Annenberg Institute
BROWN UNIVERSITY

EdWorkingPaper No. 25-1140

Unequal Access: How Public Library Closures Affect Educational Performance

Lisa Hanzl
Freie Universität Berlin

Gregory Gilpin
Montana State University

Local public institutions, such as public libraries, offer access to low-cost educational resources, potentially mitigating human capital investment disparities. However, from 2008 to 2019, 766 public library outlets closed across the US, reducing access to these critical resources. This study examines the effect of public library outlet closures on library use and educational outcomes in nearby school districts. Using geolocated data and an event study approach, we find that library use declines by 32-42%, and reading and math scores decline by 0.021 and 0.046 standard deviations, respectively, in non-metropolitan areas, although high school graduation rates remain unaffected.

VERSION: February 2025

Suggested citation: Hanzl, Lisa, and Gregory Gilpin. (2025). Unequal Access: How Public Library Closures Affect Educational Performance. (EdWorkingPaper: 25 -1140). Retrieved from Annenberg Institute at Brown University: https://doi.org/10.26300/asmz-tt79

Unequal Access: How Public Library Closures Affect Educational Performance

Lisa Hanzl[a] Gregory Gilpin[b]

January 21, 2025

Abstract

Local public institutions, such as public libraries, offer access to low-cost educational resources, potentially mitigating human capital investment disparities. However, from 2008 to 2019, 766 public library outlets closed across the US, reducing access to these critical resources. This study examines the effect of public library outlet closures on library use and educational outcomes in nearby school districts. Using geolocated data and an event study approach, we find that library use declines by 32-42%, and reading and math scores decline by 0.021 and 0.046 standard deviations, respectively, in non-metropolitan areas, although high school graduation rates remain unaffected.

Keywords: Public libraries closures, education, local public institutions, event study

Highlights:

- Between 2008 and 2019, 766 public library outlets closed across the U.S.
- Closures reduce library visits and circulation by 40-42% in non-metro areas.
- Reading and math test scores decline by -0.021 and -0.046 std. dev. post-closure.
- We find no measurable effects on high school graduation rates post-closure.

[a]Freie Universität Berlin, Garystrasse 21, 14195 Berlin, Germany. lisa.hanzl@fu-berlin.de
[b]Montana State University, P.O. Box 172920, Bozeman, MT 59717-2920, United States. gregory.gilpin@montana.edu

1 Introduction

Inequality in access to educational resources persists in the US school system, leading to significant gaps in academic outcomes for different groups of children (Blanden et al., 2023; Card & Rothstein, 2007; Reardon et al., 2019). These disparities not only exacerbate inequality in higher education opportunities and lifetime earnings but also lead to broader societal challenges, including increased crime rates and reduced civic participation (Deming, 2011; Lochner, 2011, 2020; Rumberger, 2010). Local public institutions, such as libraries, have the potential to mitigate these disparities by serving as equalizers for access to educational resources (Saez, 2021).

In the United States, public libraries play an essential role in providing low-cost educational resources, particularly through their focus on children's programming and collections. As critical components of social infrastructure, libraries offer one of the few free and universally accessible public spaces, helping to address inequalities in access to educational resources (Klinenberg, 2019). In 2018, there were 9,261 public library systems across the United States operating 15,427 branches, with combined operating costs of $12 billion dollars.[1] Patrons borrowed over 2 billion items, including 750 million materials for children, and over 80 million people attended library programs geared toward children.

This paper examines the impact of public resources on their communities, focusing on the closure of public library outlets across the U.S. Between 2008 and 2019, 766 public library outlets closed, limiting access to critical resources. These closures are particularly impactful for children due to U.S. public libraries' emphasis on children's programming and collections. On average, children's collection stock is 31% of total library collections, and 67% of library programming is geared toward children and teens (IMLS, 2024). The closure of a public library eliminates not only access to books but also study spaces, internet and computer access, interactions with librarians, and library programming such as storytimes, drop-in homework help, and study sessions. Horrigan (2015) highlights the importance of these spaces for children's development, reporting that 70% of parents express concern about the negative impacts of library closures on their children.

We investigate how public library outlet closures influence library system operations, patron use, and students' educational performance in nearby school districts across the United States. Our primary outcomes of interest include public library resource availability, library use patterns, student test scores in grades 3 to 8 (2009-18), and high school

[1] Author's calculations using the 2018 Institute of Museum and Libary Services (IMLS) Public Libraries Survey.

graduation rates (2010-19). To conduct this analysis, we combine data from the Public Libraries Survey (PLS) by the Institute of Museum and Library Services (IMLS), student achievement data from the Educational Opportunity Project at Stanford University (SEDA) and the Urban Institute, along with additional community-level characteristics. Using the geo-location of library outlet closures and a two-mile radius as treatment perimeter, we identify the causal effects of library outlet closures on educational outcomes.

We begin by examining the impact of library outlet closures on public library system capacity and use within non-metro school districts. We find substantial declines in library capacity following a library outlet closure: closures result in a 50.4% reduction in operational expenditures, along with declines in staffing, children's programming, and the number of internet-connected computers. Patron activity also decreases significantly, with library visits and circulation dropping by 40.2% and 42.3%, respectively.

Next, we show that closures lead to statistically and economically significant declines in reading and math test scores, concentrated entirely in non-metro areas. Specifically, reading and math scores of 3rd-8th graders decrease by 0.021 and 0.046 standard deviations, respectively, but these effects dissipate entirely as the distance from the school district to the closed library exceeds 4 miles. No effects on high school graduation rates are estimated.

Our analysis of heterogeneous effects reveals that Black and Hispanic students experience slightly larger declines in test scores compared to their White peers. The impact is evident across elementary and middle school levels, with economically disadvantaged students showing significant declines in math but not reading scores—likely due to targeted support in Title 1 schools. Similar patterns emerge when analyzing neighborhood poverty rates. Additionally, the effects are most pronounced in areas with low public school funding and a low library outlet density. As with the overall sample, no effects on high school graduation rates are found across subgroups.

Our analysis shows that school district and community characteristics remain remarkably stable over time. When a library outlet closes, the community experiences a loss of public space and its associated library resources, and patrons face a switching cost to another branch. These staggered closures provide quasi-experimental variation in library access, which we leverage to estimate a causal effect.

The impact of library closures varies based on the urbanicity of the school district. In metropolitan areas, closures have minimal effects due to low switching costs, as the distance to the next closest branch is relatively small. In suburban and rural areas, however, the effects are more pronounced and long-lasting. This contrast between metropolitan

and non-metro areas is expected, as suburban and rural areas often lack reliable public transportation, making it more difficult and costly to access another branch. Additionally, these areas typically have fewer library branches per square mile, disproportionately affecting access to educational resources.

This paper contributes to the literature on local public institutions and student academic performance. First, we focus on the loss of access to local public resources, which may yield larger effects than increases. Second, we leverage outlet-level library closure data, including precise latitude and longitude coordinates, to pinpoint the neighborhoods affected. Third, we employ a rigorous identification strategy that enhances the internal validity of prior research. These contributions deepen our understanding of educational disparities, highlighting the critical role of accessible public resources like libraries in supporting student outcomes.

The remainder of this paper is organized as follows: Section 2 provides an overview of the U.S. public library system. Section 3 describes the data on public libraries and educational outcomes used in our analysis. Section 4 outlines our empirical strategy and explains how library closures serve as the identification mechanism. Section 5 presents the main results, detailing the effects on public library use and student performance. Next, we discuss different robustness checks in Section 6 and provide heterogeneity analyses in Section 7. Section 8 explores the impacts on high school graduation rates. Finally, Section 9 concludes with a discussion of potential policy implications.

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

Public libraries in the U.S. play crucial roles in providing free access to information, resources, and services to communities nationwide. Established in the mid-19th century, public libraries have become vital centers for education, technology access, community engagement, and lifelong learning (Klinenberg, 2019). The first public libraries in the United States debuted in Boston in 1854, aiming to provide free access to books and educational resources. This movement gained momentum with the efforts of philanthropists such as Andrew Carnegie, who funded the construction of more than 1,600 public libraries across the country in the late 19th and early 20th century (Berkes & Nencka, 2024). These libraries form the foundation for today's expansive public library networks.

Public libraries are primarily funded by local government revenue, supplemented by state funds, federal grants, and private donations (American Library Association, 2019). Local property tax accounts for the majority of library funding. Library systems

are typically governed by boards of directors or commissions to ensure they meet the needs of their communities. On a national level, organizations like the American Library Association (ALA) and Public Library Association (PLA) advocate for libraries, provide guidelines, and support library professionals.

Modern public libraries offer a wide array of services beyond book lending. These include internet access, digital literacy training, and access to e-books and online databases. Libraries also host programs for all ages, such as storytimes for children, homework help for students, and continuing education classes for adults. Furthermore, libraries serve as community hubs, offering meeting spaces, cultural events, maker spaces, free wi-fi, and resources for job seekers and business owners.

Library closures, often due to aging facilities, budget cuts, natural disasters, or factors discussed in section 4, have significant impacts on the communities they serve. Closures limit access to essential resources, particularly for underserved populations who depend on libraries for internet access, educational support, and communal spaces. A survey by the Pew Research Center found that Hispanics, parents, and women expressed particular concern about public library closures (Horrigan, 2015).

Closures are particularly concerning in non-metropolitan areas as there are significant differences in accessibility and transportation costs between metropolitan and non-metropolitan areas, with the latter consisting exclusively of suburban and rural areas. Non-metropolitan areas are typically characterized by lower population density and fewer infrastructure resources, with suburban areas acting as transitional zones between densely populated urban centers and sparsely populated rural regions.

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. These statistics reflect the stark contrast in library access, with metropolitan residents enjoying closer proximity to library branches compared to suburban and rural residents. This translates to travel distances of 1-2 miles between branches in metropolitan areas, 4-5 miles in suburban areas, and 10-20 miles in rural areas (Donnelly, 2015).

Such distances in rural areas are further exacerbated by limited transportation options. Public transportation access is far more restricted in rural areas (10-20%) compared to metro areas (83%), with suburban regions falling in between (60-70%) (Bureau of Transportation Statistics, 2023). Moreover, public transportation services are often infrequent and less reliable (Puentes & Roberto, 2008).

To address these accessibility barriers, many rural libraries have turned to innovative alternatives, such as bookmobiles and partnerships with neighboring libraries, to deliver services. Digital services, including e-books and online databases, also play a growing

role in bridging gaps caused by physical branch closures. However, these solutions often fall short of fully replacing the comprehensive resources offered by physical libraries, especially for populations lacking reliable internet access. (IMLS, 2024).

Research supports the importance of proximity to libraries. Gilpin and Bekkerman (2020) show that increased distance from a library reduces students' library usage. Similarly, Bhatt (2010) finds that proximity to public libraries influences children's library use, which in turn affects the time they spend reading, watching television, and completing homework. Libraries also benefit communities as a whole. For example, adult programming at libraries has been linked to increased labor force participation (Ferreira Neto, 2023), and extended library hours in Los Angeles were associated with reduced crime rates (Porter, 2015). Lastly, Gilpin et al. (2024) find that an additional $200 per child investment within public library systems improves reading test scores by 0.02-0.04 standard deviations in nearby school districts.

Economic historians highlight that the expansion of public libraries in the U.S. was driven by urbanization and a diverse migrant population, underscoring the importance of these spaces for non-white communities (Kevane & Sundstrom, 2014). Beyond 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 significance of public libraries for vulnerable populations and community development.

3 Data Construction

We combine several datasets to conduct the analysis.

First, the annual Public Libraries Survey (PLS, IMLS, 2024) provides data on nearly all public library systems in the United States with a response rate of approximately 97%. The PLS comprises three companion data files. We use the PLS' *Public Library System Data File* to obtain information on library resources and patron use at the system level, such as the total librarians, total staff, operating expenditures, total visits, circulation counts, and programs offered and attended. A library system is defined as the administrative entity overseeing its outlets, with a prescribed service area. The data cover the years 2008 to 2019 and include, on average, 9,152 public library systems per year across 48 states[2].

Second, to construct our treatment variable, we use the PLS' *Public Library Outlet Data File* to identify permanently closed library outlets. This file is a directory of library

[2]We exclude Alaska, Hawaii, Puerto Rico, and other U.S. territories.

outlets, detailing their address, latitude/longitude, outlet type (e.g., 'physical outlets' such as central or branch libraries and 'non-physical outlets' such as bookmobiles and books-by-mail), administrative entity, and structure change status. The structure change variable codes outlet status changes, such as no change, opening, temporary closure, permanent closure, or merger with another administrative entity. We use this variable to identify the year an outlet becomes permanently closed and differentiate between 'physical outlets' and 'non-physical' outlets.

Third, we use district-level test scores from the Educational Opportunity Project at Stanford University (SEDA, Reardon et al., 2023). These annual data provide standardized tests for grades 3-8 in Reading Language and Arts (RLA or reading from here on) and math. States design the tests according to their standards, and the Department of Education collects the data, which SEDA processes to ensure comparability across states and over time. SEDA standardizes the test scores within subject and grade, relative to the mean of the four cohorts in 4th grade in 2009, 2011, 2013, and 2015 (Reardon et al., 2023). Test scores are centered at 0 with a standard deviation of 1, allowing results to be interpreted as changes in standard deviations. The data span the 2008/09 to 2017/18 school years and include a wide range of additional variables, such as racial composition, number of students, and socio-demographic characteristics at the district-grade level. These cohort-standardized test scores by district and grades for math and reading are our main outcome variables.

Fourth, to analyze impacts on students over age 14, we examine cohort graduation rates using U.S. Department of Education's EDFacts data provided by the Urban Institute from 2010 to 2019 (EDFacts, 2024). EDFacts provides low-end, midpoint, and high-end values of graduation rates for each school district. For our analysis, we use the midpoint values. The graduation rates analysis is presented after the test scores analysis in Section 8.

Fifth, we use various ancillary. Public school funding data and school district shapefiles come from the National Center for Education Statistics (NCES, Common Core of Data, 2019). We differentiate between school districts in metropolitan and non-metropolitan counties, the latter comprising exclusively of suburban and rural areas, using the USDA Rural-Urban Continuum Codes from the U.S. Department for Agriculture (USDA, Economic Research Service, 2013). A detailed explanation of the definitions appears in Table A1 in the Appendix. Lastly, we deflate all monetary values to 2018 dollars using CPI data from the Bureau of Labor Statistics (Bureau of Labor Statistics, 2024).

We combine these datasets using the districts' 7-digit identifiers, contained in the

SEDA and all additional datasets, but not in the PLS. To assign library outlets to district IDs, we use the NCES 2019 shapefiles and intersect the districts' multipolygons with the longitude and latitude of each library unit. 956 out of 17,896 library units do not have information on their geo-location and are therefore excluded from our analysis. In 2018, there were 18,274 districts in the contiguous United States. SEDA provides data for 12,838 of these districts, which we restrict in our main specification to a balanced panel from 2009 to 2018. This restriction includes only districts with reading or math test scores for all ten years.

The full grade 3-8 test score sample consists of 563,070 district-grade-year observations across 5,919 districts, of which 2,761 are in non-metropolitan counties. This leaves us with 136,290 district-grade-year observations for reading and 122,010 for math in our main analysis that focuses on non-metro districts, which is reduced to 135,376 and 121,191, respectively, for reading and math due to missing values in the student weight variable. Summary statistics for our main variables in non-metro districts are presented in Table A2 in the Appendix, while Table A3 provides sample means by metro, suburban, and rural areas.

To analyze high school graduation rates, we again use the 7-digit identifiers to combine the EDFacts data with the district shapefile and treatment indicators. EDFacts provides information on 10,786 districts, which we restrict to a balanced panel between 2010 and 2019. This leaves us with 80,850 district-year observations, of which 36,590 are in non-metropolitan counties. The average high school graduation rate is very similar across urbanicities, with 87.9%, as shown in Table A3.

Construction of the Treatment Variable The treatment variable indicates whether a public library outlet is permanently closed within a certain distance of a district. To construct this variable, we first layer the latitude and longitude of permanently closed outlets onto the districts' boundaries using shapefiles from the NCES (Geverdt, 2019). Next, recognizing that districts vary in size, we define a treatment radius around each closed outlet and label a district as treated if it falls within a circumscribed area. Our preferred specification defines districts as treated if they are within a two-mile radius of a library outlet closure. We also vary the treatment radius to examine how distance from an outlet closure impacts library use and student achievement.

To illustrate the data construction process, Figure 1 provides a visual representation of Connecticut and Rhode Island districts, highlighting library outlet closures during the sample period. A district's treatment status is determined by the radius around a public library outlet, ranging from zero miles (closure occurring within a district's boundaries)

to four miles. As the radius expands, more districts are classified as treated, emphasizing the role of distance and accessibility in our analysis. One caveat is that treatment radii are not permitted to cross state borders, as obtaining an out-of-state library card is often expensive, costing $50-$150 per year.[3] Panel D introduces a 4- to 10-mile treatment 'donut' which we will use in a robustness check.

The data show that 766 public library outlets closed permanently between 2008 and 2019, about 64 per year. Figure 2 displays a histogram of yearly closures and Figure A1 presents a histogram of the number of closures per district, illustrating the frequency of treatments. There is no observable time-trend in yearly outlet closures, and the vast majority of districts only experience one closure during the sample period, reducing concern about multiple treatments. Table 1 summarizes the types of library outlets and the number of closures by urbanicity. As shown in the table, 63.7% of all closures occurred in metropolitan areas, while the remaining were in suburban and rural areas. Over $2/3^{rd}$ of closures were physical outlets.

4 Methodology and Identification

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

$$y_{gdt} = \sum_{j \in -5...0...6} \gamma_j \times Closure_{d,t-j} + \alpha_{gd} + \delta_{st} + \epsilon_{dgt}, \tag{1}$$

where y_{gdt} is the cohort-standardized test score in district d for grade g in the year t, in either reading or math. $Closure_{d,t-j}$ indicates the relative timing of a library outlet's permanent closure within district d. The model includes grade-district fixed-effects, α_{gd}, and state-year fixed-effects, δ_{st}. Standard errors are clustered at the district level, as this is the level of treatment. For the analysis on high school graduation rates, the unit of analysis is at the district level. Our outcome y_{dt} represents the four-year adjusted cohort graduation rate in district d in the year t. Correspondingly, we use district fixed effects, α_d.

To address limited observations in later periods, we group the final three post-treatment periods into a single bin. The methodology proposed by Sun and Abraham

[3] As a robustness check, we allow the treatment radii to cross state borders. Estimates are very similar, see Table A6.

(2021) allows us to estimate an average treatment effect for each relative period and use these to construct cohort average treatment on the treated effects (CATTs). Student population weights are included in our estimations to account for differences in district size. The resulting coefficient estimates are comparable to those derived from other estimators, such as two-way fixed effects (TWFE) and Gardner (2022).

Identification. The PLS provides stated reasons for a library outlet dropping out of the panel. Aside from permanent closures, it documents temporary closures, mergers with other library systems, and other administrative changes.[4] Figure 3 illustrates the geographic distribution of permanent library closures in the U.S. from 2008 to 2019, showing that these closures were evenly distributed geographically. There is no evidence of significant time trends in closures, apart from a noticeable uptick following the 2007–2008 financial crisis (see Figure 2). We control for this uptick in a robustness check.

One concern for identification is the issue of outlet relocations; as these outlet status changes are not included in the PLS dataset. To address this, we exclude all permanent outlet closures if another library outlet opens in the same library system within two years after the closure. While the number of openings is similar to the number of closures in our sample, these two events are weakly correlated ($\rho = 0.04$).

Another concern is the shared funding sources for local public schools and public libraries. Both are primarily funded by local and state sources, with minimal federal funding. This overlap could pose an identification challenge, as reductions in funding for both entities could lead to declining test scores that might mistakenly be attributed to library closures rather than reduced school funding. To show that this is not an issue, we demonstrate that public school funding is not correlated with the timing of public library outlet closures. Furthermore, including school funding as a control variable in our analysis does not alter the results.

Our main identifying assumption is that treated and untreated districts follow comparable trends in the outcomes, meaning treated districts would have evolved similarly to untreated districts had a library closure not occurred.

Figure 4 compares district and community characteristics between 2009 and 2018, using 2009 as the base year and separating districts into those that experienced a permanent library outlet closure (treated group) and those that did not (control group). As shown, these characteristics evolved similarly over time, suggesting that macroeconomic trends affected all areas uniformly. We also conduct a rigorous balancing test in Section

[4]We exclude library outlets that were moved to newly created administrative units, that were incorrectly deleted at some point, and that were wrongfully reported at some point. For more details see the documentation of the 2021 PLS data.

6, which indicates no significant changes in these characteristics surrounding a closure event.

Lastly, the pre-trends of our main analyses are all statistically insignificant and jointly zero, further supporting our identifying assumption. These findings allow us to identify the causal effects of permanent library closures on students' educational performance.

5 Main Results

5.1 Impacts on Library Capacity and Use

Before presenting evidence on the effect of public library outlet closures on students' performance, we first examine their impact on public libraries. Figures 5 and 6, along with Table A4 in the Appendix, present results on library use and capacity for non-metro areas (rural and suburban). All estimations are based on Equation (1) and include outputs with 95% cluster-robust confidence intervals. To account for zeroes in the data, we log-transform the dependent variables using $log(1+y)$. We interpret the ATT estimates of a public library closure, $\hat{\gamma}$, as a $(e^{\hat{\gamma}}-1)\times 100\%$ change in the outcome measure.[5]

The results indicate that library outlet closures lead to a statistically significant reduction in library capacity and use in affected communities, as evidenced by declines observed in the post-periods. Importantly, no pre-trends are detected in the years leading up to closure, suggesting that the outcomes are not driven by pre-existing differences.

Focusing on use, the results show that library visits and circulation decreased by 40.2% and 42.3%, respectively, within non-metro communities that experienced an outlet closure. Additionally, impacts on children's library use are substantial: children's circulation dropped by 39.5%, while attendance at children's programs declined by 32.8% in these districts.[6]

The decline in library use is modest in the first year following a closure but intensifies over time. The full impact may take several years, as individuals' habit formation offsets the additional travel costs to visit another library branch. Over time, however, this behavior diminishes—likely due to changing habits and the unsustainable burden of increased travel distance—resulting in long-term reductions in library use.

Figure 5 and the lower panel of Table A4 showcase four primary measures of library capacity. The results indicate a significant decline in capacity following a library outlet closure: total staff decreases by 14.5%, operational expenditures decrease by 50.4%,

[5]Using inverse hyperbolic sine transformation yields similar results. Results are available on request.
[6]Separate suburban and rural results are available upon request.

children's programming decreases by 25.8%, and the number of internet-connected computers available by 12.6%.

The combined results show considerable reductions in library capacity and use in non-metro communities following a library outlet closure, highlighting substantially diminished access to public library resources in these areas. A separate analysis of metropolitan areas shows similar patterns, with no pre-trends observed prior to the closure and declines in library visits and circulation afterward. However, these post-closure declines are only about a third of the non-metro effect sizes, suggesting that individuals in metropolitan areas are less affected by library outlet closures and are more likely to retain comparable access relative to those in non-metro areas. These results are available upon request.

5.2 Impacts on Students' Performance

We present the main findings on the impact of library outlet closures on children's test scores. Figure 7 displays the event study plots for our main specification, estimating the effect of library closures on average grade-level reading and math test scores for students in grades 3-8 within non-metro districts. Test scores are standardized, with a one-unit increase indicating a one-standard deviation improvement.

The event study plots show the lasting negative effects of library outlet closures on students' reading and math test scores. In Panel A, reading test scores exhibit statistically insignificant pre-trends that are jointly zero. During the first year following a closure, reading test scores decline by 0.014 standard deviations, declining further to 0.024 standard deviations during the second and third years post-closure. Scores then begin to recover but generally remain below pre-closure levels. The slight improvement in reading test scores observed in years 3-5 may reflect increased unobserved school administrator and teacher effort. Overall, library outlet closures result in an approximate 0.021 standard deviation decline in reading test scores.

In Panel B, math test scores drop by 0.021 standard deviations in the first year following closure and further to 0.047 standard deviations during the second year. This negative impact persists through years 3-6. The math test scores similarly show no significant pre-trends. The overall decline in math test scores is approximately 0.046 standard deviations as a result of a library outlet closure.

While both reading and math test scores are negatively affected, the impact on math test scores is larger than the effect on reading. Throughout this study, we find that math test scores consistently show stronger effects than reading scores, in line with prior re-

search indicating larger effects of educational interventions on math outcomes than on reading (Jackson et al., 2014). This disparity may highlight the importance of public library spaces beyond books, as math often requires a more structured study environment. Additionally, reading interventions may be more easily supported at home than math interventions. For example, districts may encourage students to check out books from school libraries or promote reading activities at home, whereas math assignments may require additional resources or skills that parents are less equipped to provide, especially with Common Core math standards and updated curriculum.

Table 2 presents the ATTs of the event study estimates for reading and math test scores separately for metro, non-metro, suburban, and rural districts. The results show that the negative effects are entirely concentrated in non-metro districts, which include suburban and rural areas. These areas are particularly susceptible to the loss of public library outlets due to lower library branch density and limited public transportation, consistent with these vulnerabilities highlighted by this research. The effects of library closures on test scores are consistent across suburban and rural areas. While the signs and magnitudes of effect are similar, the results for rural districts exhibit larger standard errors due to the smaller number of treated rural districts, which substantially reduces statistical power. Consistent with the findings on library capacity and use, no significant effects on math or reading test scores are observed in metropolitan districts.

6 Robustness

We now demonstrate the robustness of our main test score results. First, we show that community and district characteristics do not affect the results. Second, we show the results remain consistent across alternative specifications and estimators. Third, we establish that proximity to library outlet closure plays a significant role in the observed effects.

6.1 Balancing Tests

The primary identifying assumption for the empirical design is the presence of parallel trends: in the absence of treatment, the average difference between the treatment and control groups would remain constant over time. We have demonstrated that pre-trends in the outcomes of interest are small and statistically indistinguishable from zero. Additionally, Figure 4 shows that district and community characteristics follow similar trends across the sample period. In this section, we further show that these characteristics do

not influence the results.

First, we demonstrate that district characteristics are similarly unaffected by library outlet closures. Figure 8 provides event studies for district characteristics, including public school funding, the number of public school librarians and media specialists (full-time equivalents), and the shares of Black and economically disadvantaged students. The results reveal no discernable pre-trends and no statistically significant impacts on these school characteristics post-event. Notably, the findings for school librarians indicate that school libraries cannot fully compensate for the loss of public library services from outlet closures.

Second, Figure 9 displays event study plots using community characteristics as outcomes. The results indicate that 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 significantly due to outlet closures. Furthermore, there are no discernable pre-trends or post-trends in any of these characteristics. These findings suggest that the timing of the public library closures is plausibly independent of local changes in community characteristics.

In sum, the results demonstrate that observable district and community characteristics remain unchanged before and after public library outlet closures.[7]

6.2 Alternative Specifications and Estimation Approaches

The results of alternative specifications are presented in Table 3. In column (2), we include grade-year fixed effects, δ_{gt}, and subject-year fixed effects, δ_{st}, to capture additional variation. In column (3), we add a set of control variables, including 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 at the district-year level. Additionally, we include grade-district-year control such as the share of Black and Hispanic students. In column (4), we combine the more restrictive fixed effects with these controls. Across all specifications, the impact of public library outlet closures remains statistically significant, and the magnitude of effects remains roughly constant, suggesting that unobservables are unlikely to bias our results.

Next, we estimate our main specification using alternative estimators, Gardner (2022) and a two-way fixed effects model to validate our findings. The results of these estimations are displayed in Figure A2. As shown, the results are robust to these alternative estimators, with similar pre- and post-trends. As another robustness check, we exclude

[7]The balancing tests for the metro districts are available upon request.

student weights and find that the magnitude of our coefficients remains consistent for the non-metro sample (see Table A5). Additionally, we relax the assumption that only districts within the same state as the library closure are treated by extending the treatment across state borders. Table A6 in the Appendix shows adjustment does not influence our results.

To assess whether our results are driven by outlet closures following the Great Recession of 2007-09, we exclude the years 2009 and 2010 and re-estimate the main specification—these years had more outlet closures than other periods within the sample. The results, displayed in Figure A3, remain consistent.

Finally, we estimate the model using different distances for the treatment radius. As displayed in Figure 1, we vary the treatment radius as follows: (A) 0 miles (closure within the district), (B) 2 miles, (C) 4 miles, and (D) a concentric circle 'donut' that treats districts 4-10 miles away from the library outlet closure while excluding districts within the 4-mile radius. These estimation results are displayed in Table 4 and indicate that the farther an outlet closure occurs from the district, the smaller the effect on test scores. This highlights the importance of the accessibility of library outlets. Figure A4 in the Appendix shows the event study graphs for these estimations, which again clearly illustrate the weakening of the impact with increases in distance. The placebo treatment of districts 4-10 miles away shows no significant impact of outlet closures on test scores of any magnitude.

7 Heterogeneity Analysis

To investigate the effects of library closures across different subgroups, we conduct heterogeneity analyses based on students' characteristics—such as race, grade level, and economic disadvantage—and then by community characteristics—such as neighborhood poverty, public school funding, and public library density.

7.1 Students' Characteristics

Race. The heterogeneity analysis by race reveals significant negative effects for all groups, with notable differences in the magnitudes of effect for Black, Hispanic and White students.[8] Consistent with our main specification, the ATTs in Figure 10 indicate that math test scores are more strongly affected across all groups than reading test scores.

[8]We are unable to estimate the impact on Asian students due to the small Asian sample size—708 and 713 district-grade-year observations, respectively, for reading and math.

Among math outcomes, the effect size for Black students is slightly larger than for White students and nearly twice as large for Hispanic students.

While prior research by Gilpin et al. (2024) suggests that public library infrastructure projects, on average, do not significantly benefit Black or Hispanic students, our results show that closures have a substantial negative impact on these groups. Several factors may contribute to this discrepancy. First, in the South—where a larger proportion of the Black population resides—residents tend to live farther from library outlets compared to those in the North (Donnelly, 2015). As a result, a library closure in these areas exacerbates the challenge of accessing alternative outlets. Second, public library closures may disproportionately affect racial groups that rely more heavily on library services. For instance, a Pew Research Center survey on public library use (Horrigan, 2015) found that nearly 80% of Hispanics stated that a library outlet closure would considerably impact their community. The survey also revealed that Hispanics stated they value public library services more highly than other racial groups, which might explain the pronounced effects on Hispanic students' test scores. However, because the PLS does not provide demographic-specific library use data, we cannot analyze changes in library use among subpopulations when an outlet closes.

We also estimate heterogeneous effects using the extended specification that includes student and community controls. These analyses, available upon request, show that the inclusion of these controls does not alter our findings. This supports that the observed heterogeneities are driven by differences in effects across groups rather than by the characteristics in our controls.

Grade Level. Library closures may affect children of various ages differently, as the types of books and programming offered by libraries vary by age group. For instance, elementary-aged children tend to read a higher quantity of shorter books compared to middle-school-aged children. On the other hand, the decrease in access may have similar impacts on both groups. According to Horrigan (2015), 70% of parents with minors express concern about library closures, emphasizing the critical role these spaces play in children's development and education. Figure 11 displays the results by school level, showing that test scores at elementary schools (grades 3-5) and middle schools (grades 6-8) are similarly impacted.

Economic Disadvantage. The SEDA data provides test score information disaggregated by economic disadvantage, allowing us to analyze how library outlet closures impact students differently based on their economic status. On the one hand, higher-

income families tend to use public libraries more (Gilpin & Bekkerman, 2020). On the other hand, the resources provided by libraries may offer greater value-added benefits for lower-income families (Horrigan, 2015). Consequently, the loss of library resources could have significant impacts on children from both high- and low-income households. To explore this, we differentiate between the test scores of economically disadvantaged students (ECD) and those who are not (Non-ECD).

The results in Figure 12 show a larger decline in reading scores for non-ECD students, while math scores are similarly affected for both groups. As high-income families tend to use libraries more frequently, the loss of access has a greater impact on their children.

7.2 School District and Library Characteristics

Neighborhood. In the following section, we further examine these differential impacts by analyzing the intersection of students' economic status and the average poverty rate of neighborhoods where their schools are located. We estimate the main specification separately for districts with varying socioeconomic statuses, using the community-level poverty rate. Districts are divided into three groups based on terciles of their 2009 poverty rates.

The findings, presented in Table 5, and the event study graphs in Figure A5, show that the effect of a library closure are similar across communities, with magnitudes of approximately 0.03 standard deviations for reading test scores and 0.04 standard deviations for math test scores, although the effects are not consistently significant at 95% confidence levels. However, reading test scores of students in the poorest districts appear to be less affected, with a reduction of only 0.01 standard deviations. These results align with the findings for economically disadvantaged students in the previous section.

We further study whether economically disadvantaged students are differentially impacted based on the poverty levels of their neighborhoods. To do so, we differentiate, first, by the district's poverty level and, second, by students' economic disadvantage status. Table 6 provides the results and shows no clear evidence of heterogeneity in the impact based on either individual economic disadvantage or community poverty. The event study graphs can be found in the Appendix in Figure A6 for reading and Figure A7 for math.

We conclude that children across all districts appear to be impacted similarly by library outlet closures, regardless of individual or community poverty indicators.

Public School Funding. We now turn to the role of public school funding and whether children in higher-funded public schools are impacted differentially from those in lower-funded public schools. Public schools may mitigate and offset the negative impact of public library outlet closures. We expect well-funded districts to show smaller or insignificant effects of library closure on math and reading test scores. To examine this, we divide districts into terciles based on the annual school funding per student in 2008. Table 7 and Figure A8 in the Appendix show that districts with the lowest annual funding experience statistically significant reductions in reading and math test scores of 0.022 and 0.069 std. dev., respectively. Districts with medium and high school funding show no statistically significant effects on math and reading test scores.

Density of Library Outlets. The impact of library closure on test scores might depend on the availability of alternative library outlets. We expect a closure in districts with fewer library outlets per square mile to have more severe effects compared to those with high library density. To test this, we split the sample into terciles based on library density, focusing exclusively on suburban districts to avoid confounding differences between suburban and rural areas. Table 8 reports the ATTs for these groups, with event study plots in Figure A9 in the Appendix. For reading and math scores, the effects are largest in districts with the lowest library density and diminish to a precise zero as density increases. The impact on reading scores, however, is not statistically significant. In contrast, math scores in low library outlet districts decline by -0.054 standard deviations. These findings highlight the importance of library accessibility, as greater availability of alternatives counteracts the negative consequences of library closures.

8 High School Graduation Rates

We now focus on high school students and investigate the impact of library closures on their outcomes. Specifically, we estimate the effect on graduation rates using the baseline estimation Equation (1). The analysis is conducted at the district level, and as such, we use district-level fixed effects in lieu of grade-district fixed effects.

As shown in Figure 13, the closure of a library outlet does not significantly affect high school graduation rates. Panel A shows post-period effects that are close to zero, and all are statistically insignificant. Subsample analysis by student race and economic disadvantage similarly reveal no measurable impacts.

There are several reasons likely explaining these findings. First, high schools often remain open after regular school hours, allowing students to gain teacher assistance and

access to study spaces. Second, library programming typically targets younger children, meaning high school students may rely less on these resources. Finally, high school students are generally more mobile and can better visit alternative library outlets.

9 Conclusion

Local public institutions play a vital role in shaping and supporting their communities, and public libraries are among the most significant of these anchoring institutions. This paper provides some of the first evidence of the negative consequences of losing public library access on children's human capital development. Specifically, we highlight the critical importance of public library accessibility by examining the impact of library outlet closures on library use and children's test scores.

Local policymakers frequently face difficult trade-offs between maintaining funding for public libraries and allocating resources to other essential public services. Our findings demonstrate the causal and significant effects of library outlet closures in non-metropolitan areas, including substantial reductions in library use and reading and math test scores. These effects are not confined to a single demographic; they cut across racial groups and are particularly pronounced among Black and Hispanic students. Importantly, these declines are not attributable to changes in community demographics, student populations, or public school funding.

These results have significant policy implications: there is no cost-free solution to closing public library outlets. Public libraries are essential components of social infrastructure, and policymakers must consider the broader consequences of reducing access to these critical resources. Strengthening public libraries through increased funding and support not only addresses educational disparities but also helps mitigate other dimensions of inequality, given the diverse services and resources libraries provide to their communities.

Acknowledgements. We want to thank Jan Bietenbeck, Natalia Danzer, Olivier Marie, Jan Marcus, Max Steinhardt, Marc Bachmeier, Klara Kinnl, Alexander Obermueller, and all participants of the 13th ifo Dresden Workshop on Labor Economics and Social Policy, the 17th RGS Doctoral Conference in Economics, the BeNA 20-Year Jubilee Conference, the 2nd Essex PhD Conference in Applied Economics, the 2nd FU Berlin PhD Workshop in Applied Microeconomics, the 37th Annual Conference of the ESPE, the 39th Annual Meeting of the EEA as well as those of the 36th Annual Conference of the EALE for their valuable feedback and insights.

References

Aabø, S. (2005). Valuing the Benefits of Public Libraries. *Information Economics and Policy*, *17*(2), 175–198. https://doi.org/10.1016/j.infoecopol.2004.05.003

American Library Association. (2019). Library Funding. Retrieved June 25, 2024, from https://www.ala.org/advocacy/library-funding

Berkes, E., & Nencka, P. (2024). Knowledge Access: The Effects of Carnegie Libraries on Innovation. *The Review of Economics and Statistics*, 1–45. https://doi.org/10.1162/rest_a_01446

Bhatt, R. (2010). The Impact of Public Library Use on Reading, Television, and Academic Outcomes. *Journal of Urban Economics*, *68*(2), 148–166. https://doi.org/10.1016/j.jue.2010.03.008

Blanden, J., Doepke, M., & Stuhler, J. (2023). Educational Inequality. In *Handbook of the Economics of Education* (pp. 405–497, Vol. 6). Elsevier.

Bureau of Labor Statistics. (2024). Consumer Price Index for All Urban Consumers (CPI-U). Retrieved December 13, 2024, from https://data.bls.gov/timeseries/CUUR0000SA0

Bureau of Transportation Statistics. (2023). Commute Mode. Retrieved September 26, 2024, from https://www.bts.gov/browse-statistical-products-and-data/state-transportation-statistics/commute-mode

Card, D., & Rothstein, J. (2007). Racial Segregation and the Black–White Test Score Gap. *Journal of Public Economics*, *91*(11-12), 2158–2184. https://doi.org/10.1016/j.jpubeco.2007.03.006

Common Core of Data. (2019). Local Education Agency (School District) Universe Survey, 2009 to 2018. Retrieved June 25, 2024, from https://nces.ed.gov/ccd/pubagency.asp

Deming, D. J. (2011). Better Schools, Less Crime? *The Quarterly Journal of Economics*, *126*(4), 2063–2115. https://doi.org/10.1093/qje/qjr036

Donnelly, F. P. (2015). Regional Variations in Average Distance to Public Libraries in the United States. *Library & Information Science Research*, *37*(4), 280–289. https://doi.org/10.1016/j.lisr.2015.11.008

Economic Research Service. (2013). Rural-urban Continuum Codes. Retrieved September 14, 2024, from https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/

EDFacts. (2024). Education Data Portal (Version 0.22.0). Retrieved November 26, 2024, from https://educationdata.urban.org/documentation/

Ferguson, S. (2012). Are Public Libraries Developers of Social Capital? A Review of their Contribution and Attempts to Demonstrate It. *The Australian Library Journal*, *61*(1), 22–33. https://doi.org/10.1080/00049670.2012.10722299

Ferreira Neto, A. B. (2023). Do Public Libraries Impact Local Labour Markets? Evidence from Appalachia. *Spatial Economic Analysis*, *18*(2), 216–238. https://doi.org/10.1080/17421772.2022.2123552

Gardner, J. (2022). Two-stage Differences in Differences. *arXiv*. https://doi.org/10.48550/ARXIV.2207.05943

Geverdt, D. E. (2019). Education Demographic and Geographic Estimates Program (EDGE): Composite School District Boundaries File Documentation, 2018 (NCES 2017-035. *National Center for Education Statistics*. Retrieved March 11, 2024, from https://nces.ed.gov/programs/edge/Geographic/DistrictBoundaries

Gilpin, G., & Bekkerman, A. (2020). Households' Public Library Use Across the School Calendar. *Library & Information Science Research*, *42*(2), 101012. https://doi.org/10.1016/j.lisr.2020.101012

Gilpin, G., Karger, E., & Nencka, P. (2024). The Returns to Public Library Investment. *American Economic Journal: Economic Policy*, *16*(2), 78–109. https://doi.org/10.1257/pol.20210300

Horrigan, J. B. (2015). Libraries at the Crossroads. Retrieved September 12, 2024, from https://www.pewresearch.org/internet/2015/09/15/libraries-at-the-crossroads/

IMLS. (2024). Public Library Survey. Retrieved March 15, 2024, from https://www.imls.gov/research-evaluation/data-collection/public-libraries-survey

Jackson, C. K., Rockoff, J. E., & Staiger, D. O. (2014). Teacher Effects and Teacher-related Policies. *Annual Review of Economics*, *6*(1), 801–825. https://doi.org/10.1146/annurev-economics-080213-040845

Johnson, C. A. (2010). Do Public Libraries Contribute to Social Capital?: A Preliminary Investigation into the Relationship. *Library & information science research*, *32*(2), 147–155. https://doi.org/10.1016/j.lisr.2009.12.006

Kevane, M., & Sundstrom, W. A. (2014). The Development of Public Libraries in the United States, 1870–1930: A Quantitative Assessment. *Information & Culture*, *49*(2), 117–144. https://doi.org/10.7560/IC49201

Klinenberg, E. (2019). *Palaces for the People: How Social Infrastructure Can Help Fight Inequality, Polarization, and the Decline of Civic Life*. Broadway Books.

Lochner, L. (2011). Chapter 2–Nonproduction Benefits of Education: Crime, Health, and Good Citizenship. In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Hand-*

book of The Economics of Education (pp. 183–282, Vol. 4). Elsevier. https://doi.org/10.1016/B978-0-444-53444-6.00002-X

Lochner, L. (2020). Chapter 9–Education and Crime. In S. Bradley & C. Green (Eds.), *The Economics of Education* (Second Edition, pp. 109–117). Academic Press. https://doi.org/10.1016/B978-0-12-815391-8.00009-4

Porter, A. J. (2015). *Essays in Crime and Behavior* [Doctoral dissertation, UC Irvine].

Puentes, R., & Roberto, E. (2008). Commuting to Opportunity: The Working Poor and Commuting in the United States. Retrieved September 26, 2024, from https://www.brookings.edu/articles/commuting-to-opportunity-the-working-poor-and-commuting-in-the-united-states/

Reardon, S., Fahle, E., Ho, A., Shear, B., Kalogrides, D., Jang, H., Chavez, B., & Saliba, J. (2023). Stanford Education Data Archive (SEDA). https://doi.org/10.25740/DB586NS4974

Reardon, S., Kalogrides, D., & Shores, K. (2019). The Geography of Racial/Ethnic Test Score Gaps. *American Journal of Sociology*, *124*(4), 1164–1221. https://doi.org/10.1086/700678

Rumberger, R. W. (2010). Education and the Reproduction of Economic Inequality in the United States: An Empirical Investigation. *Economics of Education Review*, *29*(2), 246–254. https://doi.org/10.1016/j.econedurev.2009.07.006

Saez, E. (2021). Public Economics and Inequality: Uncovering our Social Nature. *AEA Papers and Proceedings*, *111*, 1–26. https://doi.org/10.1257/pandp.20211098

Stenstrom, C., Cole, N., & Hanson, R. (2019). A Review Exploring the Facets of the Value of Public Libraries. *Library Management*, *40*(6/7), 354–367. https://doi.org/10.1108/LM-08-2018-0068

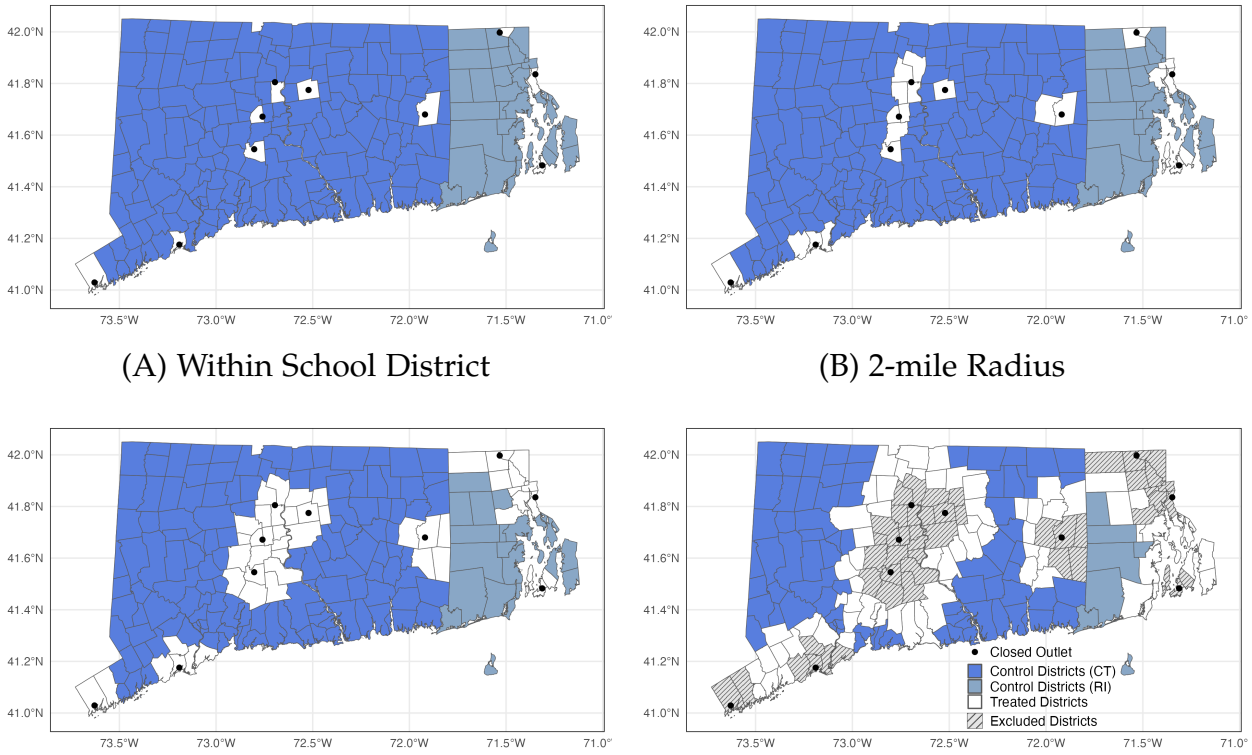
Sun, L., & Abraham, S. (2021). Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects. *Journal of Econometrics*, *225*(2), 175–199. https://doi.org/10.1016/j.jeconom.2020.09.006

Vårheim, A., Steinmo, S., & Ide, E. (2008). Do Libraries Matter? Public Libraries and the Creation of Social Capital. *Journal of Documentation*, *64*(6), 877–892. https://doi.org/10.1108/00220410810912433

Wojciechowska, M. (2020). Social Capital, Trust and Social Activity among Librarians: Results of Research Conducted in 20 Countries across the World. *Library & Information Science Research*, *42*(4), 101049. https://doi.org/10.1016/j.lisr.2020.101049

Tables and Figures

Figure 1: District Treatment Status by Distance from Library Outlet Closure, Rhode Island and Connecticut



(A) Within School District

(B) 2-mile Radius

(C) 4-mile Radius

(D) 4 to 10-mile Donut

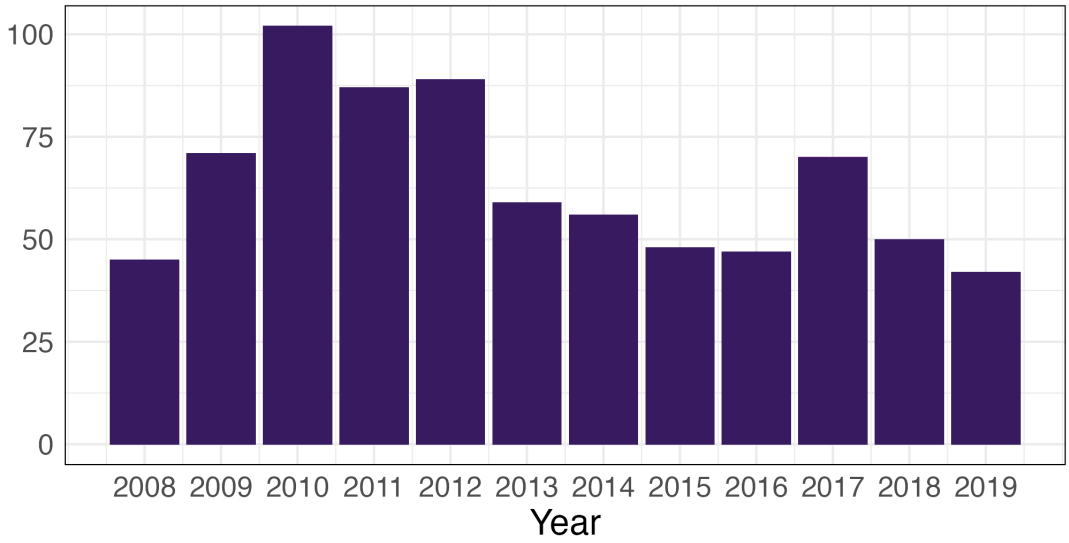
Notes: Shows school district treatment status based on proximity to library outlet closures, from 0 miles (within district boundaries) to 10 miles. Authors' calculations using PLS data and NCES school district shape files.

Table 1: Permanent Library Outlet Closures by Urbanicity

	Total Number of Closures			
Library Outlet	Metro	Suburban	Rural	All
Physical Library Branch	339	139	62	540
Non-Physical Library Branch	149	65	12	226
All Closures	488	204	74	766

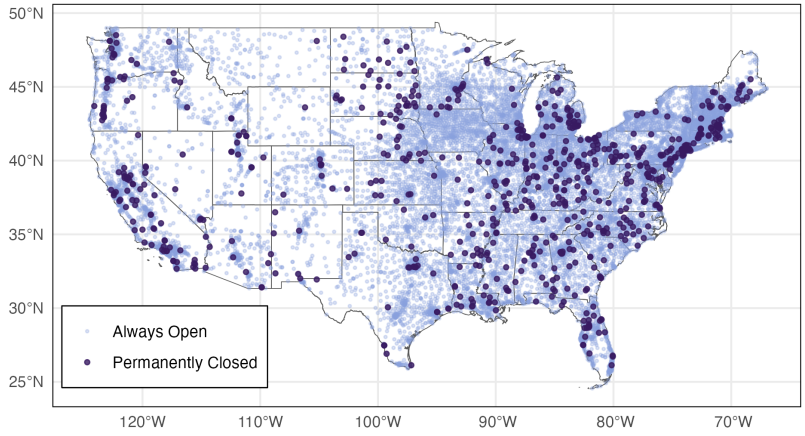
Notes: Closures between 2008 and 2019. Authors' calculations using PLS and USDA data.

Figure 2: Permanent Public Library Outlet Closures, 2008 to 2019



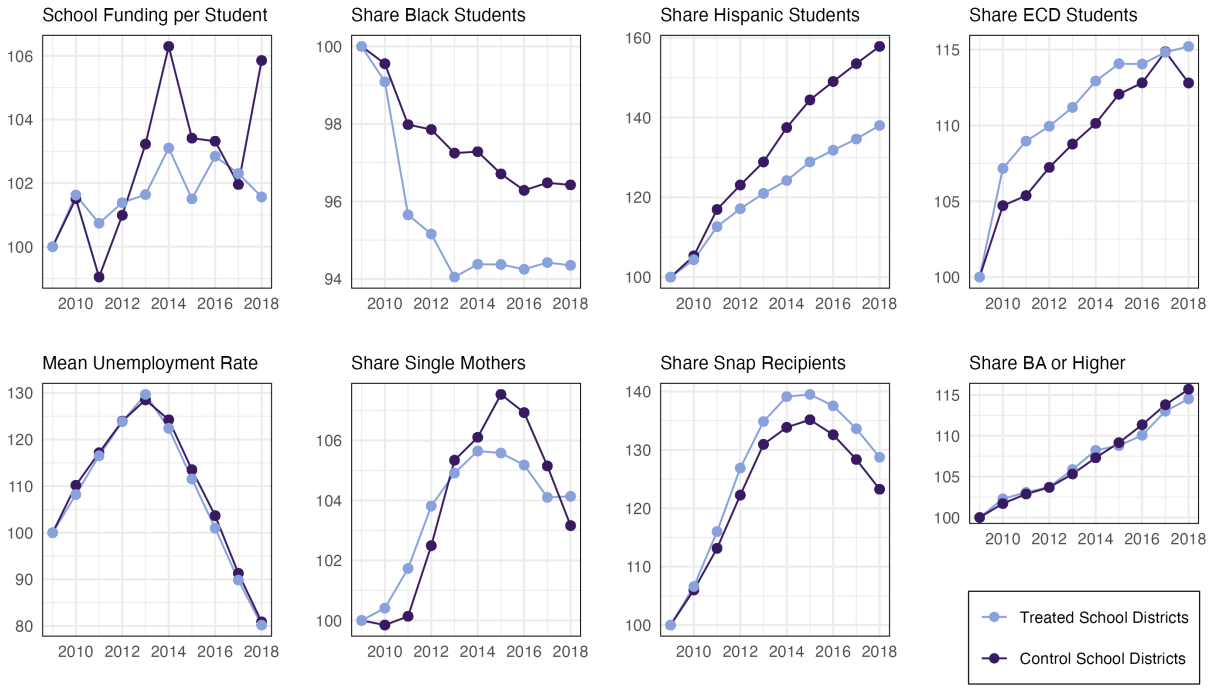
Note: Authors' calculations using PLS data.

Figure 3: Locations of Public Library Outlets between 2008 and 2019



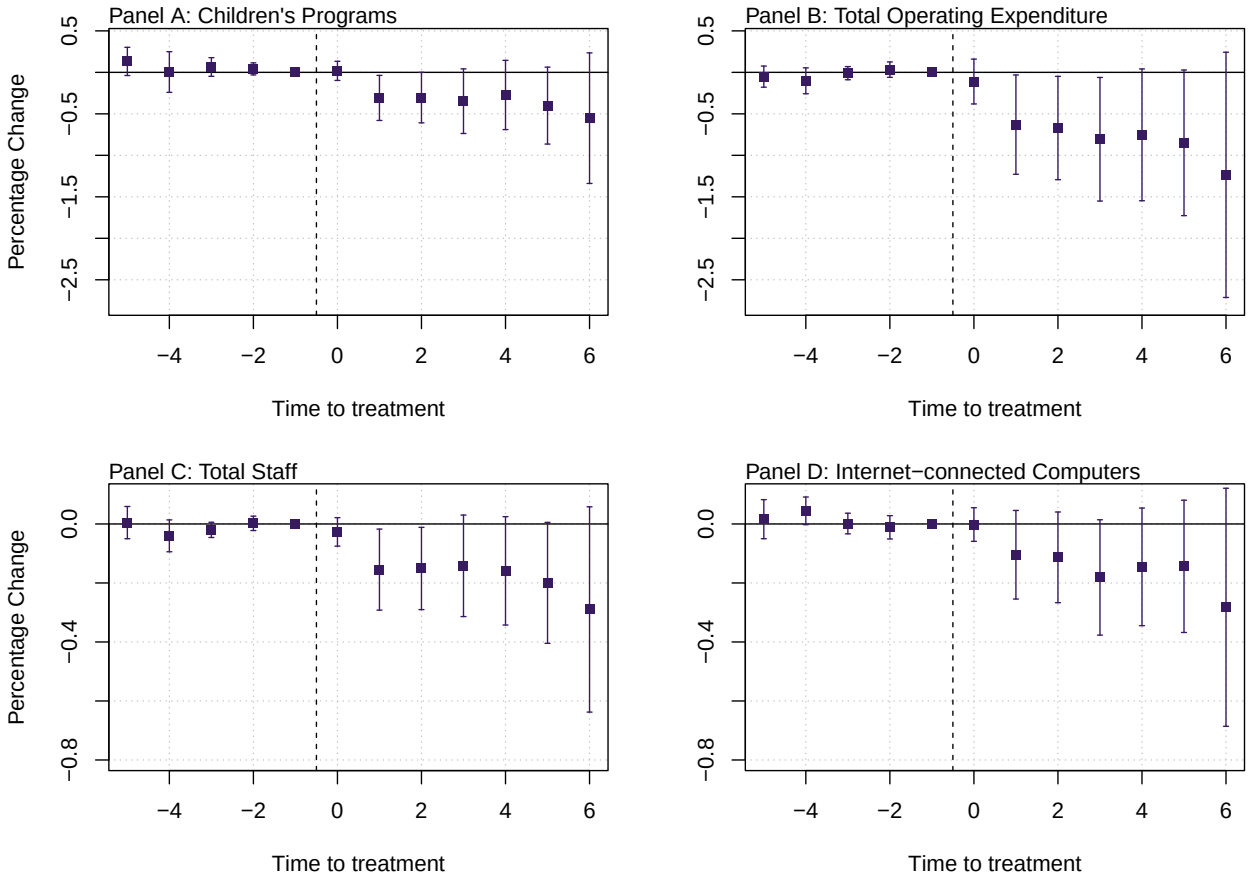
Notes: Shows locations of outlets that remained open or closed permanently during 2008-19. Data: PLS and U.S. Census.

Figure 4: Trends in Student and Community Demographics by Treatment Status



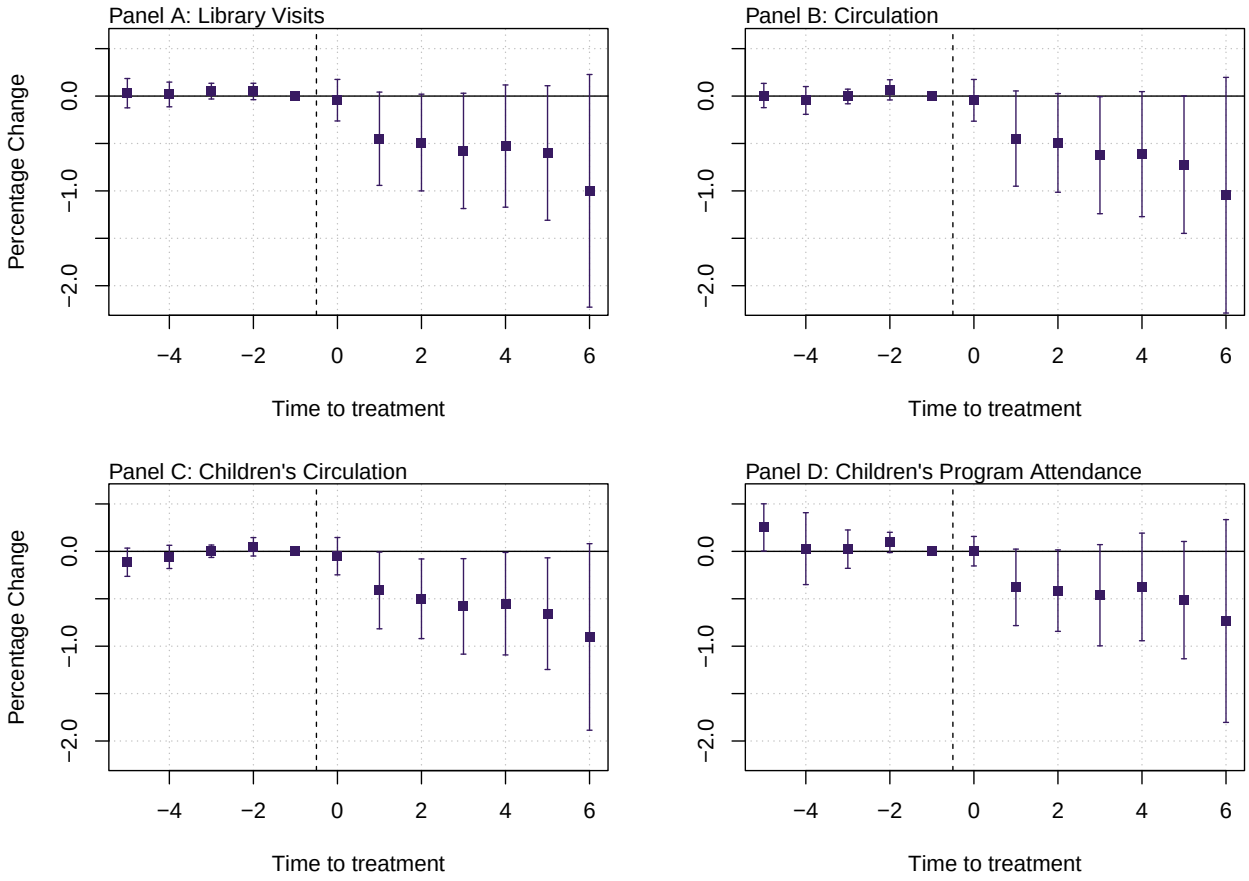
Notes: 2009 base year. Authors' calculations using data from SEDA, PLS, USDA, and U.S. Census Bureau.

Figure 5: Impact of Library Outlet Closure on Library Capacity



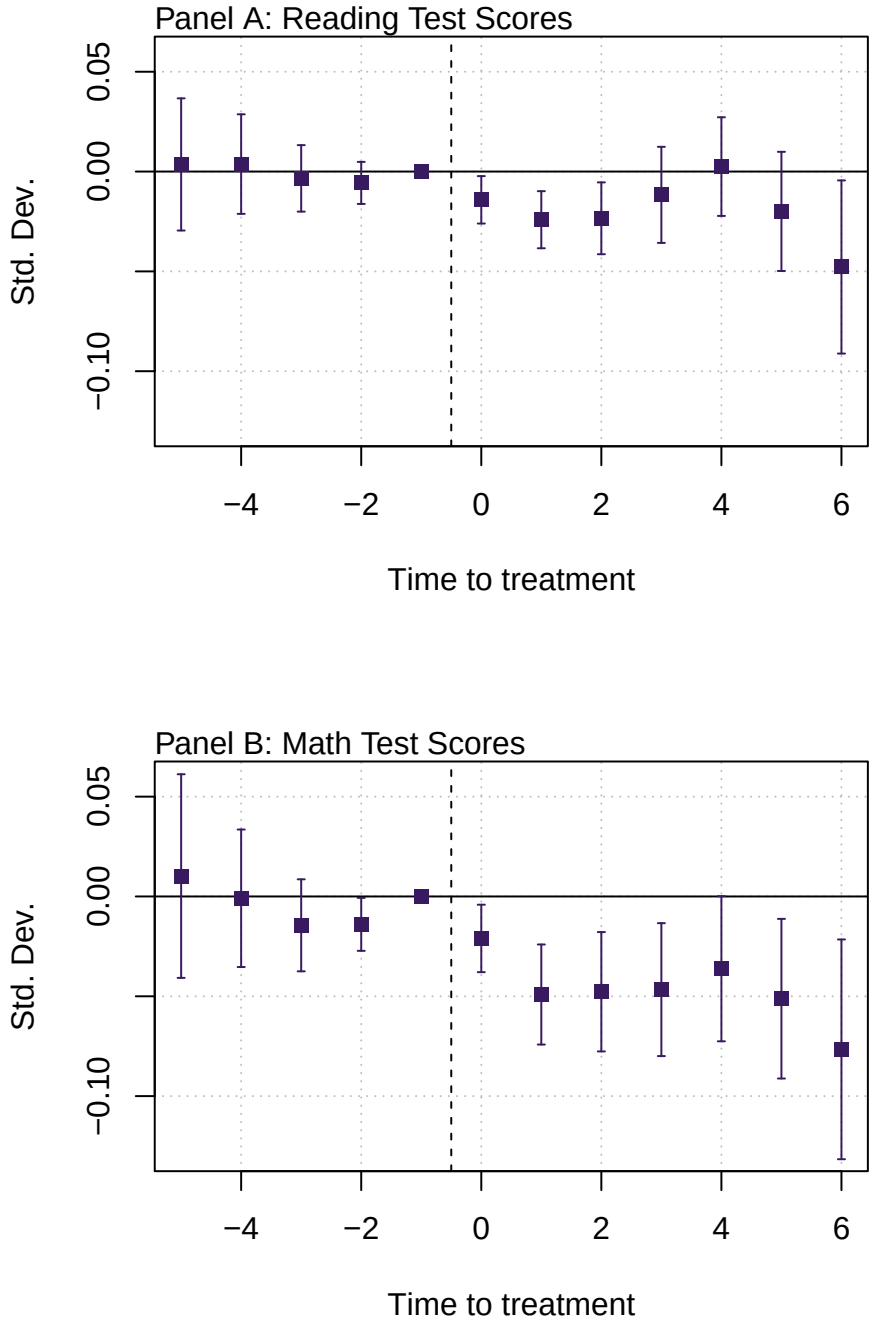
Notes: The figures show estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. Impacts measured in percent changes. All figures show 95% cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. Data: Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure 6: Impact of Library Outlet Closure on Library Use



Notes: The figures show estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. Impacts measured in percent changes. All figures show 95% cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. Data: Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure 7: Impact of Library Outlet Closures on Test Scores, Grades 3-8



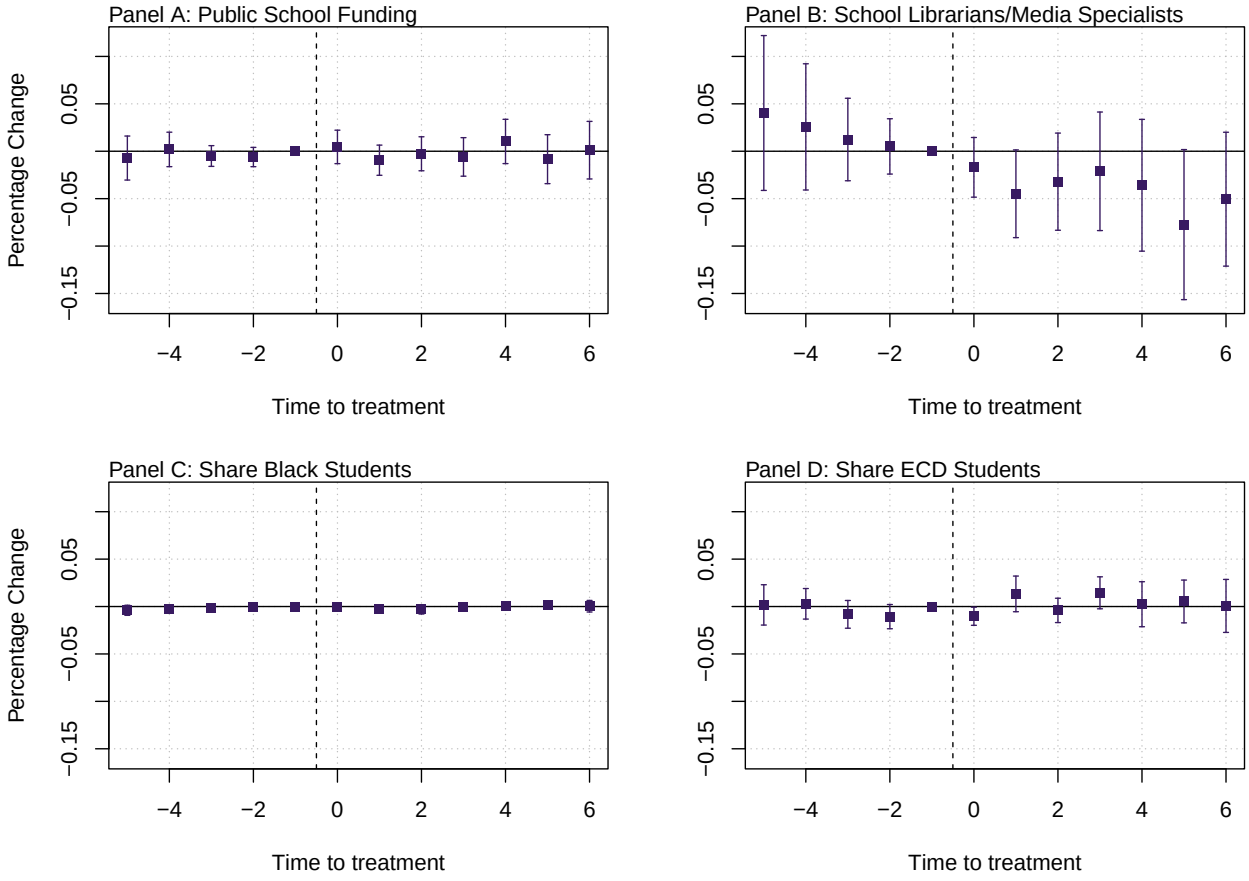
Notes: The figures show estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. Results are conditional on grade-district and state-year fixed effects. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table 2: Impact of Library Outlet Closures on Test Scores, by Urbanicity

			Non-Metro	
	Metro	Non-Metro	Suburban	Rural
Reading Test Scores, Grades 3-8				
Library Closure (ATT)	-0.006	-0.021**	-0.020**	-0.022
	(0.010)	(0.008)	(0.009)	(0.019)
Dep. var. mean	0.060	-0.049	-0.046	-0.061
Observations	160,305	135,376	113,540	21,835
Math Test Scores, Grades 3-8				
Library Closure (ATT)	-0.010	-0.046***	-0.047***	-0.045*
	(0.016)	(0.012)	(0.013)	(0.025)
Dep. var. mean	0.072	-0.039	-0.035	-0.063
Observations	142,169	121,191	102,209	18,981
Grade-District FEs	✓	✓	✓	✓
State-Year FEs	✓	✓	✓	✓

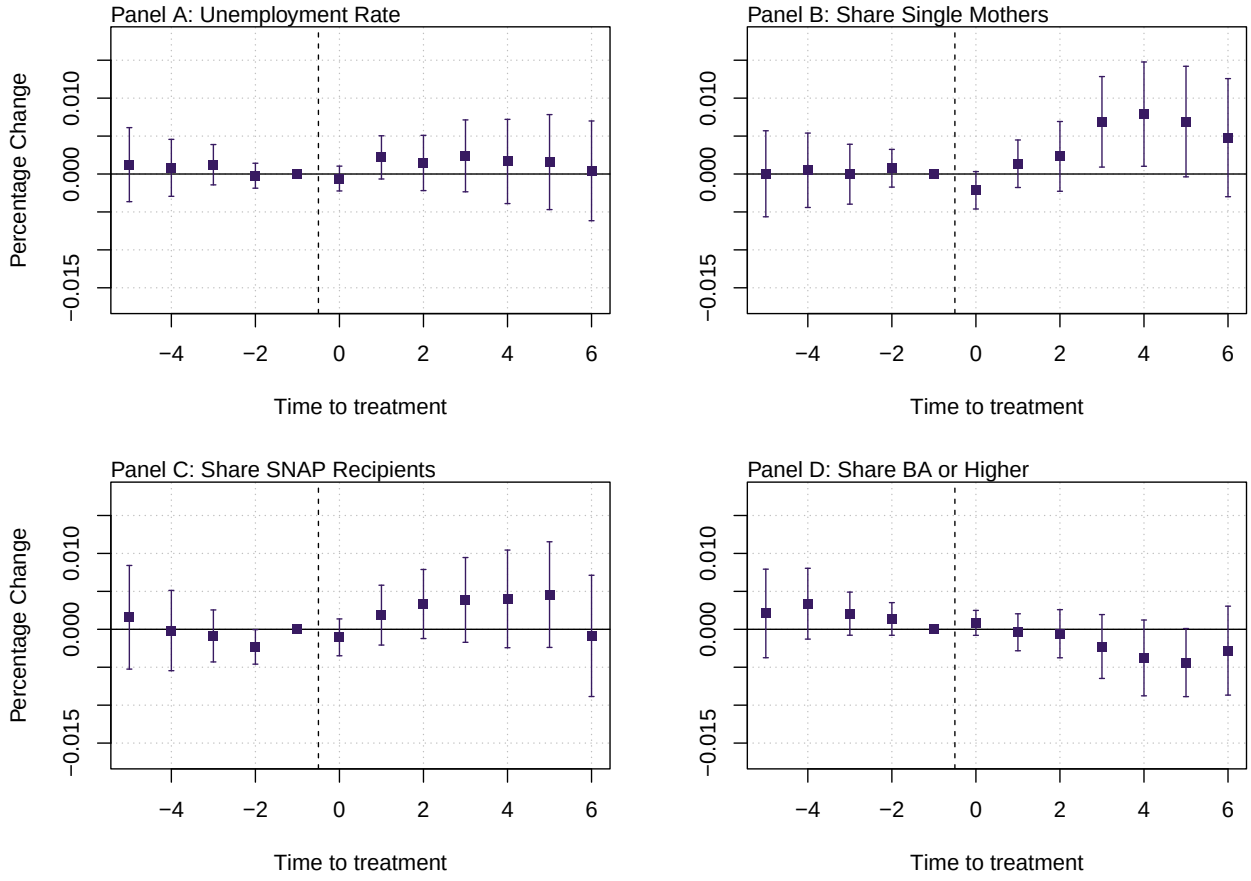
Notes: The table shows estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are reading and math test scores measured in standard deviations. The unit of analysis is the grade-school-district-year level. All, metro, suburban, and rural samples. Student population weights included. Clustered (School district) standard errors in parentheses. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Pre-trends are jointly zero. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure 8: Balancing Tests for District Characteristics



Notes: The figures show estimates of the average treatment effects on the treated (ATTs) of the event study as specified in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are public school funding, school librarians and media specialists, and the shares of Black, and economically disadvantaged students. Non-metro sample. All figures show 95% cluster-robust confidence intervals. Impacts measured in percent change. Student population weights included. Results are conditional on district and state-year fixed effects. Data: Educational Opportunity Project at Stanford University (SEDA), EDFacts, U.S. Department of Agriculture (USDA), and Public Libraries Survey (PLS).

Figure 9: Balancing Tests for Community Characteristics



Notes: The figures show estimates of the average treatment effects on the treated (ATTs) of the event study as specified in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are the community's unemployment rate, the share of single mothers, the share of Supplemental Nutrition Assistance Program (SNAP) recipients, and the share of adults with a BA or higher. Non-metro sample. Student population weights included. All figures show 95 percent cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. Data: Educational Opportunity Project at Stanford University (SEDA), U.S. Department of Agriculture (USDA), and Public Libraries Survey (PLS).

Table 3: Impact of Library Outlet Closures on Test Scores, Alternative Specifications

Test Scores:	(1)	(2)	(3)	(4)
Reading Test Scores, Grades 3-8				
Library Closure (ATT)	-0.021**	-0.021**	-0.022***	-0.022***
	(0.008)	(0.008)	(0.009)	(0.009)
Dep. var. mean	-0.049	-0.049	-0.048	-0.048
Observations	135,376	135,376	134,494	134,494
Math Test Scores, Grades 3-8				
Library Closure (ATT)	-0.046***	-0.046***	-0.046***	-0.047***
	(0.012)	(0.012)	(0.012)	(0.012)
Dep. var. mean	-0.039	-0.039	-0.039	-0.039
Observations	121,191	121,191	120,377	120,377
Grade-District FEs	✓	✓	✓	✓
State-Year FEs	✓	✓	✓	✓
Subject-Year		✓		✓
Grade-Year		✓		✓
Controls			✓	✓

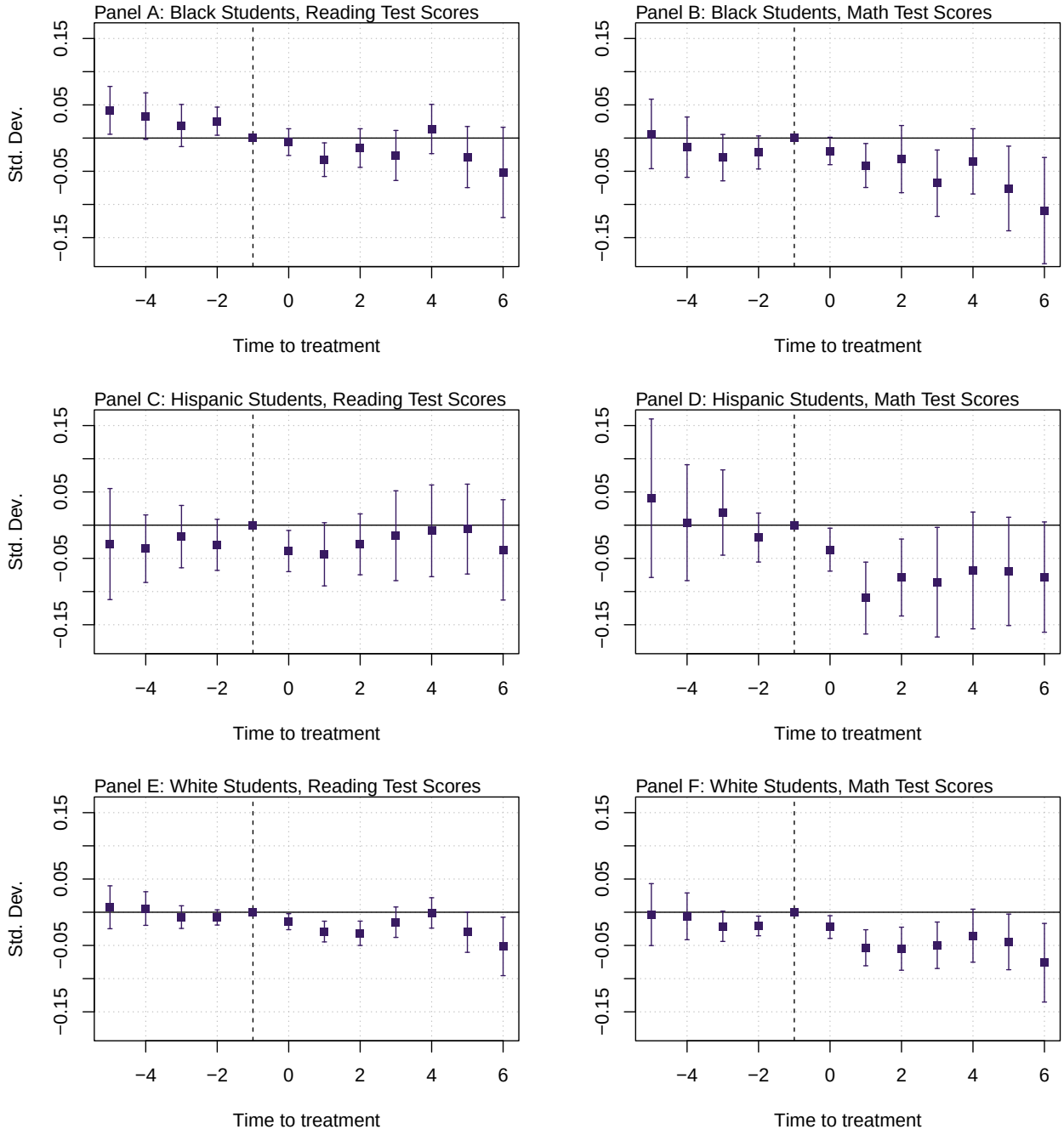
Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are reading test scores and math test scores measured in standard deviations. Non-metro samples. Controls include public school funding, annual unemployment rate, the share of single mothers, the share of SNAP receivers, the share of adults with education higher than BA, the share of Black students, and the share of Hispanic students. Impacts measured in standard deviations. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table 4: Impact of Library Outlet Closures on Test Scores, by Treatment Radius

Treatment Radius:	Within District	2 miles	4 miles	4-10 mile Donut
Reading Test Scores, Grades 3-8				
	-0.027**	-0.021**	-0.012	-0.011
	(0.011)	(0.008)	(0.009)	(0.009)
Dep. var. mean	-0.049	-0.049	-0.049	-0.046
Observations	135,376	135,376	135,376	124,592
Math Test Scores, Grades 3-8				
	-0.051***	-0.046***	-0.039***	-0.008
	(0.014)	(0.012)	(0.011)	(0.012)
Dep. var. mean	-0.039	-0.039	-0.039	-0.033
Observations	121,191	121,191	121,191	111,198
Grade-district FEs	✓	✓	✓	✓
State-Year FEs	✓	✓	✓	✓

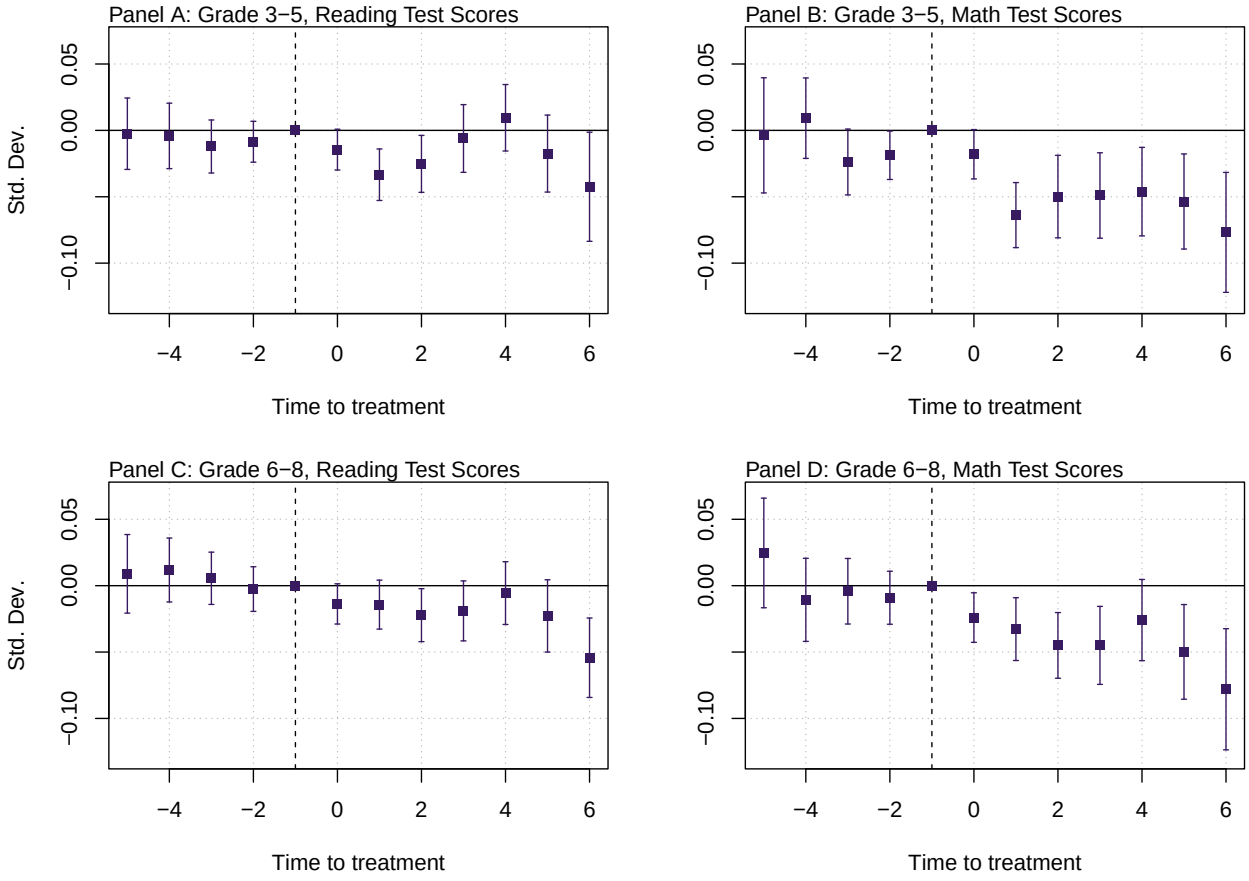
Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator varying the treatment radius from 0 to 4 miles and a treatment donut between 4 and 10 miles. The outcome variables are reading and math test scores measured in standard deviations. The unit of analysis is the grade-school-district-year level. Non-metro samples. Impacts measured in standard deviations. Student population weights included. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Pre-trends are jointly zero. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

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



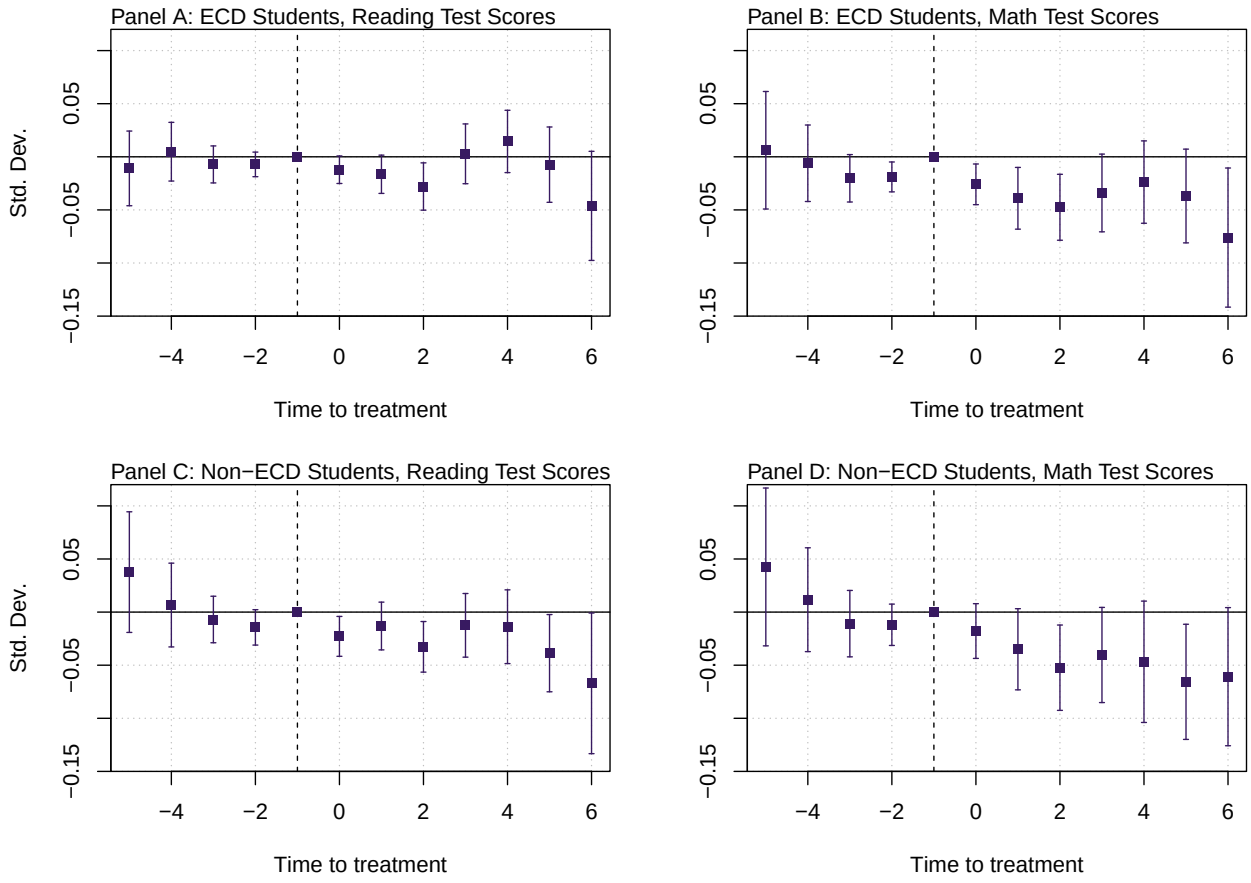
Notes: The figures show estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. All figures show 95 percent cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure 11: Impact of Library Outlet Closures on Test Scores, by Grade Level



Notes: The figures show estimates of the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. All figures show 95 percent cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure 12: Impact of Library Outlet Closures on Test Scores, by Students' Economic Disadvantage



Notes: The figures show estimates of the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. All figures show 95 percent cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table 5: Impact of Library Outlet Closures on Test Scores, by Poverty Rate

Poverty Rate:	1^{st} Tercile	2^{nd} Tercile	3^{rd} Tercile
Reading Test Scores, Grades 3-8			
	-0.036	-0.031**	-0.010
	(0.022)	(0.013)	(0.011)
Dep. var. mean	0.089	-0.044	-0.185
Observations	44,077	45,405	45,626
Math Test Scores, Grades 3-8			
	-0.038	-0.037*	-0.042***
	(0.044)	(0.019)	(0.016)
Dep. var. mean	0.125	-0.036	-0.215
Observations	41,556	39,968	39,449
School-Grade-Subject	✓	✓	✓
State-Year	✓	✓	✓

Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are reading and math test scores measured in standard deviations. The unit of analysis is the grade-school-district-year level. Non-metro sample. Column (1) shows school districts with a poverty rate in the first tercile (lowest poverty), column (2) shows school districts with a poverty rate in the second tercile (medium poverty), and column (3) shows school districts with a poverty rate in the third tercile (highest poverty). Impacts measured in standard deviations. Student population weights included. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Pre-trends are jointly zero. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table 6: Impact of Library Outlet Closures on Test Scores, by Neighborhood Poverty and ECD Status

Poverty Rate	1^{st} Tercile		2^{nd} Tercile		3^{rd} Tercile	
	Non-ECD Students	ECD Students	Non-ECD Students	ECD Students	Non-ECD Students	ECD Students
Reading Test Scores, Grades 3-8						
	-0.032	-0.013	-0.029**	-0.026	-0.021	-0.005
	(0.026)	(0.020)	(0.013)	(0.018)	(0.014)	(0.013)
Dep. var. mean	0.288	-0.174	0.250	-0.249	0.226	-0.344
Observations	37,432	30,920	32,899	39,359	31,739	43,665
Math Test Scores, Grades 3-8						
	-0.030	-0.034	-0.031	-0.037*	-0.038*	-0.040**
	(0.041)	(0.050)	(0.023)	(0.021)	(0.021)	(0.017)
Dep. var. mean	0.326	-0.142	0.251	-0.232	0.182	-0.358
Observations	35,174	28,946	28,729	34,732	26,743	37,942
School-Grade-Subject	✓	✓	✓	✓	✓	✓
State-Year	✓	✓	✓	✓	✓	✓

Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are reading and math test scores measured in standard deviations. Columns (1) and (2) show school districts with a poverty rate in the first tercile (lowest poverty), columns (3) and (4) show school districts with a poverty rate in the second tercile (medium poverty), and columns (5) and (6) sho school districts with a poverty rate in the third tercile (highest poverty)—always for Non-ECD and ECD students, respectively. The unit of analysis is the grade-school-district-year level. Non-metro sample. Impacts measured in standard deviations. Student population weights included. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table 7: Impact of Library Outlet Closures on Test Scores, by School Funding

Public School Funding:	1^{st} Tercile	2^{nd} Tercile	3^{rd} Tercile
Reading Test Scores, Grades 3-8			
	-0.022**	-0.018	-0.022
	(0.010)	(0.018)	(0.015)
Dep. var. mean	-0.057	-0.042	-0.047
Observations	44,869	45,417	43,608
Math Test Scores, Grades 3-8			
	-0.069***	-0.030	-0.020
	(0.016)	(0.023)	(0.016)
Dep. var. mean	-0.083	-0.006	-0.028
Observations	39,588	39,265	40,930
School district-Grade	✓	✓	✓
State-Year	✓	✓	✓

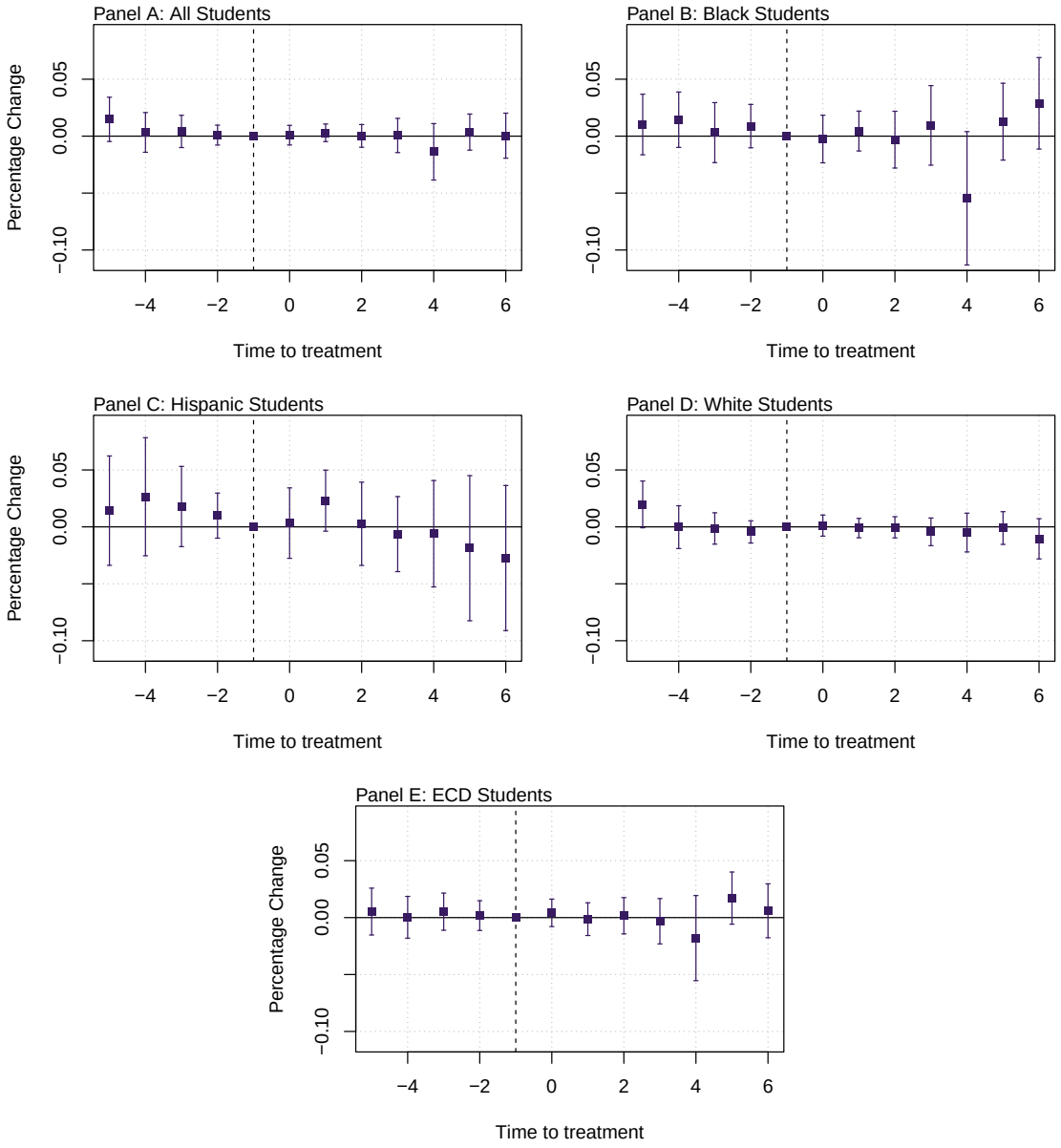
Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are reading test scores and math test scores measured in standard deviations. The unit of analysis is the grade-school-district-year level. Non-metro sample. Column (1) shows school districts in the first tercile of public school funding (least funding), column (2) shows school districts in the second tercile of public school funding, and column (3) shows school districts in the third tercile of public school funding (most funding). Impacts measured in standard deviations. Student population weights included. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table 8: Impact of Library Outlet Closures on Test Scores, by Library Outlet Density

Library Outlet Density:	1^{st} Tercile	2^{nd} Tercile	3^{rd} Tercile
Reading Test Scores, Grades 3-8			
	-0.018	0.003	-0.012
	(0.017)	(0.023)	(0.023)
Dep. var. mean	-0.137	-0.043	0.022
Observations	31,085	30,697	29,595
Math Test Scores, Grades 3-8			
	-0.054**	-0.012	-0.001
	(0.024)	(0.037)	(0.030)
Dep. var. mean	-0.114	-0.022	0.010
Observations	27,110	27,578	28,386
School-Grade-Subject	✓	✓	✓
State-Year	✓	✓	✓

Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. The outcome variables are reading and math test scores measured in standard deviations. The unit of analysis is the grade-school-district-year level. Suburban sample. Student population weights included. Results are estimated separately for school districts by terciles of the number of libraries per square mile. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Pre-trends are jointly zero. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure 13: Impact of Library Outlet Closures on Cohort High School Graduation Rates



Notes: The figures show estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. All figures show 95 percent cluster-robust confidence intervals. Results are conditional on district and state-year fixed effects. *Source*: Authors' calculations. Data: EDFacts, Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Appendix

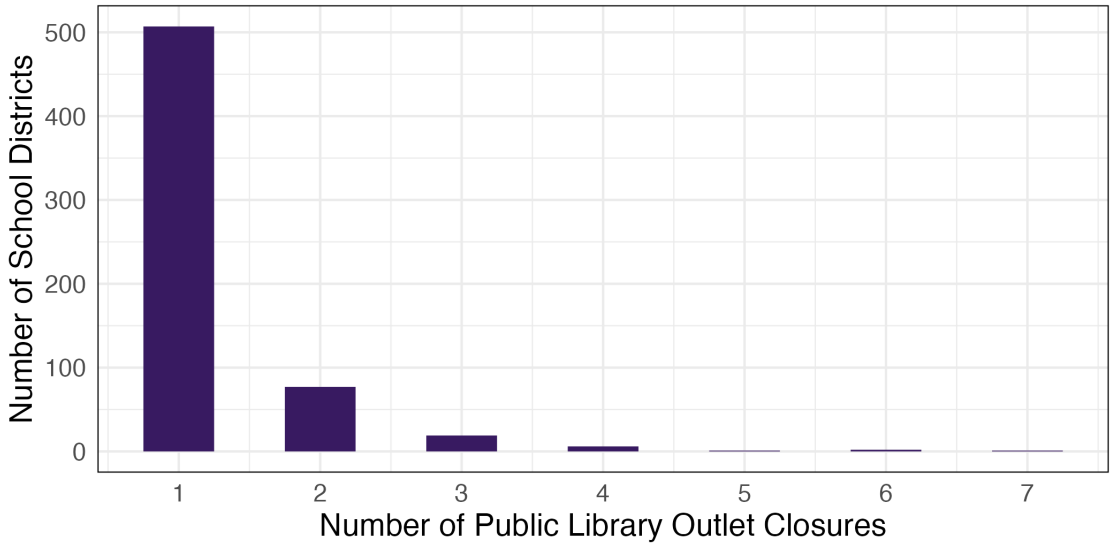
A Ancillary Tables and Figures

Table A1: Rural-Urban Continuum Codes 2013

Metropolitan Counties	
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
Suburban Counties	
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999, not adjacent to a metro area
Rural Counties	
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

Notes: The table shows the definition of urbanicity using Rural-Urban Continuum Codes from the USDA. Codes 1 to 3 are "metro", codes 4 to 7 are "suburban", and codes 8 to 9 are "rural" counties. In this study, we combine suburban and rural counties to build "non-metro" areas. *Source*: Economic Research Service (2013).

Figure A1: Number of Closures per School District, 2008 to 2019



Note: Authors' calculations using Public Libraries Survey.

Table A2: Summary Statistics for Non-Metro School Districts

	Obs.	Mean	Median	Min	Max	Std.Dev.
SEDA Test Scores						
Math Score	122,010	-0.04	-0.03	-3.74	2.15	0.11
Reading Score	136,290	-0.05	-0.04	-1.83	1.75	0.12
Public Libraries						
Number of Libraries	211,921	1.57	1.00	1.00	9.00	1.02
Library Visits (in 1,000s)	163,451	65.19	34.59	0.00	7,391.35	108.84
Circulation (in 1,000s)	163,451	85.38	45.09	0.00	3,964.94	145.63
Kids' Circulation (in 1,000s)	163,451	26.62	13.19	0.00	1,387.73	46.23
Library Programs	163,451	260.79	146.00	0.00	7,887.00	400.76
Kids' Library Programs	163,451	160.30	89.00	0.00	4,110.00	245.41
Kids' Prog. Attendance (in 1,000s)	163,451	3.66	1.82	0.00	110.70	5.98
Total Staff	163,451	6.96	4.08	0.00	202.51	9.04
Internet Computers	163,451	19.65	13.00	0.00	293.00	22.01
Total Op. Expend. (in 1,000s)	163,451	435.32	228.62	0.00	14,715.77	641.53
School District Characteristics						
Number of Students	258,282	678.08	411.00	18.00	11,230.00	808.66
Log School Funding per Student	257,053	10.51	10.38	9.43	13.41	0.50
Share Black Students (in %)	258,282	9.37	1.41	0.00	100.00	19.41
Share Hispanic Students (in %)	258,282	11.00	3.47	0.00	100.00	18.71
Share ECD Students (in %)	257,533	57.59	57.14	0.40	100.00	18.55
HS Graduation Rate (in %)	217,466	87.95	90.00	2.00	99.00	8.75
Community Characteristics						
Unemployment Rate (in %)	257,800	7.49	7.26	0.05	21.62	2.66
Share Single Mothers (in %)	257,800	15.76	14.88	0.90	49.85	5.86
Share SNAP Recipients (in %)	257,800	13.25	12.56	0.14	45.06	6.02
Share BA or Higher (in %)	257,800	16.67	15.42	1.71	83.44	6.74

Notes: The table displays the 5-number summary for the balanced panel between 2009 and 2018. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table A3: Mean Summary Statistics, by Urbanicity

	All	Metro	Suburban	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)	188.47	295.69	67.69	52.78
Circulation (per 1,000)	304.25	494.62	87.26	76.05
Kids' Circulation (per 1,000)	107.51	177.87	27.48	22.33
Library Programs	590.41	877.12	267.60	226.94
Kids' Library Programs	343.87	503.55	164.08	141.53
Kids' Program Attendance	9.52	14.61	3.79	3.02
Total Staff	18.83	29.15	7.22	5.70
Internet Computers	40.67	58.95	19.92	18.31
Total Op. Expenditure	1,484.61	2,397.33	452.60	349.44
School District Characteristics				
Number of Students	1,785.91	2,751.33	721.96	455.81
Log School Funding per Student	10.49	10.46	10.50	10.58
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
HS Graduation Rate (in %)	87.95	87.94	87.97	87.88
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
Number of Districts	563,070	304,770	217,050	41,250

Notes: The table shows the means of our main variables for the balanced panel between 2009 and 2018 by urbanicity.
Source: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

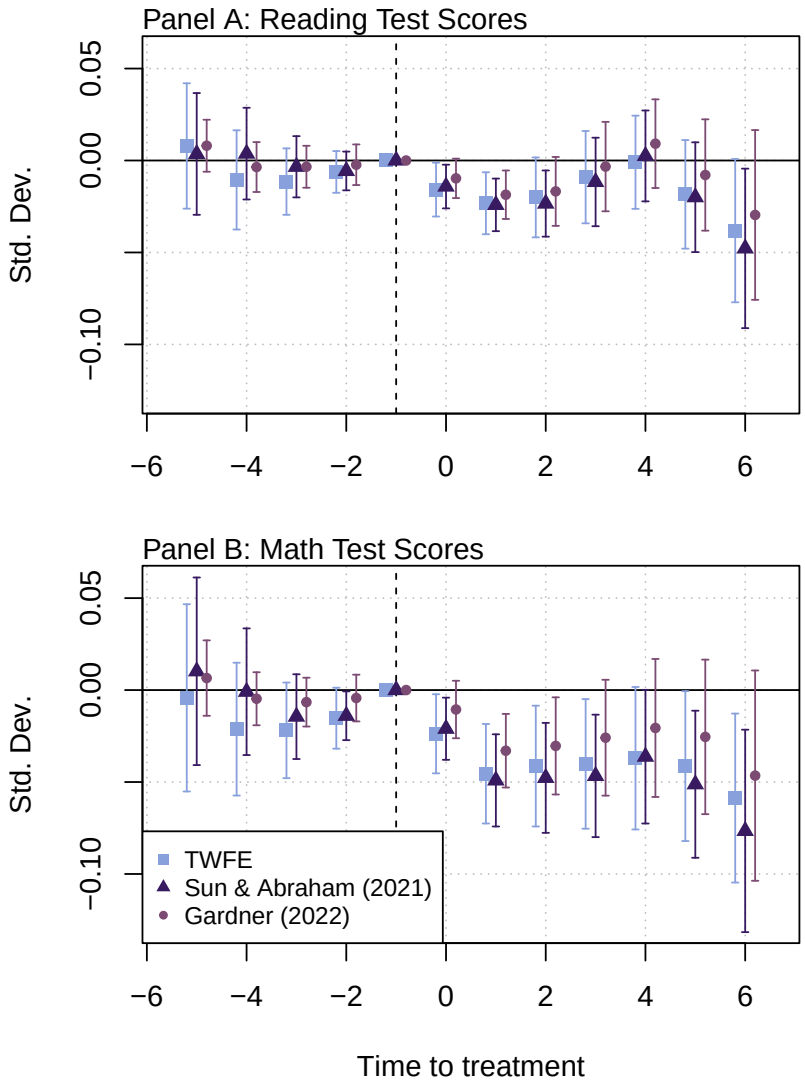
Table A4: Impact of Library Outlet Closure on Library Use and Capacity

Library Use	Visits	Circulation	Kid's Circulation	Kid's Prog. Att.
	-0.514*	-0.550*	-0.503**	-0.398
	(0.295)	(0.300)	(0.241)	(0.255)
Dep. var. mean	65,195	85,382	26,622	3,664
Observations	27,415	27,415	27,415	27,415
School dist.-Grade-Subject	✓	✓	✓	✓
State-Year	✓	✓	✓	✓

Library Capacity	Total Staff	Op. Expend.	Kid's Programs	Computers
	-0.157*	-0.701*	-0.299	-0.135
	(0.083)	(0.359)	(0.184)	(0.093)
Dep. var. mean	6.964	435,316	160.302	19.647
Observations	27,415	27,415	27,415	27,415
School dist.-Grade-Subject	✓	✓	✓	✓
State-Year	✓	✓	✓	✓

Notes: The table shows the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for $log(1+y)$ of different library outcomes. We interpret the coefficient estimates as a $(e^{\hat{\gamma}}-1)\times 100\%$ change in the outcome measure. The unit of analysis is the school-district-year level. Non-metro areas only. Student population weights included. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Pre-trends are jointly zero. Data: Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A2: Robustness Check Using Alternative Estimators



Notes: The figure 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. Impacts measured in standard deviations. Student population weights included. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table A5: Robustness Check Using Weights

	Student Weights	No Student Weights
Reading Test Scores, Grades 3-8		
	-0.021**	-0.017*
	(0.008)	(0.009)
Dep. var. mean	-0.049	-0.049
Observations	135,376	135,383
Math Test Scores, Grades 3-8		
	-0.046***	-0.032**
	(0.012)	(0.015)
Dep. var. mean	-0.039	-0.039
Observations	121,191	121,202
Grade-district FEs	✓	✓
State-Year FEs	✓	✓

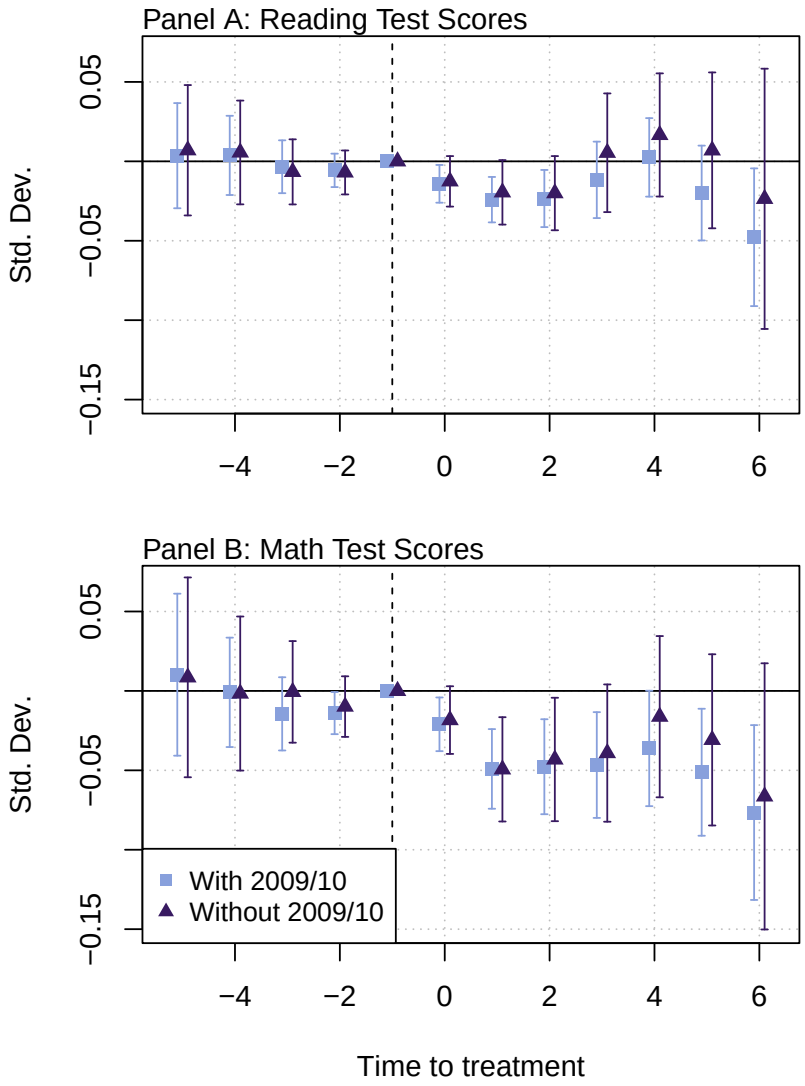
Notes: The table shows estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included and excluded, respectively. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Table A6: Robustness Check Ignoring State Borders

Treatment	Within State Borders	Ignoring State Borders
Reading Test Scores, Grades 3-8		
	-0.021**	-0.019**
	(0.008)	(0.008)
Dep. var. mean	-0.049	-0.049
Observations	135,376	135,376
Math Test Scores, Grades 3-8		
	-0.046***	-0.049***
	(0.012)	(0.011)
Dep. var. mean	-0.039	-0.039
Observations	121,191	121,191
School district-Grade	✓	✓
State-Year	✓	✓

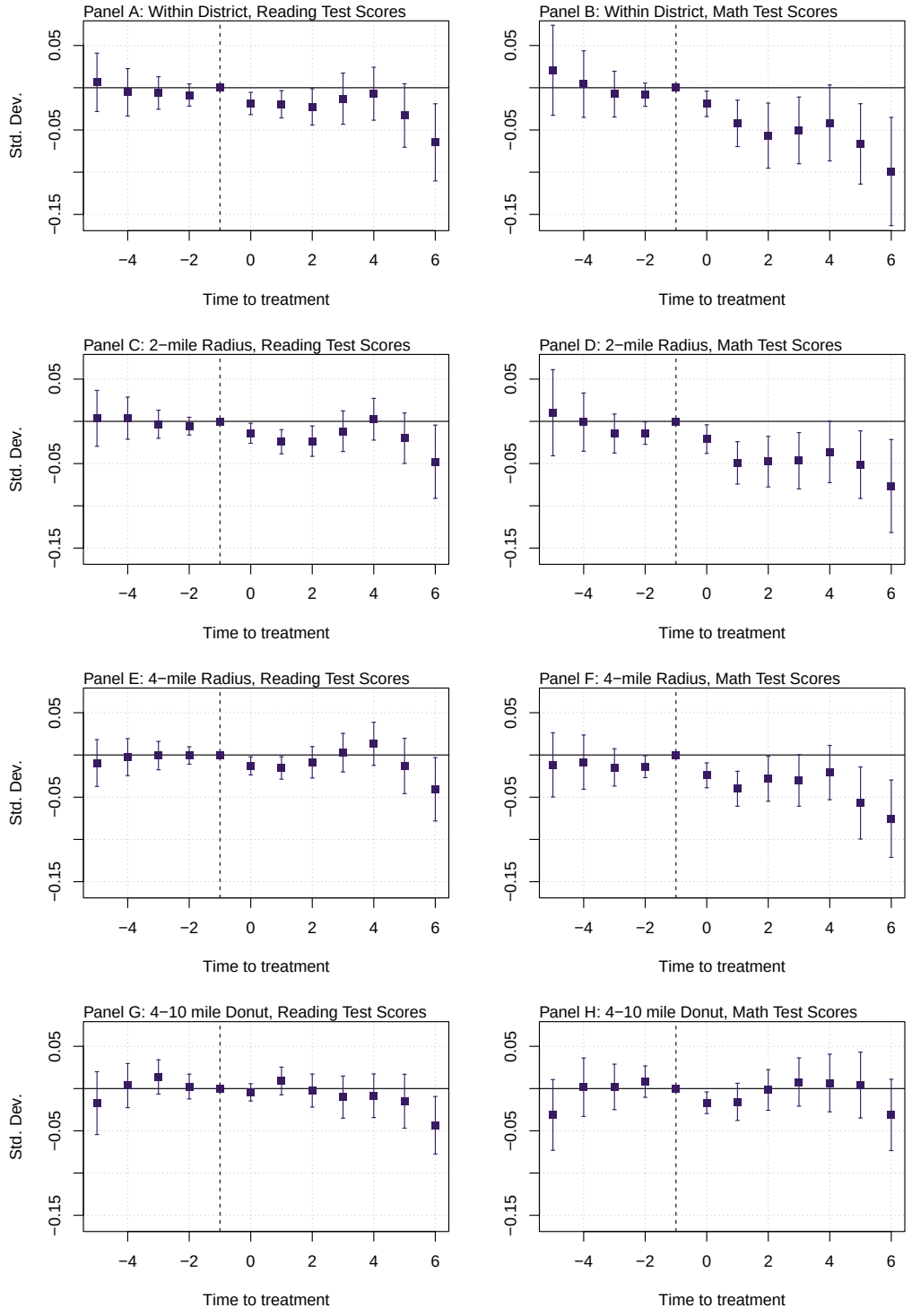
Notes: The table shows estimates of the average treatment effect on the treated (ATTs) of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Non-metro sample. Student population weights included. Results are conditional on grade-district and state-year fixed effects. School district cluster-robust standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A3: Robustness Check Excluding the Years 2009 and 2010



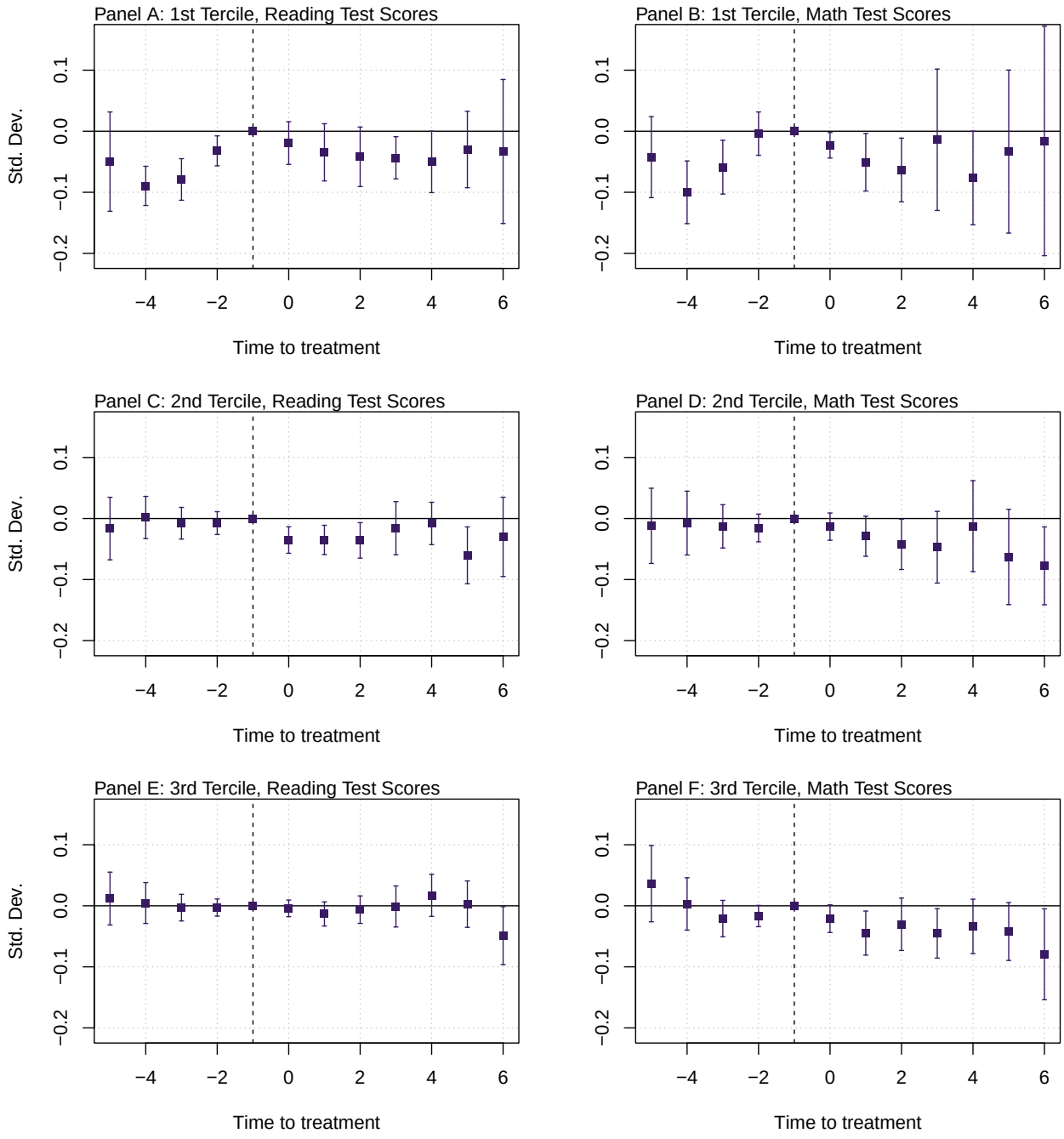
Notes: The figure shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Impacts measured in standard deviations. Student population weights included. Non-metro sample excluding potential crisis years 2009 and 2010. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A4: Impact of Library Closures on Test Scores by Varying Radius



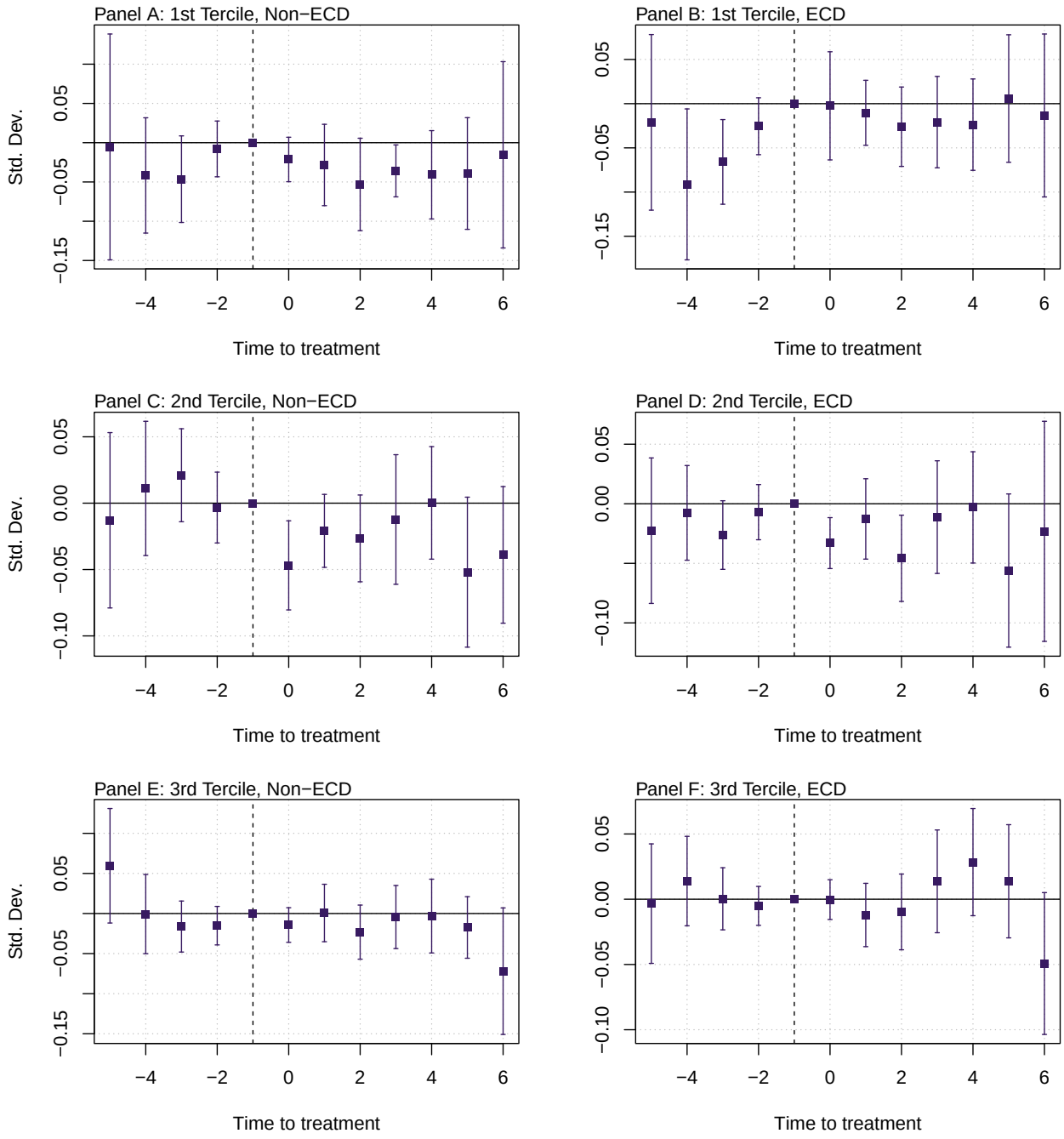
Notes: The figure shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator varying the treatment radius from 0 to 10 miles. Non-metro samples. Impacts measured in standard deviations. Student population weights included. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A5: Impact of Library Closures on Test Scores by the Poverty Rate



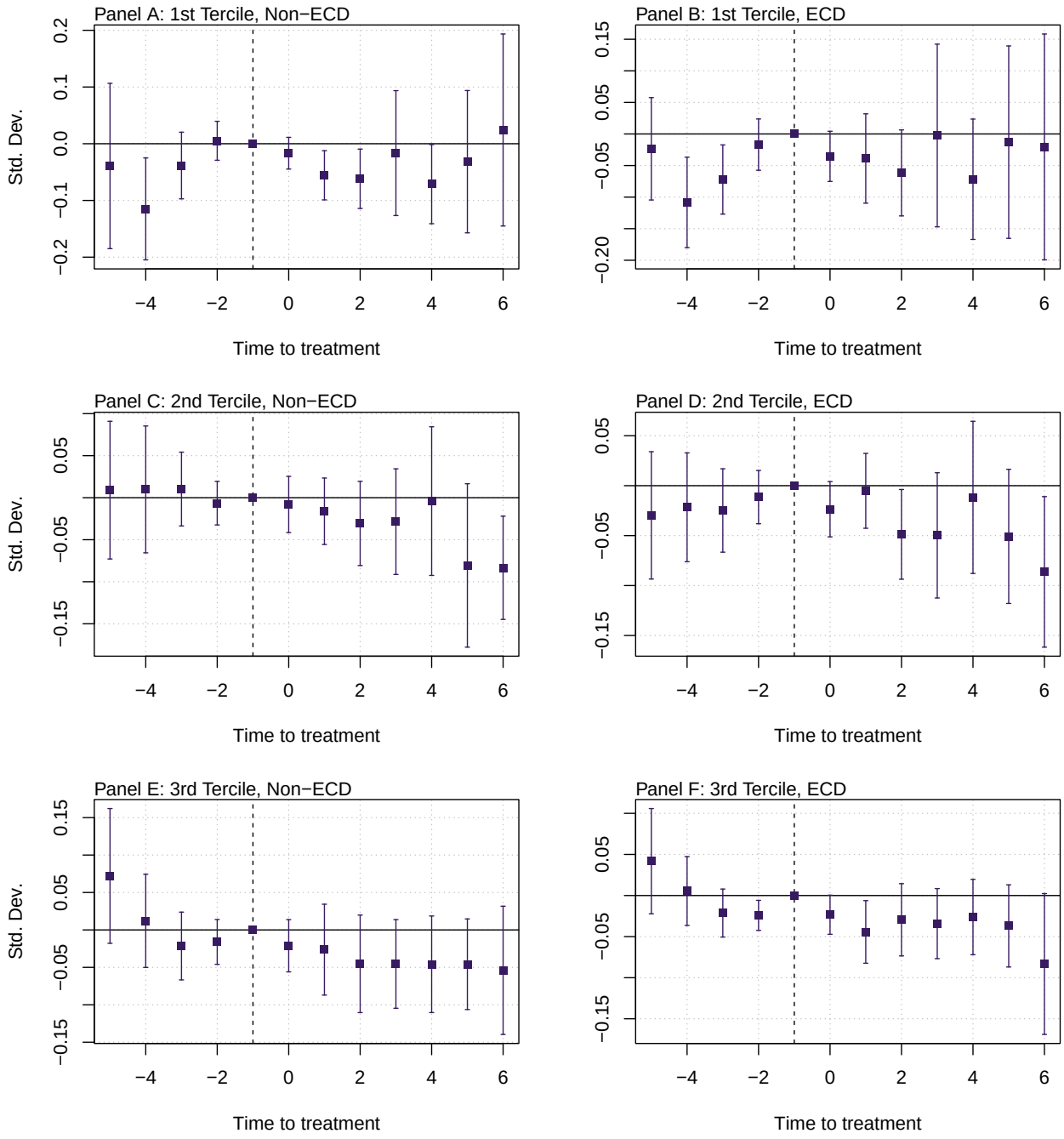
Notes: Figure A5 shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Panels (A) and (B) show school districts with a poverty rate in the first tercile (lowest poverty), panels (C) and (D) show school districts with a poverty rate in the second tercile (medium poverty), and panels (E) and (F) show school districts with a poverty rate in the third tercile (highest poverty). Non-metro sample. Impacts measured in standard deviations. Student population weights included. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A6: Impact of Library Closures on Reading Test Scores by Poverty Rate and ECD Status



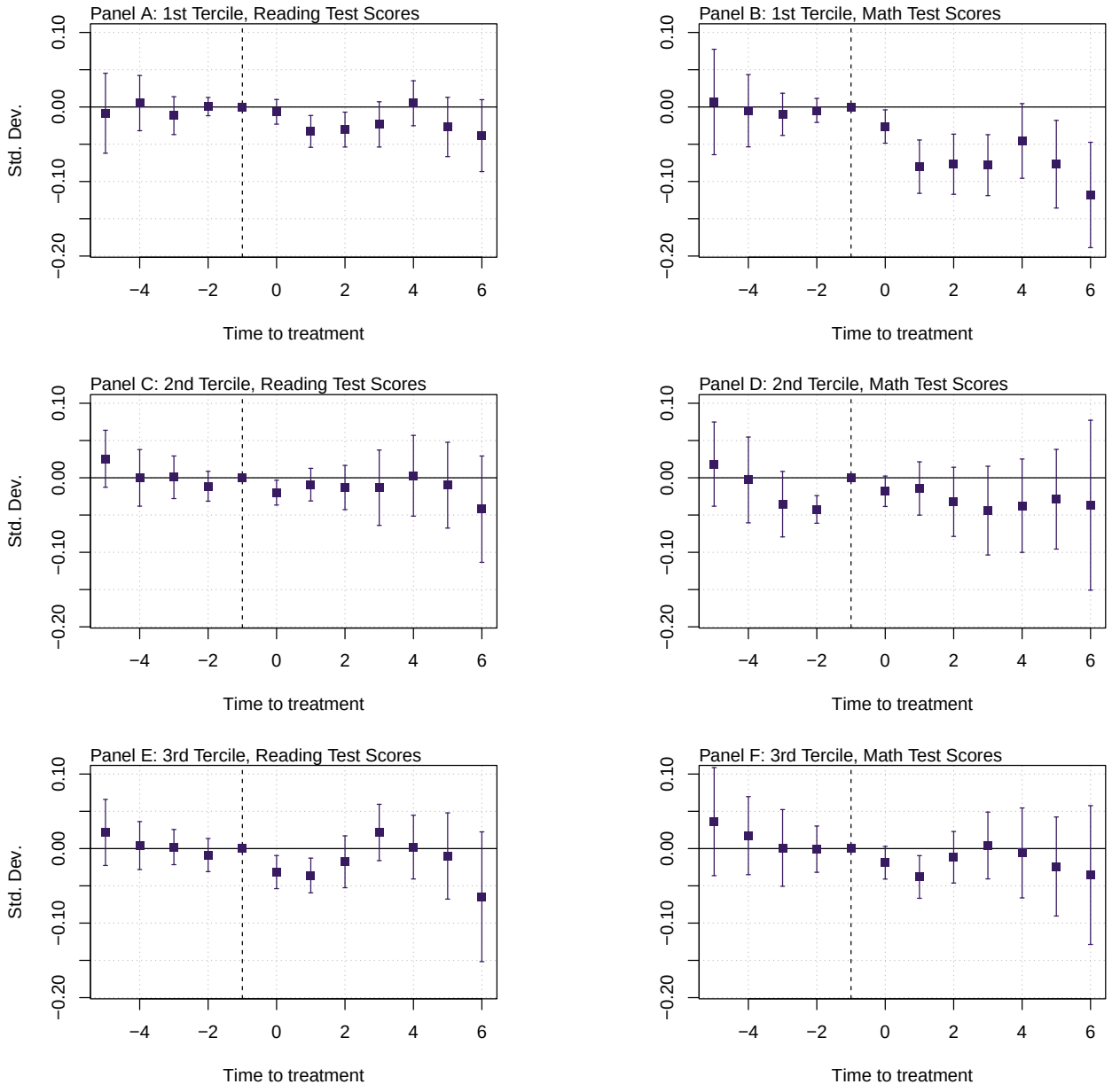
Notes: The figure shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results on reading test scores are estimated separately by economic status and neighborhood poverty. Non-metro sample. Impacts measured in standard deviations. Student population weights included. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A7: Impact of Library Closures on Math Test Scores by Poverty Rate and ECD Status



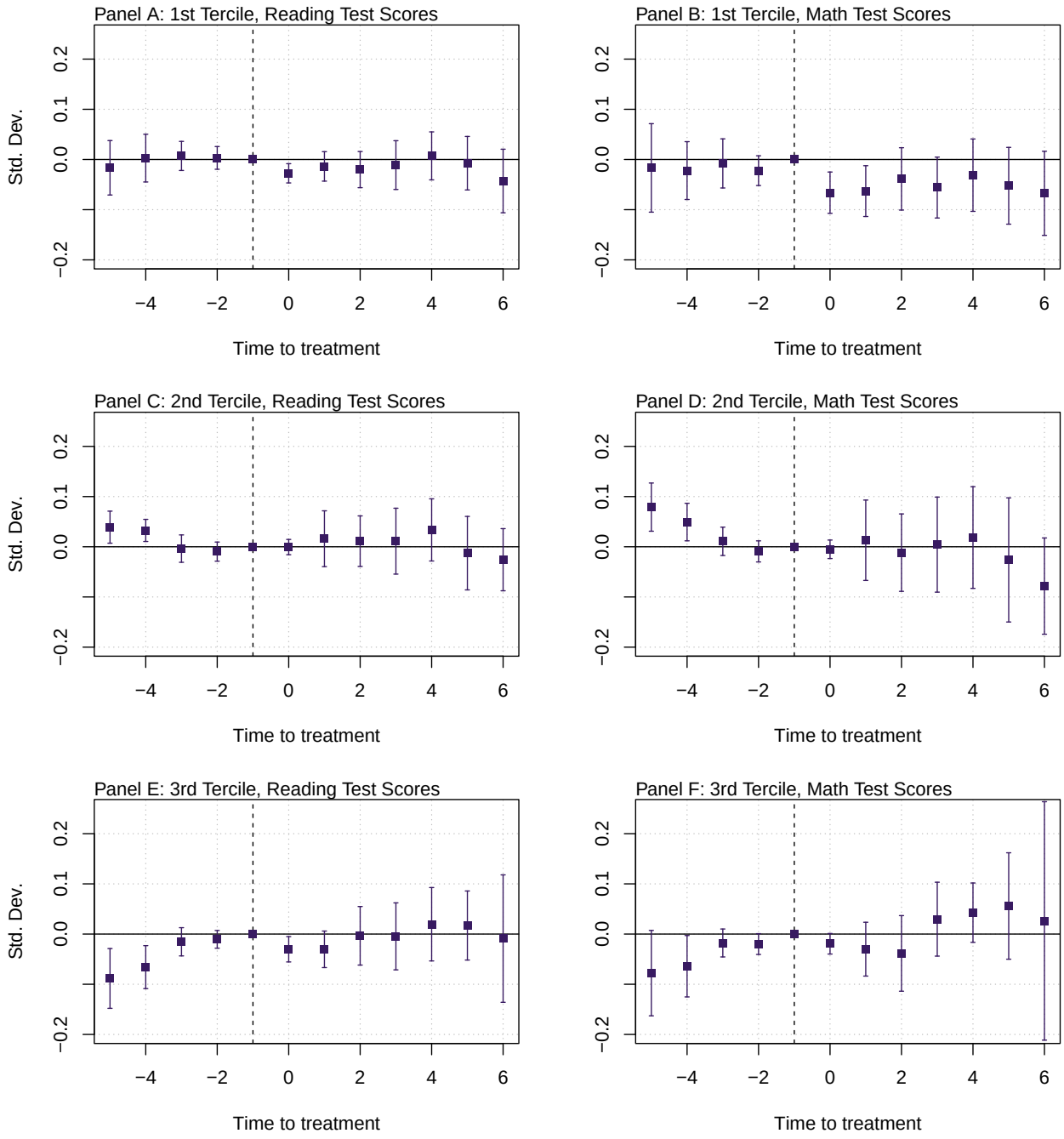
Notes: The figure shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator. Results on math test scores are estimated separately by economic status and neighborhood poverty. Non-metro sample. Impacts measured in standard deviations. Student population weights included. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A8: Impact of Library Closures on Test Scores by Terciles of Annual School Funding



Notes: The figure 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. Panels (A) and (B) show school districts in the first tercile of public school funding (least funding), panels (C) and (D) show school districts in the second tercile of public school funding, panels (E) and (F) school districts in the first tercile of public school funding (most funding). Non-metro sample Impacts measured in standard deviations. Student population weights included. *Source*: Authors' calculations. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).

Figure A9: Impact of Library Closures on Test Scores by the Public Library Outlet Density



Notes: The figure shows the results of the event study design specification as seen in equation (1) using the Sun and Abraham (2021) estimator for terciles of library density. Library density is calculated as the number of public library outlets per square mile. Urban sample. Impacts measured in standard deviations. *Source*: Authors' calculations. Data: Educational Opportunity Project at Stanford University (SEDA), Public Libraries Survey (PLS), U.S. Department of Agriculture (USDA), and National Center for Education Statistics (NCES).