularly pronounced for Black and Hispanic students as well as students from economically disadvantaged households. Juxtaposing economic status with neighborhood poverty, we show that children from high-income families in wealthy neighborhoods and children from low-income families in less affluent neighborhoods are most affected. The former are those who are statistically most likely to use libraries and are therefore more vulnerable to closures. The latter have a higher marginal utility of library services, making them even more affected (Horrigan, 2015).

Public school funding can potentially offset this effect—children in well-funded school districts do not experience a decline in test scores following a closure. The number of libraries in a school district as well as the type of library outlet that closed are key factors as well. A high number of other libraries in the district can mitigate the effect of a closure. Students' test scores are not impacted if a non-physical library closes, highlighting the importance of the library's public space.

By emphasizing the importance of public libraries for economically disadvantaged students, this paper significantly contributes to the existing literature. Our findings have substantial policy implications, especially in the context of increasing book challenges that threaten public libraries. Policies should include additional support and funding for public libraries as they are essential social infrastructure. Strengthening these services not only addresses educational disparities but may also help reduce other dimensions of inequality. Given the wide array of resources offered by public libraries, including internet access and library programming, supporting these institutions is crucial for mitigating existing inequities in the American school system.

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Appendix

A Appendix A: Tables

Table A1: Summary Statistics: Means by Urbanicity

	All	Metro	Urban	Rural
SEDA Test Scores				
Math Score	0.02	0.07	-0.04	-0.06
Reading Score	0.01	0.06	-0.05	-0.06
Public Libraries				
Number of Libraries	1.90	2.18	1.57	1.58
Library Visits (per 1,000)	186.53	293.12	67.00	52.18
Circulation (per 1,000)	300.76	488.93	86.83	75.93
Kids' Circulation (per 1,000)	106.49	176.48	27.19	22.26
Library Programs	583.87	867.21	265.62	228.88
Kids' Library Programs	338.97	496.03	162.41	143.07
Kids' Program Attendance	9.38	14.39	3.77	3.05
Total Staff	18.56	28.73	7.15	5.70
Librarians	6.60	9.72	3.11	2.63
Total Op. Expenditure	1,356.00	2,191.08	415.21	324.44
School District Characteristics				
Number of Students	1,786	2,751	722	456
Log School Funding per Student	10.41	10.39	10.43	10.50
Share Black Students (in %)	10.69	11.82	9.14	10.57
Share Hispanic Students (in %)	12.23	13.27	11.68	7.48
Share ECD Students (in %)	51.86	46.98	57.20	59.63
Community Characteristics				
Unemployment Rate (in %)	7.36	7.25	7.50	7.48
Share Single Mothers (in %)	15.97	16.15	15.92	14.97
Share SNAP Recipients (in %)	11.77	10.47	13.20	13.47
Share BA or Higher (in %)	20.99	24.77	16.80	15.97

Notes: Table A1 shows means of our main variables for the balanced panel between 2009 and 2018 by urbanicity. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS) and National Center for Education Statistics (NCES).

Table A2: Impact of Library Closures on Test Scores by Race including Controls

Dependent Variables:	White		Black		Hispanic	
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Reading						
Library Closure (ATT)	-0.0193*	-0.0212**	-0.0405**	-0.0431**	-0.0305	-0.0320
	(0.0105)	(0.0108)	(0.0186)	(0.0193)	(0.0215)	(0.0218)
Dependent variable mean	0.06740	0.06789	-0.54629	-0.54530	-0.37548	-0.37567
Observations	103,354	102,665	19,965	19,814	21,625	21,593
Math						
Library Closure (ATT)	-0.0392**	-0.0376**	-0.0745***	-0.0798***	-0.1281***	-0.1296***
	(0.0183)	(0.0189)	(0.0235)	(0.0252)	(0.0411)	(0.0404)
Dependent variable mean	0.06858	0.06924	-0.57997	-0.57910	-0.26510	-0.26504
Observations	93,615	92,959	17,574	17,423	19,100	19,080
Fixed-effects						
GEOID-grade-subject	✓	✓	✓	✓	✓	✓
YEAR-fips	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓

Notes: Table A2 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by race. Columns (1) and (2) show test scores for White students without and with controls, columns (3) and (4) show test scores for Black students without and with controls, and columns (5) and (6) show test scores for Hispanic students without and with controls. School district-grade fixed effects and state-year fixed effects are included. Controls are on the annual school district-level public school funding, annual unemployment rate, share of single mothers, share of SNAP receivers, and share of adults with education higher than BA. On the Grade-Year level controls are share of Black and Hispanic students. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Table A3: Impact of Library Closures on Test Scores by Grade Level including Controls

Dependent Variables:	Elementary School		Middle School	
Model:	(1)	(2)	(3)	(4)
Reading				
Library Closure (ATT)	-0.0237*	-0.0273**	-0.0181	-0.0159
	(0.0123)	(0.0123)	(0.0131)	(0.0134)
Dependent variable mean	-0.03296	-0.03228	-0.06143	-0.06064
Observations	59,274	58,800	54,342	53,987
Math				
Library Closure (ATT)	-0.0454***	-0.0479***	-0.0347**	-0.0295*
	(0.0159)	(0.0162)	(0.0168)	(0.0177)
Dependent variable mean	-0.03060	-0.02967	-0.04109	-0.03996
Observations	58,622	58,156	43,666	43,361
Fixed-effects				
GEOID-grade-subject	✓	✓	✓	✓
YEAR-fips	✓	✓	✓	✓
Controls		✓		✓

Notes: Table A3 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by grade. Columns (1) and (2) show grades 3 to 5 without and with controls, and columns (3) and (4) show grades 6 to 8 without and with controls. School district-grade fixed effects and state-year fixed effects are included. Controls are on the annual school district-level public school funding, annual unemployment rate, share of single mothers, share of SNAP receivers, and share of adults with education higher than BA. On the Grade-Year level controls are share of Black and Hispanic students. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Table A4: Impact of Library Closures on Test Scores by Economic Status including Controls

Dependent Variables:	Non-ECD Students		ECD Students	
Model:	(1)	(2)	(3)	(4)
Reading				
Library Closure (ATT)	-0.0217*	-0.0232*	-0.0156	-0.0173
	(0.0126)	(0.0131)	(0.0105)	(0.0108)
Dependent variable mean	0.25858	0.25936	-0.26542	-0.26484
Observations	87,342	86,858	96,442	95,815
Math				
Library Closure (ATT)	-0.0182	-0.0179	-0.0438**	-0.0434**
	(0.0214)	(0.0222)	(0.0189)	(0.0198)
Dependent variable mean	0.26260	0.26368	-0.25045	-0.24960
Observations	78,216	77,755	86,646	86,076
Fixed-effects				
GEOID-grade-subject	✓	✓	✓	✓
YEAR-fips	✓	✓	✓	✓
Controls		✓		✓

Notes: Table A4 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by grade. Columns (1) and (2) show non-economically disadvantaged students without and with controls, and columns (3) and (4) show economically disadvantaged students without and with controls. School district-grade fixed effects and state-year fixed effects are included. Controls are on the annual school district-level public school funding, annual unemployment rate, share of single mothers, share of SNAP receivers, and share of adults with education higher than BA. On the Grade-Year level controls are share of Black and Hispanic students. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

Table A5: Impact of Library Closures on Test Scores by Poverty Rate including Controls

Dependent Variables:	Non-Poor Neighborhoods		Poor Neighborhoods	
Model:	(1)	(2)	(3)	(4)
Reading				
Library Closure (ATT)	-0.0262*	-0.0297*	-0.0236*	-0.0231*
	(0.0153)	(0.0160)	(0.0134)	(0.0140)
Dependent variable mean	0.05130	0.05145	-0.14427	-0.14331
Observations	56,781	56,434	56,562	56,353
Math				
Library Closure (ATT)	0.0008	0.0090	-0.0575***	-0.0578***
	(0.0233)	(0.0226)	(0.0207)	(0.0222)
Dependent variable mean	0.08850	0.08884	-0.15824	-0.15710
Observations	51,117	50,786	50,944	50,731
Fixed-effects				
GEOID-grade-subject	✓	✓	✓	✓
YEAR-fips	✓	✓	✓	✓
Controls		✓		✓

Notes: Table A5 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by grade. Columns (1) and (2) show districts with a poverty rate below the median without and with controls, and columns (3) and (4) show districts with a poverty rate above the median without and with controls. School district-grade fixed effects and state-year fixed effects are included. Controls are on the annual school district-level public school funding, annual unemployment rate, share of single mothers, share of SNAP receivers, and share of adults with education higher than BA. On the Grade-Year level controls are share of Black and Hispanic students. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

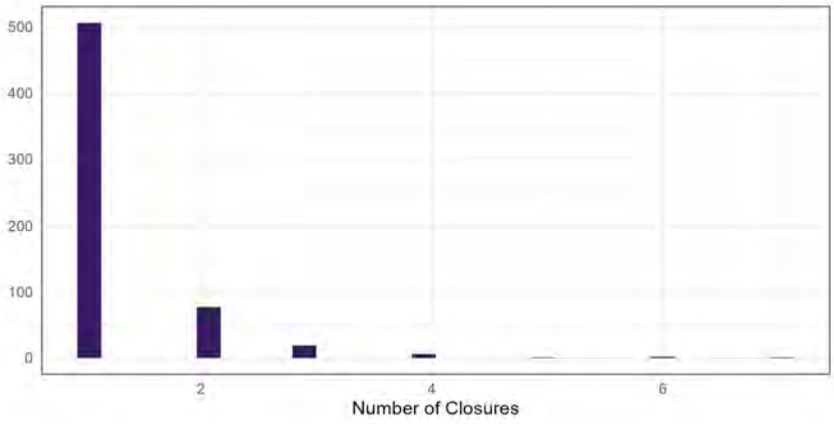
Table A6: Impact of Library Closures on Test Scores by Public School Funding including Controls

Dependent Variables:	1st Tercile		2nd Tercile		3rd Tercile	
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Reading						
Library Closure (ATT)	-0.0224*	-0.0215	-0.0393**	-0.0380**	-0.0198	-0.0193
	(0.0135)	(0.0140)	(0.0162)	(0.0162)	(0.0220)	(0.0221)
Dependent variable mean	-0.04043	-0.03950	-0.03939	-0.03917	-0.05816	-0.05844
Observations	37,003	36,887	37,517	37,467	38,526	38,426
Math						
Library Closure (ATT)	-0.0671***	-0.0657***	-0.0655***	-0.0639***	0.0460	0.0434
	(0.0204)	(0.0209)	(0.0247)	(0.0244)	(0.0391)	(0.0398)
Dependent variable mean	-0.06641	-0.06532	0.00375	0.00397	-0.04072	-0.04093
Observations	34,496	34,390	34,277	34,227	32,956	32,896
Fixed-effects						
GEOID-grade-subject	✓	✓	✓	✓	✓	✓
YEAR-fips	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓

Notes: Table A6 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by race. Columns (1) and (2) show school districts with less than $12,793.43 per student per year without and with controls, columns (3) and (4) sho districts with between $12,793.43 and $16,301.69 funding per student per year without and with controls, and columns (5) and (6) show districts with over $16,301.69 funding per student per year without and with controls. School district-grade fixed effects and state-year fixed effects are included. Controls are on the annual school district-level annual unemployment rate, share of single mothers, share of SNAP receivers, and share of adults with education higher than BA. On the Grade-Year level controls are share of Black and Hispanic students. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), Public Library Survey (PLS), and National Center for Education Statistics (NCES).

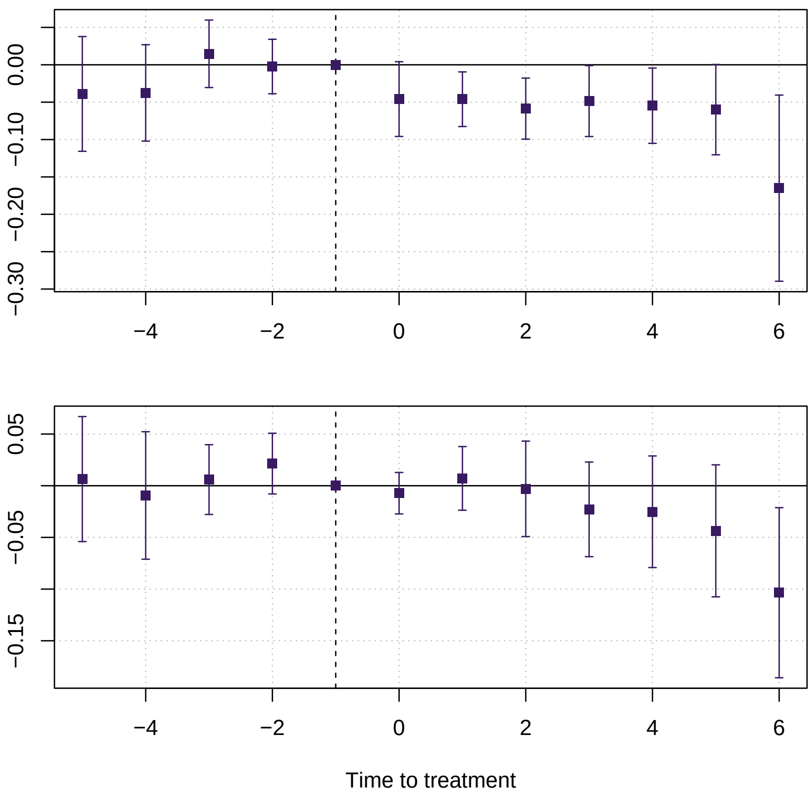
B Appendix B: Figures

Figure B1: Histogram of the Number of Closures per School District between 2008 and 2019



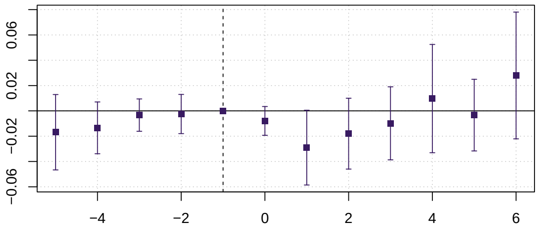
Notes: Figure B1 shows the number of library branch openings and closures between 2008 and 2019. *Source*: own calculations, data: Public Library Survey (PLS).

Figure B2: Effect of Library Closures on Library Visits and Circulation

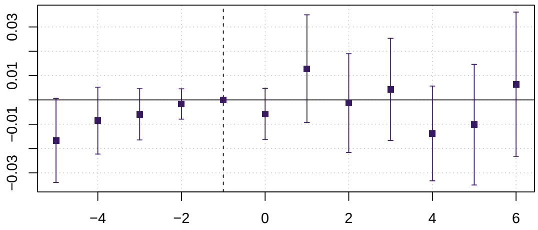


Notes: Figure B2 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for library visits and circulation. Pre-trends are jointly zero. Clustered (School district) standard-errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. *Source*: own calculations, data: Public Library Survey (PLS) and National Center for Education Statistics (NCES).

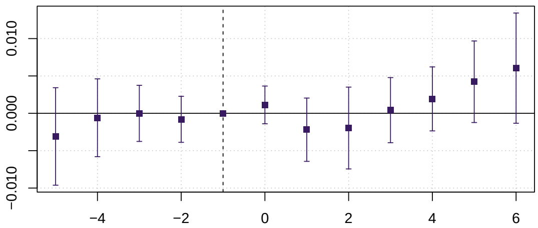
Figure B3: Balancing Tests for School District Characteristics (Urban Sample)



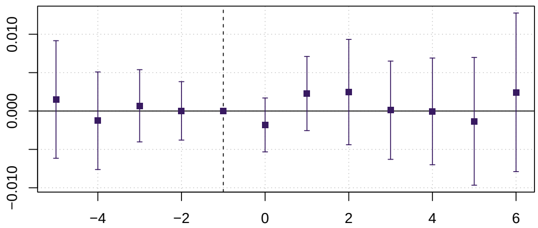
(1) Public School Funding



(2) Share ECD Students



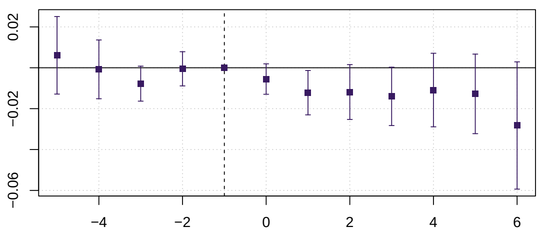
(3) Share Black Students



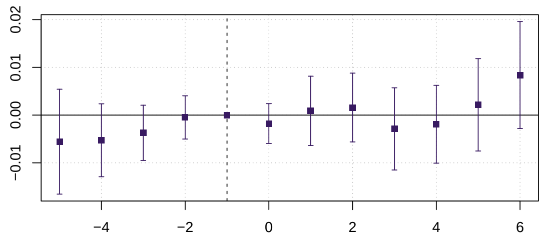
(4) Share White Students

Notes: Figure B3 shows balance tests for different school district characteristics using solely the sample of school districts in urban counties. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture (USDA), and Public Library Survey (PLS).

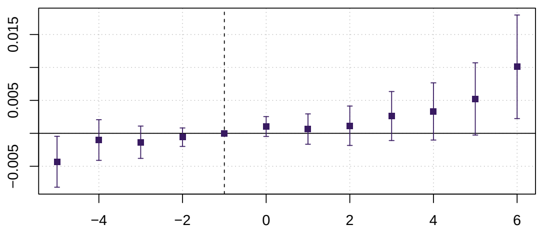
Figure B4: Balancing Tests for School District Characteristics (Full Sample)



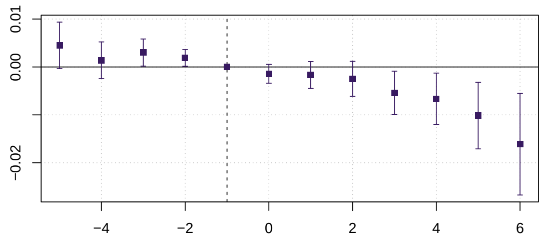
(1) Public School Funding



(2) Share ECD Students



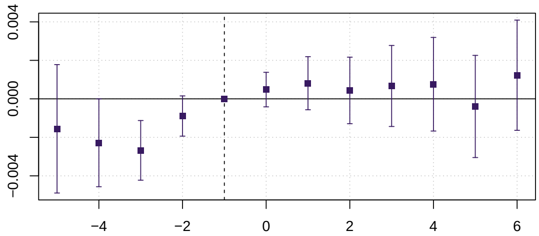
(3) Share Black Students



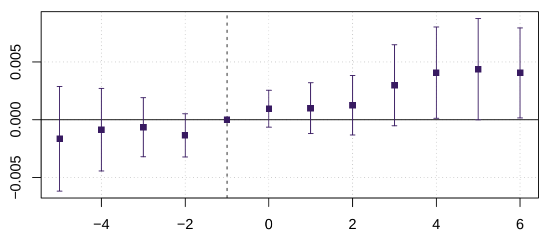
(4) Share White Students

Notes: Figure B4 shows balance tests for different school district characteristics using the full sample. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), and Public Library Survey (PLS).

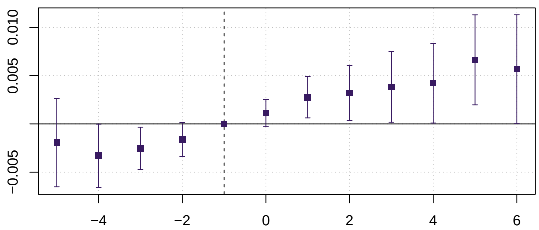
Figure B5: Balancing Tests for Community Characteristics (Full Sample)



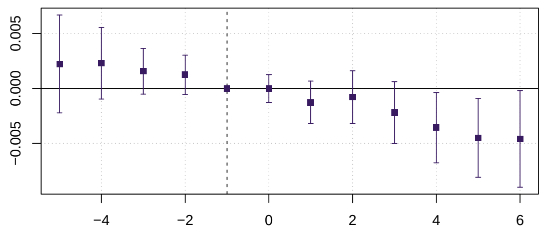
(1) Unemployment Rate



(2) Share Single Mothers



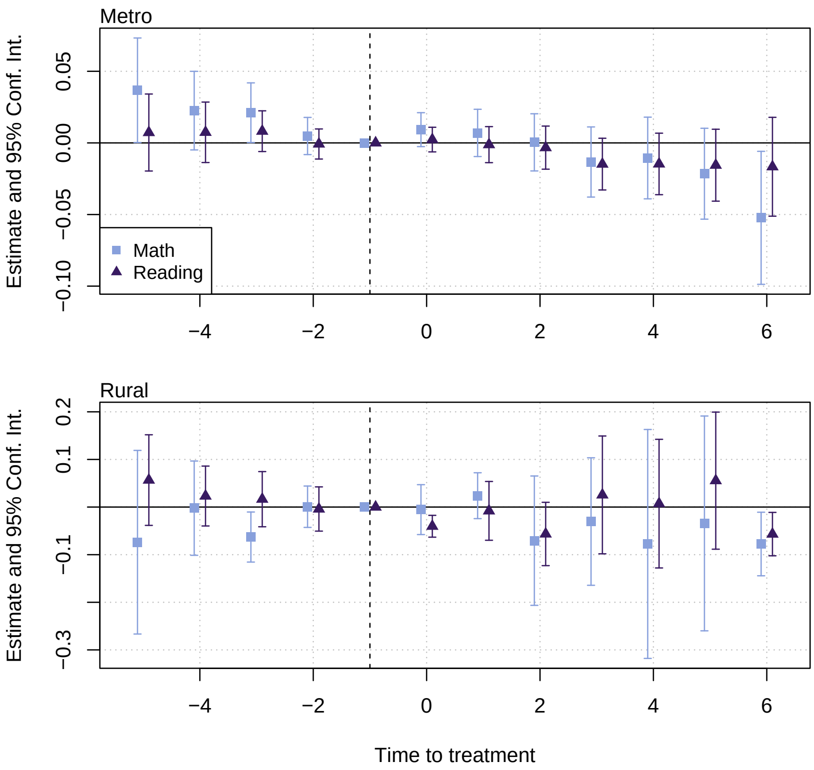
(3) Share SNAP Recipients



(4) Share BA or Higher

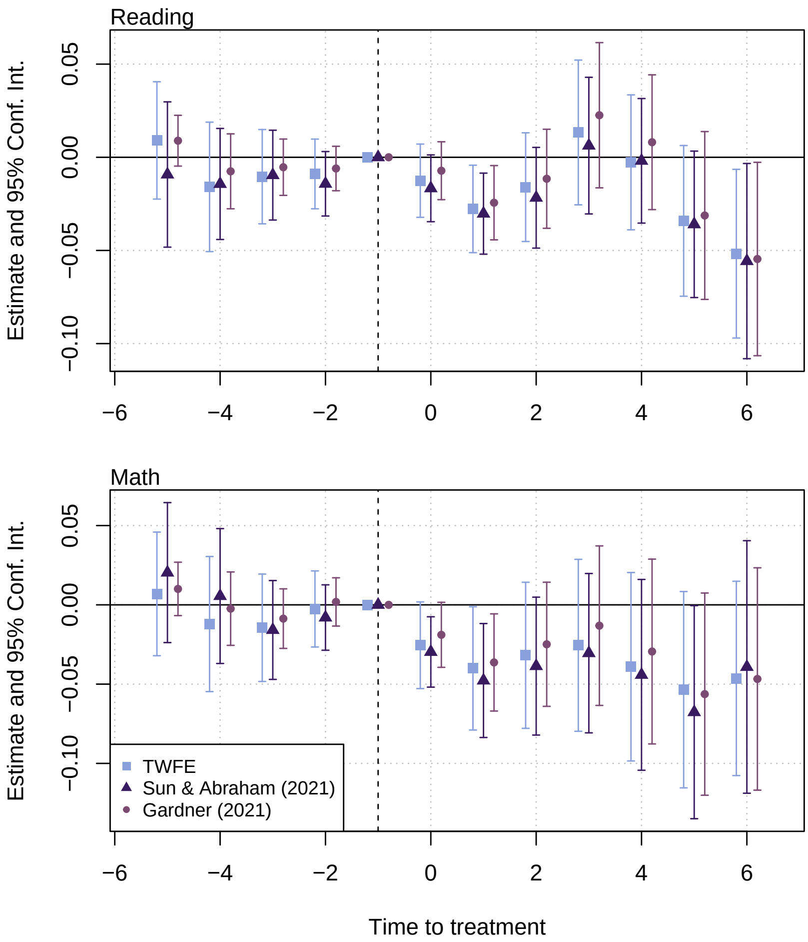
Notes: Figure B5 shows balance tests for different community characteristics using the full sample. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), and Public Library Survey (PLS).

Figure B6: Impact of Library Closures on Test Scores on Metro and Rural Areas



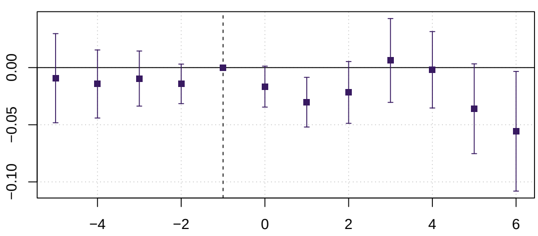
Notes: Figure B6 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator by metro and rural areas. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture (USDA), and Public Library Survey (PLS).

Figure B7: Robustness Check using Alternative Estimators

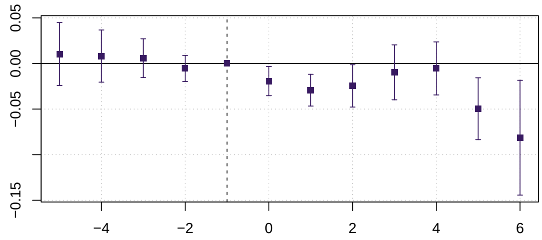


Notes: Figure B7 shows the results of the event study design specification as seen in equation (1) using TWFE, the Sun and Abraham (2021), and the Gardner (2022) estimator. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

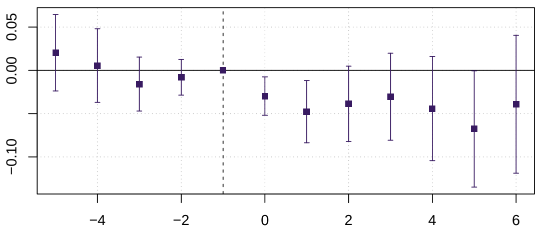
Figure B8: Impact of Library Closures on Test Scores using Student Population Weights



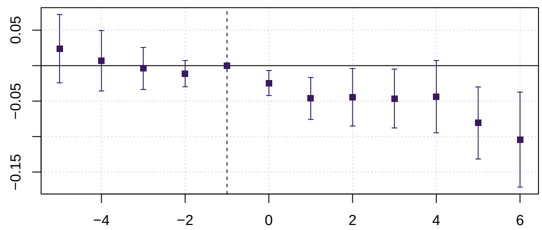
(A) No Weights, Reading



(B) Weights, Reading



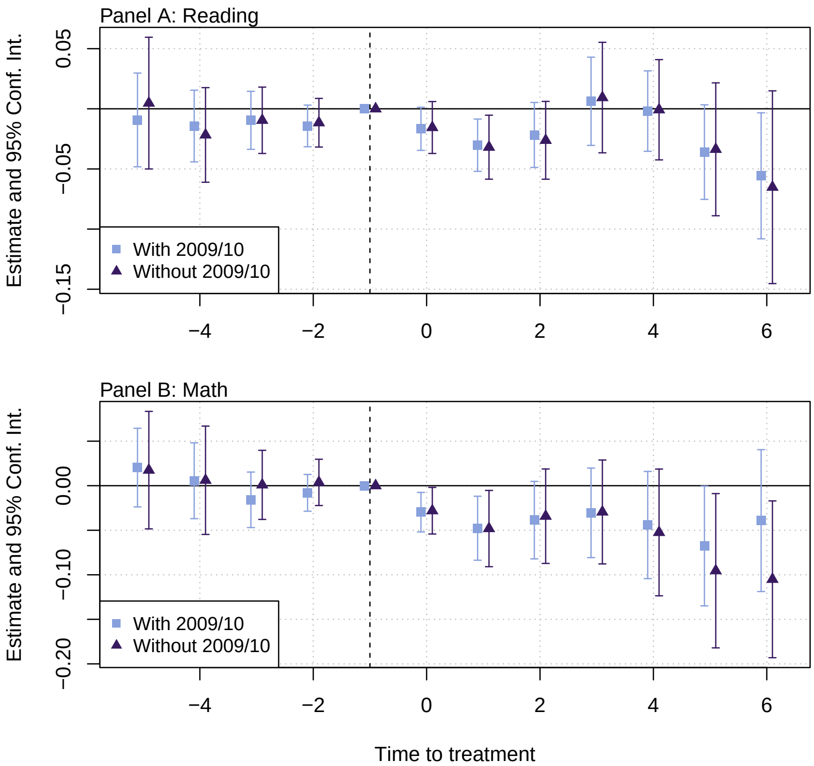
(C) No weights, Math



(D) Weights, Math

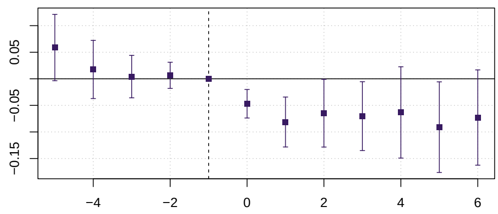
Notes: Figure B8 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Panels A and C are without weights. Panel B and D on the right-hand side are estimated using student population weights. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

Figure B9: Impact of Library Closures on Test Scores excluding the Years 2009 and 2010

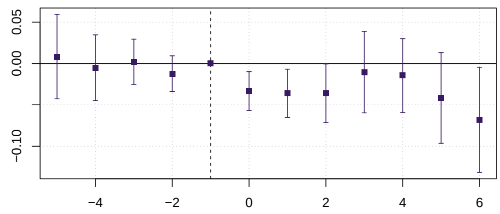


Notes: Figure B9 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator, excluding potential crisis years 2009 and 2010. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

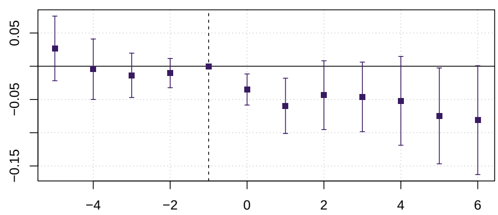
Figure B10: Impact of Library Closures on Test Scores by Varying Radius



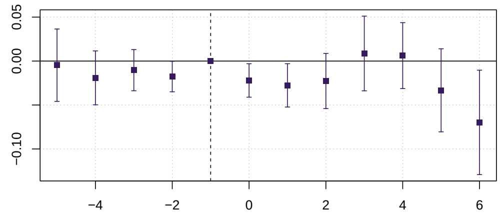
(A) No Radius, Math



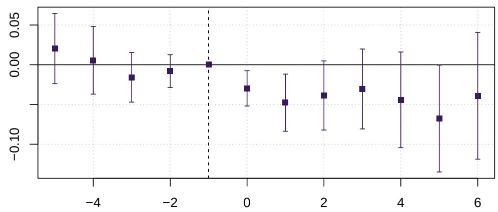
(B) No Radius, Reading



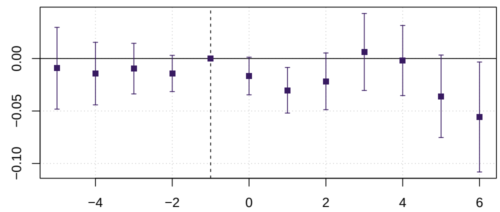
(C) 1-mile Radius, Math



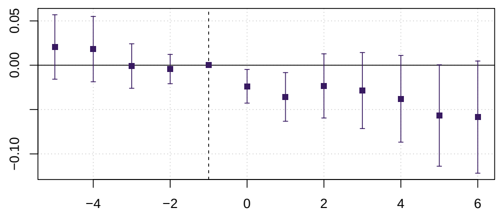
(D) 1-mile Radius, Reading



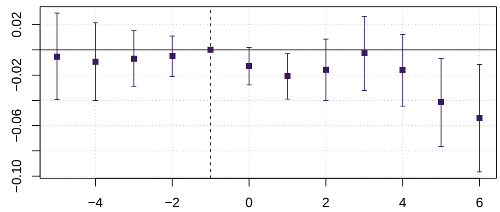
(E) 2-mile Radius, Math



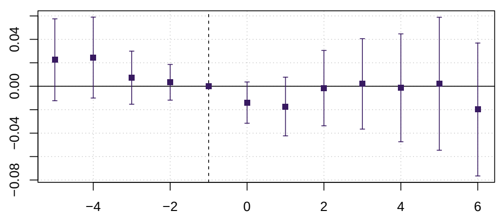
(F) 2-mile Radius, Reading



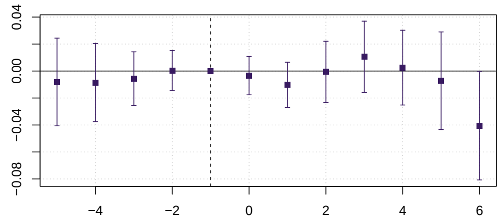
(G) 4-mile Radius, Math



(H) 4-mile Radius, Reading



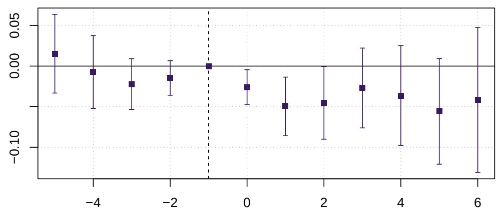
(I) 5-mile Radius, Math



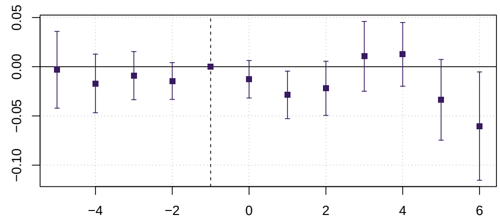
(J) 5-mile Radius, Reading

Notes: Figure B10 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator varying the treatment radius from 0 to 5 miles for school districts in urban counties. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture (USDA), and Public Library Survey (PLS).

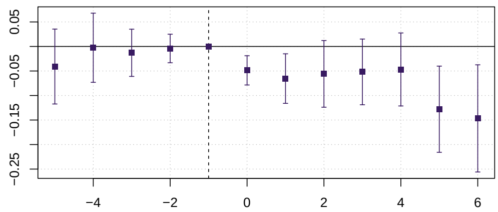
Figure B11: Impact of Library Closures on Test Scores by Race



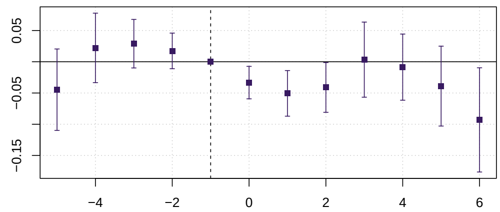
(A) White Students, Math



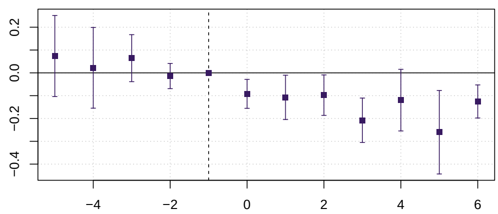
(B) White Students, Reading



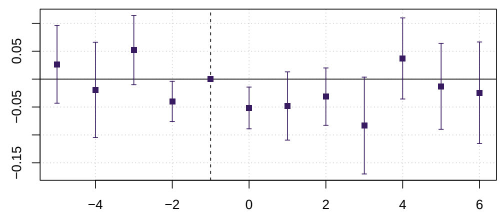
(C) Black Students, Math



(D) Black Students, Reading



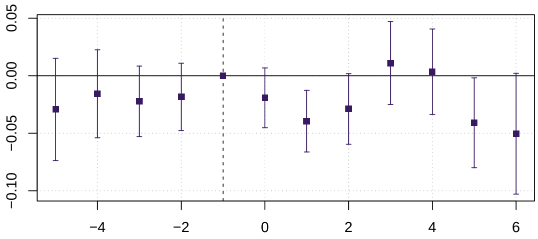
(E) Hispanic Students, Math



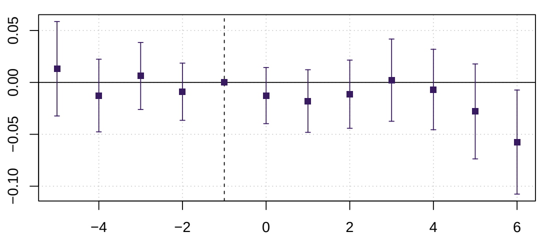
(F) Hispanic Students, Reading

Notes: Figure B11 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator by students' racial identity. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture (USDA), and Public Library Survey (PLS).

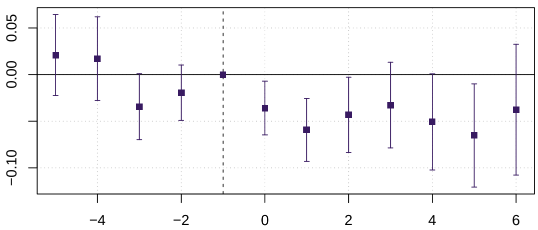
Figure B12: Impact of Library Closures on Test Scores by Grade Level



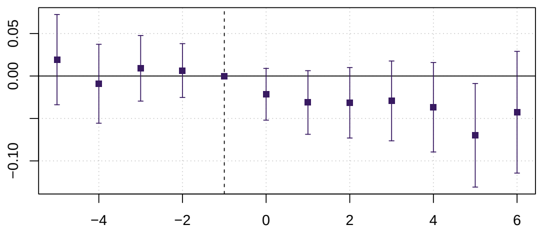
(A) Grade 3-5, Reading



(B) Grade 6-8, Reading



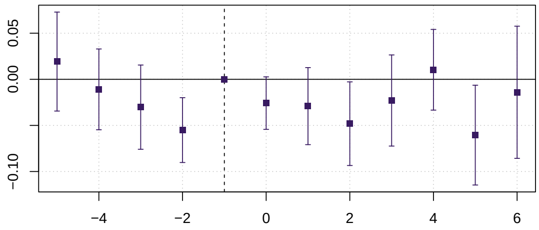
(C) Grade 3-5, Math



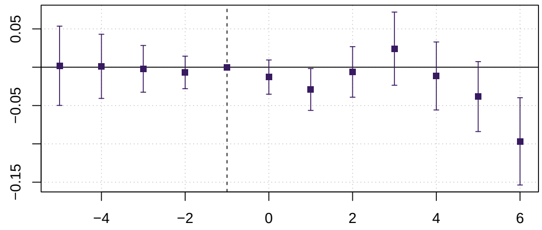
(D) Grade 6-8, Math

Notes: Figure B12 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results are estimated separately for students in grades 3 to 5 and grades 6 to 8. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

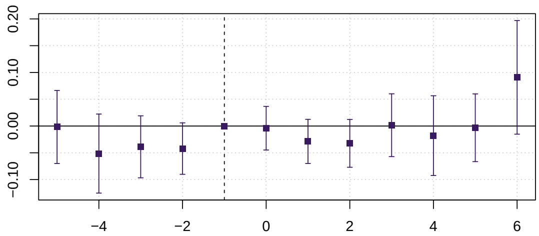
Figure B13: Impact of Library Closures on Test Scores by the Poverty Rate



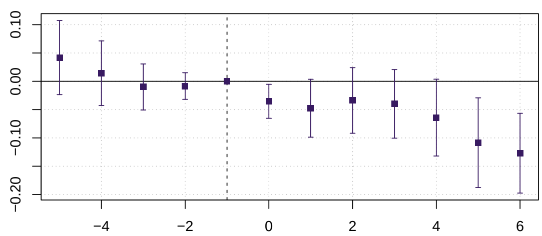
(A) Non-Poor Neighborhoods, Reading



(B) Poor Neighborhoods, Reading



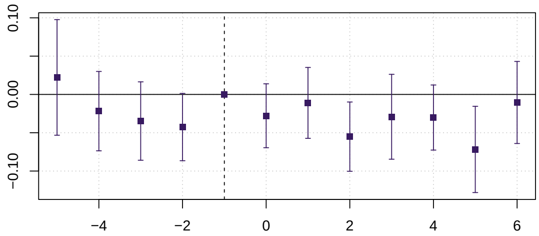
(C) Non-Poor Neighborhoods, Math



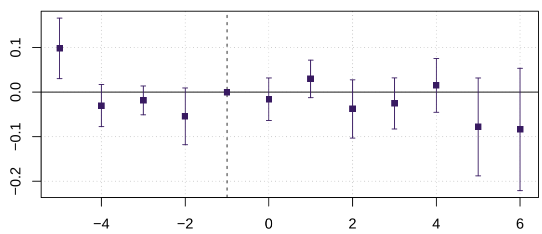
(D) Poor Neighborhoods, Math

Notes: Figure B13 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results are estimated separately for school districts with a poverty rate below the median (panels A and C), and school districts with a poverty rate above the median (panels B and D). Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

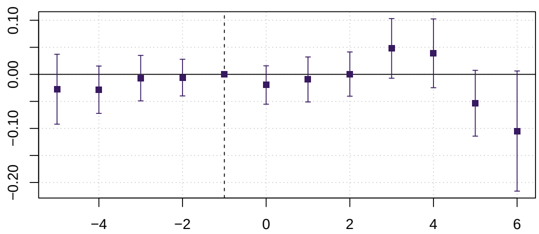
Figure B14: Impact of Library Closures on Reading Test Scores by Neighborhood and Socioeconomic Background



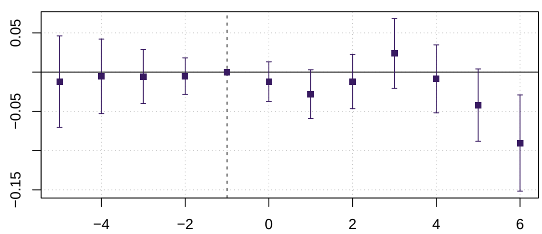
(A) Non-Poor Neighborhoods, Non-ECD



(B) Non-Poor Neighborhoods, ECD



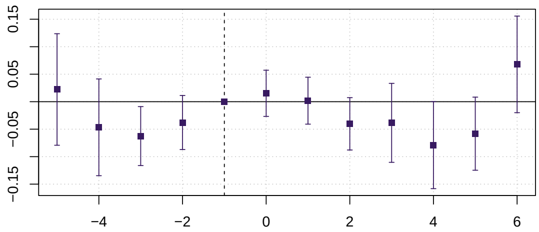
(C) Poor Neighborhoods, Non-ECD



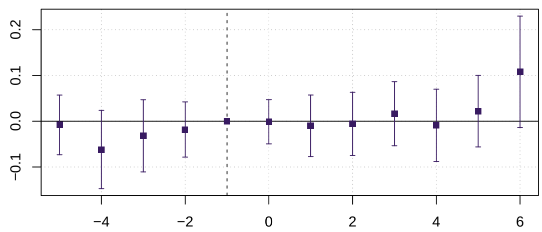
(D) Poor Neighborhoods, ECD

Notes: Figure B14 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results on reading test scores are estimated separately by economic status and neighborhood poverty. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

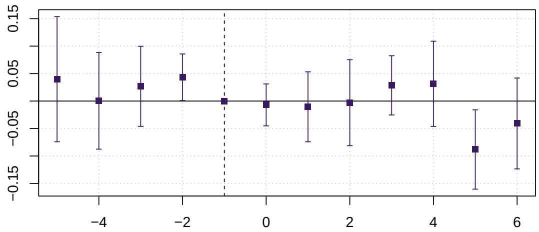
Figure B15: Impact of Library Closures on Math Test Scores by Neighborhood and Economic Status



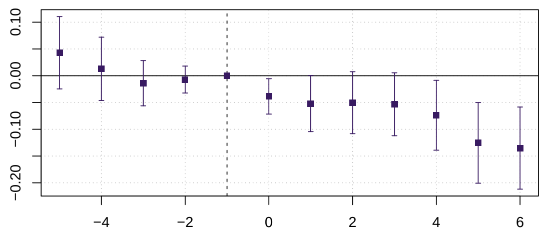
(A) Non-Poor Neighborhoods, Non-ECD



(B) Non-Poor Neighborhoods, ECD



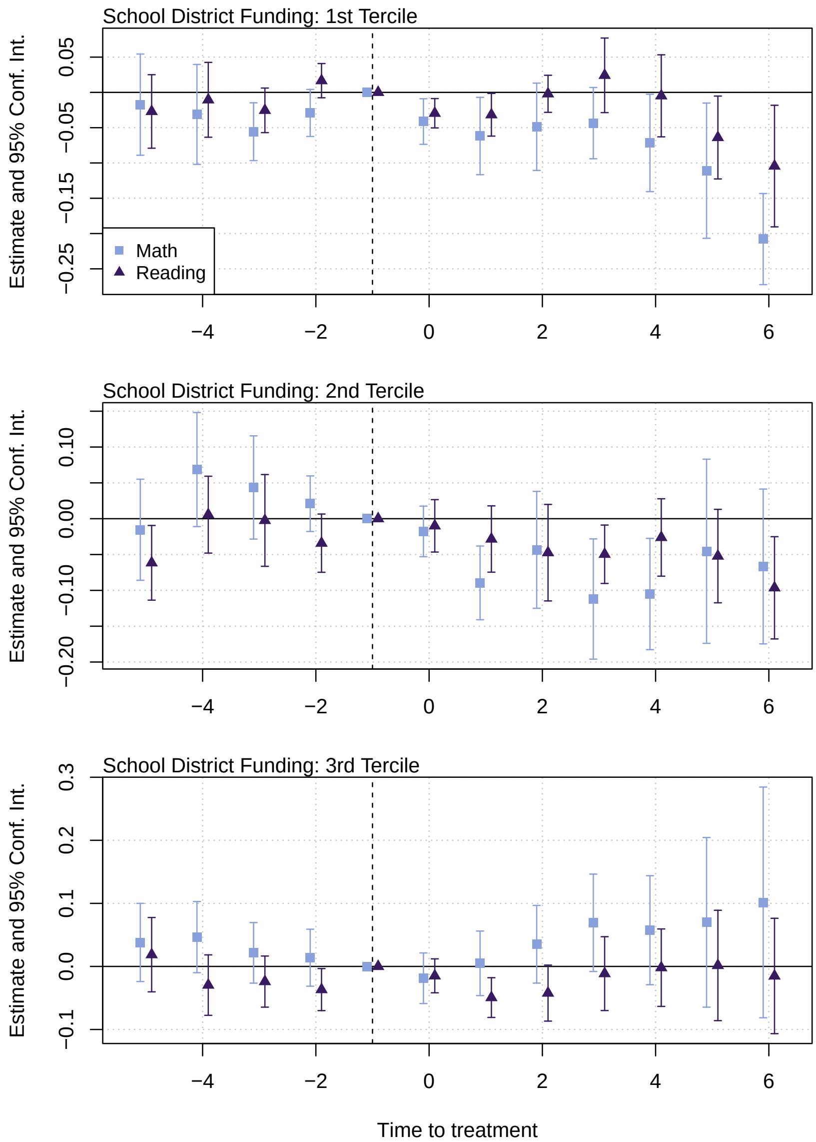
(C) Poor Neighborhoods, Non-ECD



(D) Poor Neighborhoods, ECD

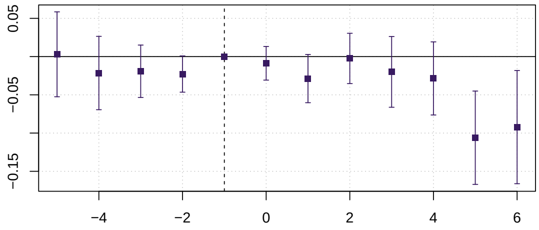
Notes: Figure B15 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results on math test scores are estimated separately by economic status and neighborhood poverty. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).

Figure B16: Impact of Library Closures on Test Scores by Annual School Funding

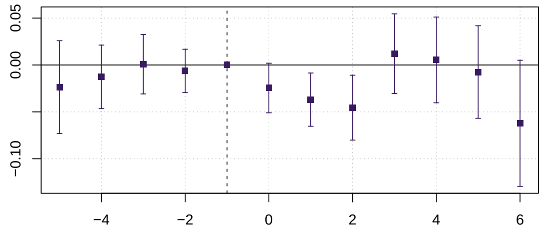


Notes: Figure B16 shows the average treatment effect on the treated (ATT) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator differentiated by annual school district funding. Panel (1) shows school districts with less than \$12,793.43 per student per year, panel (2) shows school districts with between \$12,793.43 and \$16,301.69 funding per student per year, panel (3) shows school districts with over \$16,301.69 funding per student per year. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture, Economic Research Service (ERC), and Public Library Survey (PLS).

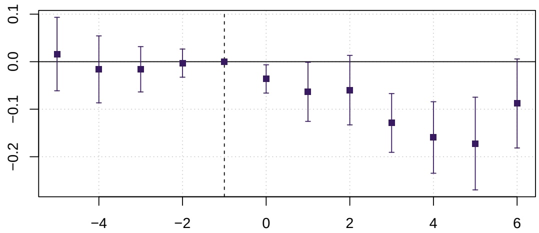
Figure B17: Impact of Library Closures on Test Scores by Number of Branches



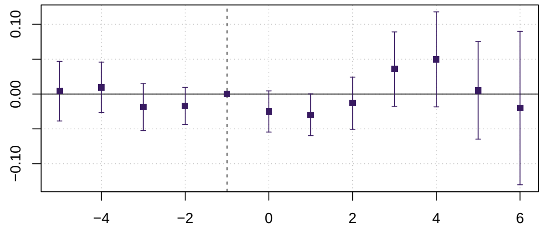
(A) Less than 3 Branches, Reading



(B) 3 or more Branches, Reading



(C) Less than 3 Branches, Math



(D) 3 or more Branches, Math

Notes: Figure B17 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results are estimated separately for school districts with one or two library branches and those with three or more branches. Pre-trends are jointly zero. *Source*: own calculations, data: Educational Opportunity Project at Stanford University (SEDA) and Public Library Survey (PLS).