Out of School, Out of Mind? An Analysis on Public Library Use and Academic Calendars

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During periods when public schools are closed, some parents may be economically constrained to provide private supplemental educational resources to their children. Public libraries may provide a low-cost, structured supply of educational materials and services that could promote human capital investment and reduce learning losses. Using a unique patron-level longitudinal panel of weekly library checkouts, we model the demand for library materials throughout two school calendar years. We find a significant 6.0% increase in circulation during weeks when a break occurred during a school-year, but no change in library use during summer break relative to weeks when school is in session. Estimates across socioeconomic status indicate differential library use across socioeconomic status and mobility. The most pronounced use of public libraries during school breaks is by patrons with above median incomes and those living in suburban areas. However, the results also indicate that lowest SES households actually decrease their library use during summer breaks. The analysis suggests that, in general, families use public libraries for supplemental education resources when public schools are closed, but that the benefits are not distributed equally across the socioeconomic spectrum.

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JEL classification codes: H42, I42

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1 Introduction

Research suggests substantial educational losses can occur during school breaks (see, for example Heyns 1987; Cooper et al. 1996; Downey, von Hippel, and Broh 2004). Moreover, student achievement losses have been shown to be concentrated primarily among students who do not participate in supplemental learning opportunities and can have lasting impacts on high school track placements, high school completion rates, and four-year college attendance (Alexander, Entwisle, and Olson 2007; Cornelius and Semmel 1982). Consequently, programs that encourage the continuation of learning outside of school environments—such as summer school and independent reading curricula—are considered beneficial through increasing the time that children are engaged in educational activities.

However, the ability to participate in and benefit educationally from learning activities outside of a school may be unequally distributed across students due to parents' monetary and time constraints associated with providing supplemental opportunities. Generally, existing research has predominately found that students from middle-class socioeconomic classes tend to increase learning outcomes during school breaks, but that learning outcomes for students from lower socioeconomic classes tend to either remain stagnant or even decrease. For example, Cooper et al. (1996) suggests that summer learning losses result from differential availability of opportunities to practice over the summer and that these opportunities are directly related to family income. Quinn (2015) and Gershenson (2013) also show that learning losses occurring during summer school breaks are associated with differences across families' socioeconomic status.

Despite the extensive literature describing the learning loss impacts from school breaks, only limited and somewhat mixed research examines the role of publicly provided educational supplemental services. For example, unstructured learning activities such as students' independent use of Internet resources have been shown to be ineffective at improving various aspects of educational attainment (Lawrence 2009). However, Matsudaira (2008) finds that mandatory public summer school increases math and reading achievement by 0.12 standard deviations, suggesting that public educational supplements may provide a more effective alternative to improving student achievement independent of parental income. These differences in learning outcomes may, therefore, be to an extent driven by the nature of the supplemental learning environment, such that more structured models could be more effective.

Public libraries are low-cost providers of educational information, have trained staff who can identify and find specific educational content, and host continuing education programs for individuals of all ages. Moreover, public libraries are nearly ubiquitous across the United States, regardless of the size or location of a community. The structured information transfer frameworks that exist in public libraries could be an alternative supplement for public schools during periods of school closures. A limited literature on summertime readership suggests that library-hosted summer reading clubs contribute to students' higher reading scores in the following school year (Goldhor and McCrossan 1966; Guryan, Kim, and Quinn 2014) and on overall cognitive development of children (Kalb and van Ours 2014). However, such analyses has not been extended across familial socioeconomic classes.

This study is a first step in evaluating whether public libraries could provide educational supplements to private instructional facilities and summer school by evaluating the demand for public library services across socioeconomic classes during school breaks. We analyze changes in the demand for information content provided by the local public library during within-school year and summer breaks, and postulate that the demand for library materials and services could increase during school breaks if students' parents seek alternative low-cost educational resources for their children. Understanding changes in patrons' behaviors during public school closures at times other than summer breaks is a unique aspect and contribution of this study because we are able to more accurately characterize the demand for supplemental educational resources during periods when there are fewer opportunities for families to engage in alternative activities (e.g., enrolling children in summer camps, traveling on extended family vacations). While there have been important findings about the role of public libraries in increasing summertime readership, our study is the first to combine patron-level data with local property tax data to identify differential demands for public library use across socioeconomic classes.

We exploit new data describing weekly patron-level circulation counts at a public library in a medium-sized Montana city collected between August 2013 and May 2015. The longitudinal data characterize the number of checkouts of printed, audio, video, interlibrary loan materials, and patron addresses. We then combine these data with publicly available home tax value information as well as U.S. Census block group demographic and socioeconomic variables to characterize economic heterogeneity across 7,246 library patrons. Using these data, we estimate a Poisson count model to estimate changes in weekly checkouts across the academic calendar. The model accounts for patrons' characteristics such as their property value, distance from the library, and visitation and checkout habits, as well as community level factors that can alter library attendance, such as weather and nearby community events.

The estimation results indicate that, on average, patrons checkout 0.88 items per week and that circulation increases by approximately 6.0% during school-year breaks relative to library use when school is in session. The greatest increases in public library use occur during the fall and Thanksgiving holiday breaks, 11.5% and 16.3% respectively. During the summer break, library use remains mostly unchanged relative to school-year use. Estimation results across socioeconomic groups indicate differential effects with above-median property value households significantly increasing library use during school-year breaks and the lowest quartile property value families significantly decreasing library use during the summer break.

The results suggest that public libraries can be cost-effective instruments for increasing children's access to supplemental educational resources for those with sufficient mobility to visit the library. This finding is particularly relevant for densely populated communities, where libraries are more closely located to population centers and public transportation is more readily available. The urban economics literature has widely document urban communities' roles in being a conduit to information transmission and knowledge spillover, and public libraries could play an important part in expanding the opportunities and impacts on human capital accumulation (Rauch 1993; Anselin, Varga, and Acs 1997; Funke and Niebuhr 2005; Rosenthal and Strange 2008). For less dense communities, where mobility is more constrained, this study's results suggest that alternative methods of providing information by a public institution (e.g., a bookmobile and other structured information delivery methods) may be necessary to attain similar educational impacts for children who are unable to visit libraries.

2 Data Description

We use information on patron-level weekly borrowing behavior of public library materials. These data are collected from a public library serving a micropolitan area in Montana.[1] The U.S. Census Bureau defines a micropolitan area to have an urban core of between 10,000 and 50,000 people. A micropolitan area consists of one or more counties within which there is high degree of social and economic integration. The public library from which the data are collected is the only such institution serving the micropolitan area, implying that patrons' circulation counts are perfectly captured. The library system only has one central location and no branches or bookmobiles,

[1]For confidentiality, we do not provide the name of the public library.

implying that patrons must physically visit the library to access library materials.[2]

2.1 Patron-level Data

All operations associated with cleaning, organizing, and geocoding weekly patron-level data were performed automatically at the public library using a computer script. Prior to making the final data available to researchers, the script removes all information that would allow for the identification of any specific patron, replacing that information with a single randomly generated identification number. The patron-level records for patrons using nearly every Montana public libraries are maintained using the SirsiDynex software, which is centrally managed by the Montana State Library.

Each individual library can access information about each of their patrons' checkout histories using a web-based Director's Station application. This application generates reports on each patron's residential address and historical circulation counts on the number of items that they checked out since the inception of the account. For example, a report created on January 1, 2015 for patron i with a library account commencing January 1, 2010 with a checkout history of 400 implies that between these two dates the patron checked out a total of 400 items. Because each report provides a historical checkout count (i.e., the stock), we calculate the number of media items checked by each patron during each week (i.e., the flow) by calculating the difference between the number of checkouts in week t and those in week $(t-1)$ for each patron i.[3]

[2]Some library materials, such as ebooks and audiobooks, have increasingly become accessible remotely. However, the use of these materials remains small relative to the use physical library materials. For example, in 2014, circulation of all electronic materials represented only 4.7% of the total circulation for the public library of interest. In the same year, only 56% of all U.S. public library systems had any electronic material circulation and of those, the circulation of electronic materials represented, on average, only 5.2% of total circulation (Institute of Museum and Library Sciences 2014). Therefore, patrons' demand for physical library materials represents the vast majority of public library use.

[3]Patrons may check out items for a period of two to four weeks, depending on the type of media and demand. For example, newly acquired media may have a shorter period after which patrons must return the item. For most items, patrons are allowed to renew once before returning the item to the library.

We use this checkout data collection process in the micropolitan library by generating historical circulation records and calculating weekly checkout records for each patron every Tuesday between August 22, 2013 and May 19, 2015. For each patron, the data contain only checkout records and the address registered for the patron's library card account. We augment these patron-level data to approximate patron demographic and socioeconomic characteristics and spatial distance from the library.

First, for each address associated with a patron record we match the property tax assessment value from the Montana Cadastral system. That is, we match patron address information from the library data to property tax assessment address information in the Montana Cadastral data. Specifically, we geocode each patron's address information to a longitude and latitude value. We then match each record to location information in Cadastral using two criteria: a distance criterion that minimizes the distance between the geographic coordinates in both of the data sources and a fuzzy match criterion that matches the numeric and character values of each address. For example, a perfect match would be one in which the geocoded location of a patron's address exactly matches a latitude and longitude coordinates of an address in the Montana Cadastral system and the address itself is a perfect match to the address in the Cadastral data. In this manner, we are able to develop a reasonable proxy of patron-level relative socioeconomic class based on property values. In cases when multiple patrons live at the same address (e.g., apartment complex), each patron is associated with the proportional value of the property tax assessment (e.g., for a duplex, each resident is assigned half of the property value). Lastly, home values are provided in 2014 dollars.

Second, we use patron's geocoded addresses to place households into U.S. Census Bureau defined census block groups (CBG). The CBG is the smallest geographical unit for which the U.S. Census Bureau publicly provides sample data. Each CBG represents between 600 and 3,000 people, covers a contiguous area, and are designated by the Census Bureau's Participant

Statistical Areas Program, which allows selected participants to review and suggest modifications to block group definitions that best represent a geographic neighborhood within which individuals are well-represented by the demographic and socioeconomic characteristic of a CBG. The CBG data provide the percent of children and the percent of household with access to a vehicle within a patrons' block group.

Some patrons in the data sample window never check out an item from the library. To ensure sufficient patron-level variation for the empirical analysis, we remove these patrons, restricting the dataset to only those who checked out at least a single item during the sample time window. The fina longitudinal panel data set represents 7,246 patrons over 92 weeks, comprising of 384,170 unique observations. It should be noted that the panel is not perfectly balanced as new patrons enter during the sample period.

2.2 Library Service Area and School District Characteristics

The micropolitan area served by the public library is served by a single school district implying that all public schools follow the same school-year schedule.[4] During the sample time window, we define school closures as any period of two or more consecutive weekdays during which all primary and secondary public schools in the school district are closed, as specified by the school district's calendar.[5] The 2013-14 school year commences on August 29, 2013 and ends on June 10, 2014, during which there are four extended closures: fall break (October 17–18), Thanksgiving break (November 27–29), winter break (December 23–January 3), and spring break (March 10–14). The summer break occurs between June 10 and September 2, 2014. The 2014-15 school year commences on September 2, 2014 and ends on June 11, 2015, during which there are four

[4]There is a limited number of private schools who follow similar academic calendars as the public school district.

[5]Early releases and other closures during which students are required to attend at least part of the day are not considered. There are no closures due to inclement weather or other reasons during the 2013–14 and 2014–2015 school years.

extended closures: fall break (October 16–17), Thanksgiving break (November 26–28), winter break (December 22–January 2), and spring break (March 9–13). The summer break occurs between June 11 and August 31, 2015. School closures during the school year represent 10.8% of the weekly observations, the summer break represents 28.3%, and in-session school weeks represent the remaining 60.9%.

One concern with investigating event-based impacts on behaviors is that other, unrelated community-level events that may influence all patrons identically for a specific week. While there are multiple idiosyncratic influences, we focus on two types of systematic and measurable influences, weather and community events. We augment the above data with these community-level influences as they are likely to discourage or encourage all patrons to use public libraries within a specific week. First, the weather data from U.S. National Oceanic and Atmospheric Administration provides weekly average temperature (measured in Fahrenheit) and precipitation (measured in inches) in the micropolitan area. Second, we use the local municipal online calendar to identify the number of events occurring each week in the downtown core area, where the library is located.

A second concern is that the library and micropolitan area for which we obtained data are unique and may not be representative of other communities in the United States. To assess the extent to which our empirical analyses of this library system and community are generalizable to public libraries and communities across the United States, we use propensity score matching (PSM) to match other libraries and communities based on a number of key characteristics. To compare public libraries, we use the most recent 2014 Public Libraries Survey data, which are collected by the Institute of Museum and Library Services (IMLS) and represent annual census of U.S. public libraries. The PSM model is estimated based on libraries' total population of the service area; number of registered patrons; total library visits; circulation of all library materials;

circulation of children's materials; total collection of books, audios, and video resources; and the total number of librarians and staff. To compare communities, we use the 2015 five-year average American Community Survey data, collected by the U.S. Census Bureau. We compare communities at the ZIP code level based on percent of the population employed, median household income, median home value, percent of the population with at least a bachelor's degree, and percent of households with at least one child. Because the micropolitan area in this study is also characterized by a predominately white population, we also consider how the inclusion of a variable that describes the proportion of the population that is white affects the PSM analysis. For both the library and community PSM assessments, any location that is estimated to have at least a 50% probability of a match is assumed to be sufficiently similar to the library and community in this study.

Figures 1(a) and 1(b) provide a visual representation of public libraries and communities, respectively, that are estimated to be similar. Many of the similar public libraries serve urban and suburban communities of metropolitan and micropolitan areas in the United States. Figures 1(a) also shows that, despite the library in this study being in Montana, its service area characteristics, collection size, and circulation rates are more closely aligned with mostly non-rural public libraries that serve more densely populated communities. In Figure 1(b), the dark dots represent communities that are similar after controlling for all characteristics including the proportion of the population that is white. The lighter dots represent communities that are additional communities that are estimated as similar if no controls for population race is included in the PSM model. Both the public library and community PSM results indicate that there do not appear to be pronounced spatial biases or patterns that would suggest that the library and community in our study may be unrepresentative of many other communities across the United States.

3 Empirical Analysis

Table 1 shows the descriptive statistics for all variables in the empirical analysis. Overall, patrons the mean property value is $402,038 and 11.7% of the population are children. Public transportation is limited and 94.7% of individuals have access to at least one vehicle in their household. The average weekly temperature is 50 degrees Fahrenheit and there is 0.43 inches of precipitation per week. The library is located within the downtown core area of the micropolitan city and, on average, 3.85 events per week occur within its vicinity. Patrons tend to be fairly active with 16.8% of registered borrowers visiting the library weekly, 33.2% of patrons visiting the library bi-weekly, 49.3% of patrons visiting every three weeks, and 65.0% of all patrons visiting at least once within a four week period.

Table 2 presents a summary of patrons' library use in time periods when public schools are in session and when schools are on break. On average, each patron checkouts out 0.88 items per week during the entire sample period with 0.87 items per week when school is in-session, and 0.89 items during schools breaks. Averages by type of school break indicate that patrons check out 0.90 items per week in weeks with a school-year break and 0.88 per week during the summer break. The table also shows patrons' use of public library for individuals who we define as "frequent" users (those checking out at least one item in 20% of the sample time window). That data indicate that infrequent patrons may be more responsive (i.e., use the library more relative to their normal use) during school breaks than frequent patrons.

We also provide analysis by patrons' frequency of library use as defined as using the library at least weekly 20% of the time period.

Figure 2 provides a graphical characterization of patrons' library use during the sample period. Figure 2(a) presents a time series of the average weekly checkouts per patrons with periods of school closures represented by gray vertical bars and average weekly checkouts per month, and Figure 2(b) shows the average checkout behavior in each month across the entire sample window. The figures show that during periods of school closure within a school year the number of checkouts are higher than the overall average. However, lower levels and variability of these two measures are observed in months that occur during the summer break.

3.1 Library Demand Model

We analyze changes in public library circulation counts during school closures to estimate the degree to which changes in the demand for library materials occur during these breaks. That is, we model weekly patron-level checkout behavior and determine how school closures affect that behavior. We model the effects of four extended closures (i.e., closures of two or more full school days) that occur during the academic year and summer breaks across two school calendars. For the summer break, we further divide the time period into three parts: a two-week period immediately following the end of the school year, a two-week period immediately preceding the beginning of the school year, and an eight-week middle period. This delineation provides an ability to test whether there are differential impacts associated with the availability of competing non-school activities. For example, during the summer, families may have higher opportunity costs of using public libraries because they are more likely to take family vacations, place children into summer camps, and participate in outdoor recreational events. However, because many of these activities may not begin immediately following a school year and do not immediately precede the beginning of a new academic year, differential school closure effects on library demand may occur during these intermediate periods. These effects could be veiled if the entire summer period is considered as a single school closure period.

We estimate the demand for library materials number of library items checked out, C_{it}, by patron i during week t, using the model

$$C_{it} = \alpha + \beta_1 \text{Schl\_brk}_t + \beta_2 \text{Sum\_brk}_t + \beta_3 V_{i,t-1} + \beta_4 Comm_t + \delta_i + \delta_m + \delta_y + \varepsilon_{it} \tag{1}$$

The term Schl_brk_t represents an indicator for whether a school break occurred during week t, and Sum_brk_t is an indicator for whether summer break occurred during week t. The variable $V_{i,t-1}$ represents the number of times patron i visited the library within the previous four weeks, which we use as a measure of potential habit formation that that patrons may develop in response to library return and renewal policies. The four-week period is chosen because the library in this study requires that most media are returned or renewed within four weeks of being checked out. Lastly, $Comm_t$ is a vector of week-varying community-level characteristics (i.e., number of community events, temperature, and precipitation), δ_m and δ_y are month and year fixed effects that control for seasonal variation, δ_i are individual fixed effects, and ε_{it} is the idiosyncratic error term.

The individual fixed effects, δ_i, make this model particularly powerful. These variables control for unobserved fixed heterogeneity associated with each patron, such as the distance a patron must travel to the library, their education level, their preferences toward using public libraries, and other characteristics that cannot be measured but can influence patrons' library use decisions. Typically, selection issues such as patrons choosing how close to live to the downtown core could bias the estimator; individual fixed effects, however, significantly attenuate possible selection issues. Moreover, the model is specified to estimate differences in per patron circulation across time for the same patron. As such, selection does not affect the estimation.

4 Estimation Results

Patrons' checkouts are a count variable, and we, thus, estimate the library demand model using the Poisson estimator. Additionally, due to the complex structure of the error term, the standard errors are bootstrapped using 500 replications. Table 3 presents estimates of the library demand model. The table first shows results of three reduced specifications, the full model as shown in equation (1), and an extended model that uses more specific patron-level characteristics variables but (as a result) does not include individual fixed effects controls.

In "Reduced Model 1," which includes only the habit formation variable and individual fixed effects, the effect of school breaks on library use is identified by variation in circulation between weeks with a school break and weeks when school is in session without accounting for seasonal fluctuations or community-level characteristics. The estimation results for this model indicate that the effect of both a school-year and summer break are statistically different from zero, but that schools closures occurring within a school year may lead to higher increases in the demand for library resources. The "Reduced Model 2" specification adds monthly seasonality controls but excludes individual fixed effects. In this model, school break effects are identified by variation between circulation counts during breaks and regular-session school weeks within the same month, but does not account for individual patron differences. The estimated coefficients show that summer breaks are no longer statistically significant—likely a result of adding seasonal controls—but that school-year breaks are still important in explaining increased per patron circulation counts relative to a regular school week. We add individual fixed effects back into the model with seasonal controls, but find no changes to the impact of school-year and summer closures ("Reduced Model 3").

Our "Full Model" includes all variables described in equation (1). Estimation results in Table 3 show that the effect of a school-year break on library use changes drops slightly relative to the estimate in "Reduced Model 3," but summer breaks continue to be statistically insignificant. Specifically, the results of the fully specified model indicate that weekly per patron circulation counts increase by 6.0% in weeks during the school closure that occur within a school year. Furthermore, both habit formation controls and community-level characteristics are estimated to have an impact on circulation counts. The estimation results indicate that patrons who have visited a library within the past four weeks are more likely to checkout a higher quantity of library resources, perhaps because they are required to visit the library to return or renew materials that they checked out within those preceding four weeks. Furthermore, the results show that a higher number of downtown events—which are unrelated to library outreach or promotion events but are located near the public library—have significant spillover effects by increasing patrons' checkout behavior. Conversely, higher precipitation has a negative marginal effect on circulation counts, likely because adverse weather deters patrons from visiting the public library.

Lastly, our "Extended Model" specifies library checkout behavior as a function of all variables in the "Full Model" except individual fixed effects. In lieu of these individual fixed effects, we include three patron-specific characteristics: a patron's home tax assessment value (as a proxy for income and wealth) and the per capita number of kids and number of cars in a patron's U.S. Census block group. While excluding individual fixed effects does reduce the fit of the "Extended Model" (as indicated by a lower log pseudo-log likelihood value than that of the "Full Model"), it does allow for a richer economic analysis of factors that alter library demand. Estimation results of the "Extended Model" indicate an identical 6.0% increase in weekly per patron circulation counts during a school closure within a school year and no significant effect of a summer break. The non-changes suggest that the inclusion of patron controls in lieu of individual fixed effects do not alter the coefficient estimates for the variables of interest outside of a reasonable interval. However, this model does add value to the economic analysis by showing that patrons with higher home values (and, thus, also likely higher incomes and/or wealth levels) are likely to checkout fewer items from a public library.

4.1 Robustness and Falsification Analyses

We conduct several robustness analyses to determine the sensitivity of our estimation results to various specification and estimator permutations. First, we estimate the full model described by equation (1) using ten different patron habit-formation variables. Table 5 presents the estimation results for these alternative specifications. Model 1 omits the habit formation variable. Models 2–5 include patrons' number of visits in the preceding week, the last two weeks, the last three weeks, and the last four weeks. Models 6–9 include the number of items checked out in the preceding week, the last two weeks, the last three weeks, and the last four weeks. Lastly, Model 10 includes a patron-specific estimated probability of visiting the library based on each patron's library use history (Appendix A presents the methodological description for creating this variable).

The results indicate that across the ten alternative habit-formation specifications, the statistical significance of the coefficients of interest remains identical and there is minimal variation in the parameter estimates' magnitudes. Specifically, increases in per patron circulation counts during school-year breaks are estimated to be between 5.7%-6.4%, and summer breaks have no statistically significant impacts on library use. These results suggest that regardless of how patron-specific library use habits are specified, the impacts of school breaks remains consistently evident.

Our second robustness analysis considers changes to the Poisson estimator. That is, we estimate the fully specified library demand model using a panel ordinary least squares. Table 4 presents the estimated parameters for the two variables of interest—school-year and summer school closures—for the original Poisson and the two alternative estimator. The consistency of the estimation results provide evidence that the magnitudes and significances are robust against alternative model specifications and estimators. Furthermore, the log-likelihood value for the Poisson estimator is substantially higher than that of the OLS estimator, suggesting that the Poisson model is a more appropriate choice.

Lastly, we acknowledge that, due to privacy concerns, our data are limited because they do not characterize the information about the types of media that patrons check out. Therefore, one might be concerned that increases in library material checkouts during school closures may not be driven by increased library use by children or parents of children. We attempt to address this concern in two ways. First, it is difficult to envision alternative explanations for increases in checkouts during periods that overlap with school closures and that do not overlap with other major events that could explain changes in patrons' behaviors. For example, a number of school closures on dates that are neither federal nor religious holidays. Therefore, it is unlikely that patrons who do not have children enrolled in public schools would systemically alter their library use behaviors in precise symmetry with a public school calendar.

To provide empirical evidence of the argument above, we develop a falsification test that estimates the fully specified library demand model by the quartile of the number of children in each patron's U.S. Census block group. A comparison of marginal effect estimates across the four estimated models can help test the hypothesis that school-year breaks have little to no effect on library use for households with few or no children. Estimation results for the four subsample regressions in Table 6 indicate that there is no differential effect on library use during school breaks in households with below-median number of children. However, for patrons whose households are in Census block groups with an above-median number of children, changes in checkout likelihoods are positive and statistically significant. Moreover, the magnitude of the marginal effects increases from 6.7% in the third quartile to 8.6% in fourth quartile. These empirical results offer suggestive evidence in support of the intuitive reasoning described above.

4.2 Frequency of Library Use

In the main analysis, we assess library demand by patrons who are both frequent and infrequent library visitors. However, there could be differential impacts of school breaks on those who use the library infrequently—defined in this study to be individuals who have checked out at least one item in fewer that 20% of weeks in the sample time window—and those who are regular visitors. To test whether there is empirical evidence of differential impacts of school breaks on these two patron groups, we estimate the model in equation (1) for two subsamples of patrons.

Table 7 presents the estimation results for the patron subsamples based on frequency of checkouts. The results show that during school-year breaks, frequent patrons increase their library use by 5.0%, with no changes during the summer break. However, infrequent patrons increase their library use by 10.9% during school-year breaks, and also exhibit no changes during the summer break. Comparing the subsample marginal effect estimates between the two groups suggests that infrequent patrons are more than twice as responsive to school breaks than those patrons that more regularly use the public library. These results provide additional evidence that public libraries may be important structured education substitutes for public schools during periods when schools are closed and when few other alternatives exist that offer structured programs. And this is especially the case for patrons who do not regularly use a library.

4.3 Timing and Individual Break Analyses

Families are provided with a school calendar well in advance (or at least at the beginning) of a school year and are, therefore, likely to know when school closures will occur. As such, it is conceivable that families may increase library use before breaks in preparation for the closures. For example, a family may visit a library one week in advance of a school break in order to check out numerous items that children can use at home while on break. By empirically investigating the potential impacts of school closure timing, we can assess the degree to which inter-temporal substitution between weeks that occur during a school break and those that lead up to and occur after the break.

Again using the fully specified model in equation (1), we add lag and lead variables to characterize patron-level library use behavior before and after school breaks. Specifically, we assess two-week pre- and post-school break effects by including five sets of variables for the school-year closure: $\{\text{Schl\_brk}_{t-2},\ \text{Schl\_brk}_{t-1},\ \text{Schl\_brk}_{t},\ \text{Schl\_brk}_{t+1},\ \text{Schl\_brk}_{t+2}\}$. Due to the substantial length of the summer break, using a similar time indexing approach would not provide much insights. Instead, we test whether differential impacts may exist across three distinct time periods: within the first two weeks after a school year concludes, within the last two weeks of summer break prior to beginning of a new school year, and during the remaining "middle" portion of the summer break. Summer activities such as summer school, summer camps, or family vacations may not begin immediately following a school year and typically do not conclude immediately before the beginning of a new school year. As such, demand for library use may be different in these "buffer" periods. Moreover, any differential effects that may occur during these two periods may be attenuated by the "middle" summer break period, which represents many more weeks.

Figure 4 and Table 8 present the estimated coefficients for the two timing analyses. For the school-year break lag and lead model, the regression results suggest that significant differences in patrons' library use occur only during the actual weeks of a school-year break. During the preceding and following weeks of a school-year break, library use behaviors do not statistically differ from those when school is in session. An interpretation of this result may be that the opportunity cost of visiting the library decreases when the opportunity cost of leisure time decreases. Thus, the results indicate an increase in library use during weeks with school breaks, but an absence of inter-temporal substitution two weeks before or after. This suggests a net overall increase in per patron circulation because the rise in circulation counts is not offset by a decline in circulation counts before/after the break. Additionally, the estimation results indicate that per patron circulation counts increase by 35.9% during the first two weeks of summer and then decline during the middle summer break period by 19.2% relative to when school is in-session.

In addition to the inter-temporal substitution analysis, we estimate marginal effects of specific school closures to investigate whether there are differential impacts across school breaks. That is, we estimate the fully specified library demand model with separate indicator variables for the four school-year breaks and an indicator for the summer break. The regression results presented in Table 9 Figure 5 indicate that all but the winter school-year break have a positive, statistically significant effect on library use. Specifically, 11.5%, 16.3%, and 7.3% increases in per patron circulation counts are identified in the fall, Thanksgiving, and spring breaks, respectively.[6] No apparent library use changes occur during the overall summer break period.

4.4 Differential Effects by Socioeconomic Status

Another important research question that we are able to investigate is whether public library use during school-break is manifest differently across families with different socioeconomic backgrounds. To test for differences, we use patrons' home tax assessment value as a proxy for their income and/or wealth status. Table 10 shows that descriptive statistics of circulation counts across home value quartiles, indicating that library use during the school year appears to be a decreasing function of home value. Conversely, during school-year breaks, higher home values appear to be associated with increased library demand.

To formally assess potential differential effects of school closures on public library demand,

[6] The statistical insignificance of the winter break effect must be interpreted with some caution because the public library was partially inaccessible due to its closures on Christmas and New Year's Day holidays.

we extend equation (1) with a series of home tax assessment value quartile interaction variables; that is,

$$\begin{aligned} C_{it} \; = \; & \alpha + \beta_1 \text{Schl\_brk}_t \times Q_1 + \beta_2 \text{Sum\_brk}_t \times Q_1 + \beta_3 \text{Schl\_brk}_t \times Q_2 + \\ & \ldots \beta_4 \text{Sum\_brk}_t \times Q_2 + \beta_5 \text{Schl\_brk}_t \times Q_3 + \beta_6 \text{Sum\_brk}_t \times Q_3 + \\ & \ldots \beta_7 \text{Schl\_brk}_t \times Q_4 + \beta_8 \text{Sum\_brk}_t \times Q_4 + \\ & \ldots \beta_9 V_{i,t-1} + \beta_{10} Comm_t + \delta_i + \delta_m + \delta_y + \varepsilon_{it}, \end{aligned} \tag{2}$$

where Q_1–Q_4 are home value quartile indicators. The coefficients of interest are β_1 through β_8. The coefficients β_1 and β_2 are the estimates of the percentage changes in per patron circulation counts of households with the lowest home value during school-year and summer breaks, respectively, relative to per patron circulation counts when school is in session. The coefficients β_3 and β_4, β_5 and β_6, β_7 and β_8, estimate similar percentage changes in per patron circulation counts for households with quartile 2, 3, and 4 home values, respectively.

Table 11 and Figure 6 present the parameter estimates associated with the variables of interest. The results indicate that during school-year breaks, patrons in the top three quartiles increase checkouts relative to the same households in weeks when school is in session. Specifically, per patron circulation counts increase by 5.4% for households in the second home value quartile, 8.5% for households in the third quartile, and 7.7% for households in the fourth quartile. The results also indicate no statistically significant difference between library use when school is in session and summer break, except for households within the lowest quartile who decrease library use by 13.3% during summer breaks.

4.5 Differential Effects by Distance from Library

In addition to assessing differential impacts across socioeconomic status, we assess the extent to which distance from the public library may affect library use during school breaks. Table 10 provides descriptive statistics of library use across different distance thresholds and we test for potential distance effects in a regression framework by extending the model in equation (1) using a series of distance indicator variables; that is,

$$\begin{aligned} C_{it} &= \alpha + \beta_1 \text{Schl\_brk}_t \times D_1 + \beta_2 \text{Sum\_brk}_t \times D_1 + \beta_3 \text{Schl\_brk}_t \times D_2 + \\ &\quad \ldots \beta_4 \text{Sum\_brk}_t \times D_2 + \beta_5 \text{Schl\_brk}_t \times D_3 + \beta_6 \text{Sum\_brk}_t \times D_3 + \\ &\quad \ldots \beta_7 \text{Schl\_brk}_t \times D_4 + \beta_8 \text{Sum\_brk}_t \times D_4 + \\ &\quad \ldots \beta_9 V_{i,t-1} + \beta_{10} Comm_t + \delta_i + \delta_m + \delta_y + \varepsilon_{it}, \end{aligned} \tag{3}$$

where D_1 – D_4 represent indicator variables corresponding to a home-to-library distance. Patrons who live less than 0.5 miles from the library are indicated by D_1, those living between 0.5 and 1 miles are indicated by D_2, those living between 1 and 2 miles are indicated by D_3, and those who live farther than 2 miles from the library are indicated by D_4. The coefficients β_1 and β_2 are the estimates of the percentage changes in per patron circulation counts of households within 0.5 miles of the library during school-year and summer breaks, respectively, relative to per patron circulation counts when school is in session. The coefficients β_3–β_8 estimate similar percentage changes in per patron circulation counts for households within the other three distance measures.

Table 11 and Figure 7 present the regression results. First, the results indicate that patrons who live more than 1 miles away increase library use by 6.8% to 10.6% during weeks of school-year breaks relative to weeks when school is in session, while no differential effect is observed for patrons less than 1 mile from the library. It may be that due to proximity, the cost of using the library is already low for patrons close to the library, suggesting that the opportunity cost of using the library during breaks is larger than for patrons farther away. The results also suggest no differential effects during the summer break across all distance groups.

5 Discussion

In this study, we exploit an information-rich, patron-level longitudinal dataset to empirically evaluate the extent to which public institutions provide low-cost supplemental educational resources during periods when public schools are not in session. Because public libraries offer low-cost access to informational media in a highly structured and directed environment, individuals may consider them to be complementary to public schools in delivering educational content to children. We provide evidence that, on average, this is indeed the case: circulation of library materials increase during periods of public school breaks. The largest and most consistent increases occur during public school closures that occur during the school year (rather than the summer break), potentially because there is a relatively high opportunity cost of engaging in other, non-educational activities during those times. These results provide important insights about the role of public libraries in enhancing human capital development.

Despite the overall positive findings associated with public libraries' potential role in supplementing educational content, we also show that there is significant heterogeneity of these marginal benefits across individuals with differential opportunities to take advantages of the benefits. Our results suggest that the greatest increases in library demand originate from those individuals with a relatively high mobility and those in the higher portions of the income and wealth distribution. The results of our analyses suggest that individuals with higher socioeconomic status are more likely to increase their use of public libraries during school closure opportunities, even though those individuals are more likely to live farther from the library. Conversely, individuals who might live near a public library may not be as engaged in its use because these patrons may face economic constraints that could prevent them from recognizing the structured educational benefits provided by public libraries during school closures.

In urban settings, where populations are more dense and access to public transportation is more readily available, it is more likely that public libraries would impact a broader socioeconomic range of patrons. However, in some communities, public libraries and associated local governments may need to enact policies and initiatives to provide greater access to these educational opportunities. For example, mobilizing library resources (e.g., bookmobiles that travel to different points in a community to provide more limited library resources) or smaller but more geographically dispersed library branches are examples of efforts undertaken by some public libraries to reduce the mobility and socioeconomic constraints.

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Table 1: Summary Statistics

	Mean	Std. Dev.	Min	Max
Number of items checked this week	0.879	3.525	0	181
Break during school year	0.108		0	1
Summer break	0.283		0	1
Distance to library	2.099	1.351	0.065	21.175
Log(Home Property Value)	12.51	0.954	5.100	16.194
Kids per capita	11.73	5.931	0	26.012
Cars per capita	94.71	5.289	79	100
Number of downtown events	3.845	1.666	1	9
Average temperature	50.47	20.16	4.14	81.29
Total precipitation	0.425	0.411	0	1.66
February	0.077		0	1
March	0.072		0	1
April	0.091		0	1
May	0.075		0	1
June	0.078		0	1
July	0.102		0	1
August	0.102		0	1
September	0.074		0	1
October	0.087		0	1
November	0.072		0	1
December	0.093		0	1
Number of visits to library in last week	0.168		0	1
Number of visits to library in last two weeks	0.332	0.617	0	2
Number of visits to library in last three weeks	0.493	0.842	0	3
Number of visits to library in last four weeks	0.650	1.057	0	4
Number of items checked last week	0.867	3.470	0	181
Number of items checked last two weeks	1.711	5.600	0	264
Number of items checked last three weeks	2.540	7.622	0	290
Number of items checked last four weeks	3.344	9.584	0	354
Observation		384,170		

Notes: Standard errors omitted for indicator variables. Distance to library from patrons' homes measured in miles. Home value measured in 2004 dollars. Temperature measured in Fahrenheit and precipitation measured in inches.

Table 2: Descriptive statistics of patrons' library use, weekly

Time Period	All	Frequent Patrons	Infrequent Patrons
School in session	0.87	2.01	0.24
School break	0.89	1.99	0.30
School-year break	0.90	2.07	0.31
Summer break	0.88	1.96	0.25
Overall	0.88	2.01	0.26
Observations	384,170	149,007	235,163

Notes: *Frequent* is defined by using the library at least weekly 20% during the sample period. Library use is defined as the number of items checked during a week.

Table 3: Estimation results on patron borrowing during school closures

	Reduced Model 1		Reduced Model 2		Reduced Model 3		Full Model		Extended Model	
Variable	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.		
School-year break	0.043***	0.016	0.077***	0.016	0.077***	0.016	0.060***	0.017	0.060***	0.017
Summer break	0.032*	0.018	-0.037	0.028	-0.039	0.028	-0.017	0.028	-0.015	0.028
Number of weeks visited library in last four weeks	0.201***	0.007	0.223***	0.013	0.209***	0.007	0.210***	0.007	0.224***	0.013
January			-0.050**	0.024	-0.047**	0.024	-0.040	0.026	-0.042	0.026
February			–	–	–	–	–	–	–	–
March			0.050**	0.026	0.051**	0.026	0.084**	0.035	0.084**	0.035
April			0.017	0.025	0.017	0.025	0.031	0.041	0.03	0.041
May			0.003	0.028	0.004	0.028	0.045	0.046	0.045	0.046
June			0.017	0.032	0.021	0.032	0.087	0.056	0.084	0.055
July			0.074*	0.040	0.074*	0.040	0.099	0.069	0.099	0.069
August			0.139***	0.040	0.134***	0.040	0.166**	0.068	0.171**	0.068
September			0.172***	0.033	0.164***	0.032	0.224***	0.059	0.232***	0.060
October			0.011	0.025	0.014	0.025	0.061	0.037	0.059	0.037
November			0.124***	0.026	0.125***	0.026	0.137***	0.030	0.136***	0.030
December			-0.102***	0.027	-0.098***	0.026	-0.082***	0.026	-0.086***	0.027
Number of downtown events							0.019***	0.003	0.019***	0.003
Average temperature							-0.001	0.001	-0.001	0.001
Total precipitation							-0.028*	0.017	-0.029*	0.017
Distance to library									-0.035	0.028
Log(Home Value)									-0.038**	0.019
Kids per capita									0.000	0.005
Cars per capita									0.006	0.006
Individual Fixed Effects	Yes		No		Yes		Yes		No	
Year Fixed Effects	Yes		Yes		Yes		Yes		Yes	
Log pseudolikelihood	-549,155		-591,100		-548,518		-548,336		-590,917	
Observations	384,170		384,170		384,170		384,170		384,170	

Notes: Dependent variable is number of items checked out during the week. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

Table 4: Habit-formation Specification Robustness Analysis

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
School-year break	0.062***	0.057***	0.060***	0.065***	0.060***	0.064***	0.064***	0.064***	0.062***	0.064***
	0.016	0.016	0.016	0.017	0.017	0.016	0.016	0.016	0.017	0.016
Summer break	-0.042	-0.028	0.000	0.007	-0.017	-0.039	-0.038	-0.038	-0.042	0.020
	0.028	0.028	0.029	0.029	0.028	0.028	0.028	0.029	0.029	0.037
Library Habit Formation	- -	0.283***	0.236***	0.205***	0.210***	0.003	0.004***	0.004***	0.005***	2.576***
	- -	0.018	0.012	0.009	0.007	0.002	0.001	0.001	0.001	0.038
Community Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log pseudolikelihood	-561,575	-553,332	-551,852	-550,907	-548,337	-555,688	-555,261	-554,886	-553,896	-552,181
Observations	384,170	384,170	384,170	384,170	384,170	384,170	384,170	384,170	384,170	384,170

Notes: Dependent variable is number of items checked out during the week. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications. Habit formation variable for Models 2 - 5 are number of visits last week, last two weeks, etc., respectively. Habit formation variable for Models 6 - 9 is number of items checked out last week, last two week, etc., respectively. Model 10 habit formation is outlined in Appendix A.

Table 5: Alternative Estimator Analysis

	Poisson		OLS	
	Coeff.	Std. Err.	Coeff.	Std. Err.
School-year break	0.060***	-0.017	0.057***	-0.015
Summer Break	-0.017	-0.028	-0.016	-0.025
Log pseudolikelihood	-548,337		-960,849	
Observations	384,170		384,170	

Notes: Dependent variable is number of items checked out during the week. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

Table 6: Estimation Results by Child Density

	Quartile 1		Quartile 2		Quartile 3		Quartile 4	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
School-year break	0.038	0.042	0.041	0.029	0.067**	0.034	0.086***	0.029
Summer Break	0.070	0.060	-0.093	0.057	-0.084	0.061	0.008	0.049
Community Control Variables	Yes		Yes		Yes		Yes	
Habit Formation Variable	Yes		Yes		Yes		Yes	
Individual Fixed Effects	Yes		Yes		Yes		Yes	
Month Fixed Effects	Yes		Yes		Yes		Yes	
Year Fixed Effects	Yes		Yes		Yes		Yes	
Log pseudolikelihood	-129,181		-125,068		-122,441		-169,050	
Observations	96,042		96,042		96,042		96,042	

Notes: Dependent variable is number of items checked out during the week. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

Table 7: Estimation Results by Frequency of Library Use

	All		Frequent Patrons		Infrequent Patrons	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
School-year break	0.060***	0.017	0.050***	0.018	0.109***	0.042
Summer Break	-0.017	0.028	-0.035	0.033	0.044	0.059
Community Control Variables	Yes		Yes		Yes	
Habit Formation Variable	Yes		Yes		Yes	
Individual Fixed Effects	Yes		Yes		Yes	
Month Fixed Effects	Yes		Yes		Yes	
Year Fixed Effects	Yes		Yes		Yes	
Log pseudolikelihood	-548,337		-365,753		-181,596	
Observations	384,170		149,007		235,163	

Notes: Dependent variable is number of items checked out during the week. *Frequent* is defined by using the library at least weekly 20% during the sample period. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

Table 8: Estimation Results of Lag/Lead School Closures

	Coeff.	Std. Err.	Coeff.	Std. Err.
School-year break$_{t-2}$	0.029	-0.020		
School-year break$_{t-1}$	0.002	-0.022		
School-year break$_{t}$	0.066***	-0.020	0.060***	-0.017
School-year break$_{t+1}$	-0.032	-0.020		
School-year break$_{t+2}$	0.002	-0.019		
Summer break	-0.166***	-0.028		
End of school			0.359***	-0.061
Middle summer break			-0.192***	-0.043
Before next school year			0.010	-0.040
Community Control Variables	Yes		Yes	
Habit Formation Variable	Yes		Yes	
Individual Fixed Effects	Yes		Yes	
Month Fixed Effects	Yes		Yes	
Year Fixed Effects	Yes		Yes	
Log pseudolikelihood	-483,126		-548,146	
Observations	384,170		384,170	

Notes: Dependent variable is number of items checked out during the week. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

Table 9: Estimation Results by School Break

	Coeff.	Std. Err.
Fall	0.115***	0.038
Thanksgiving	0.163***	0.037
Winter	-0.025	0.025
Spring	0.073**	0.037
Summer	-0.020	0.029
Community Control Variables	Yes	
Habit Formation Variable	Yes	
Individual Fixed Effects	Yes	
Month Fixed Effects	Yes	
Year Fixed Effects	Yes	
Log pseudolikelihood	-548,259	
Observations	384,170	

Notes: Dependent variable is number of items checked out during the week. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

Table 10: Descriptive statistics of patrons' library use by home value, weekly checkouts

	Home Property Value			
	Quartile 1	Quartile 2	Quartile 3	Quartile 4
School year	0.91	0.87	0.87	0.84
School-year break	0.90	0.90	0.94	0.88
Summer break	0.87	0.91	0.89	0.87
	Distance to Library			
	Distance < 0.5	$0.5 <$ Distance < 1	$1 <$ Distance < 2	Distance > 2
School year	0.85	0.90	0.87	0.87
School-year break	0.84	0.85	0.92	0.92
Summer break	0.79	0.81	0.93	0.89
Median home value	$ 418,864	$ 514,846	$ 379,466	$ 378,141

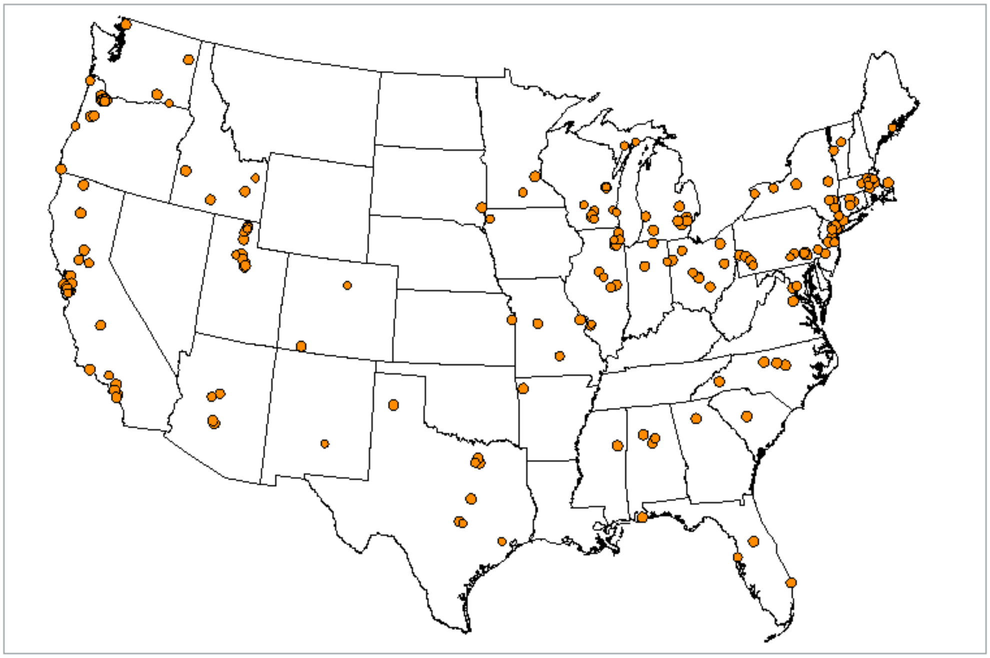
Notes: Library use is defined as the number of items checked during a week. Home value measured in 2004 dollars. Distance to library measured in miles.

Table 11: Estimation Results by Household SES and Distance to Library

	Property Value		Distance to Library	
	Coeff.	Std. Err.	Coeff.	Std. Err.
School-year break X Quartile 1	0.024	0.027	0.016	0.044
School-year break X Quartile 2	0.054*	0.028	-0.031	0.058
School-year break X Quartile 3	0.085**	0.041	0.106***	0.029
School-year break X Quartile 4	0.077**	0.03	0.068***	0.022
Summer break X Quartile 1	-0.133***	0.044	-0.045	0.075
Summer break X Quartile 2	0.058	0.041	-0.09	0.055
Summer break X Quartile 3	-0.004	0.04	0.015	0.04
Summer break X Quartile 4	0.009	0.042	-0.011	0.034
Community Control Variables	Yes		Yes	
Habit Formation Variable	Yes		Yes	
Individual Fixed Effects	Yes		Yes	
Month Fixed Effects	Yes		Yes	
Year Fixed Effects	Yes		Yes	
Log pseudolikelihood	-548,168		-548,294	
Observations	384,170		384,170	

Notes: Dependent variable is number of items checked out during the week. Coefficient estimates and standard errors (underneath) are displayed. *, **, and *** indicate statistically significant differences at the 10%, 5%, and 1% levels, respectively. Bootstrap standard errors with 500 replications.

(a) Similar Public Libraries



(b) Similar Communities

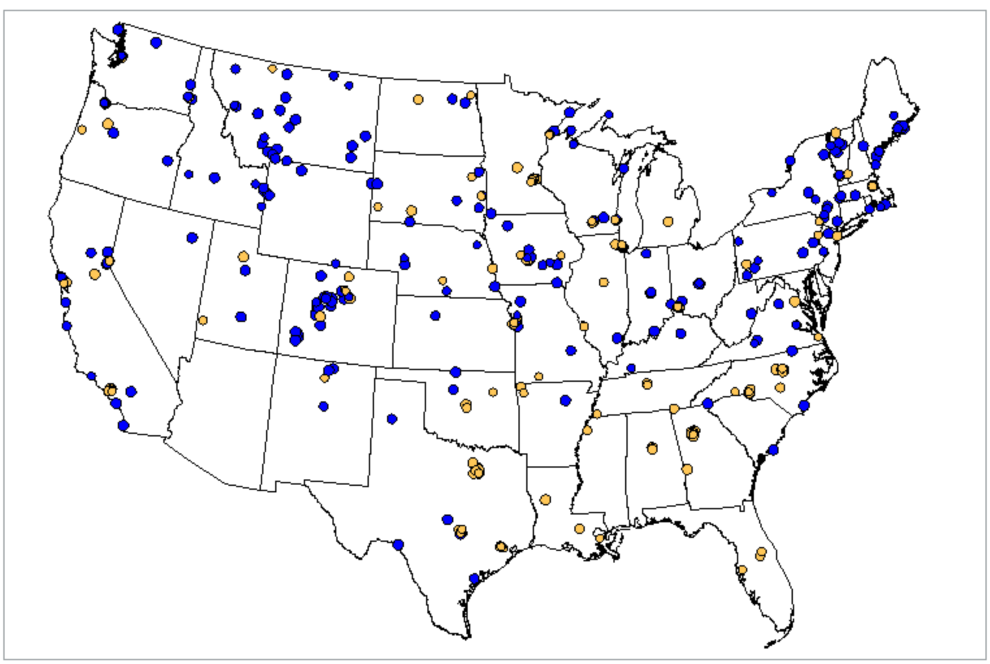
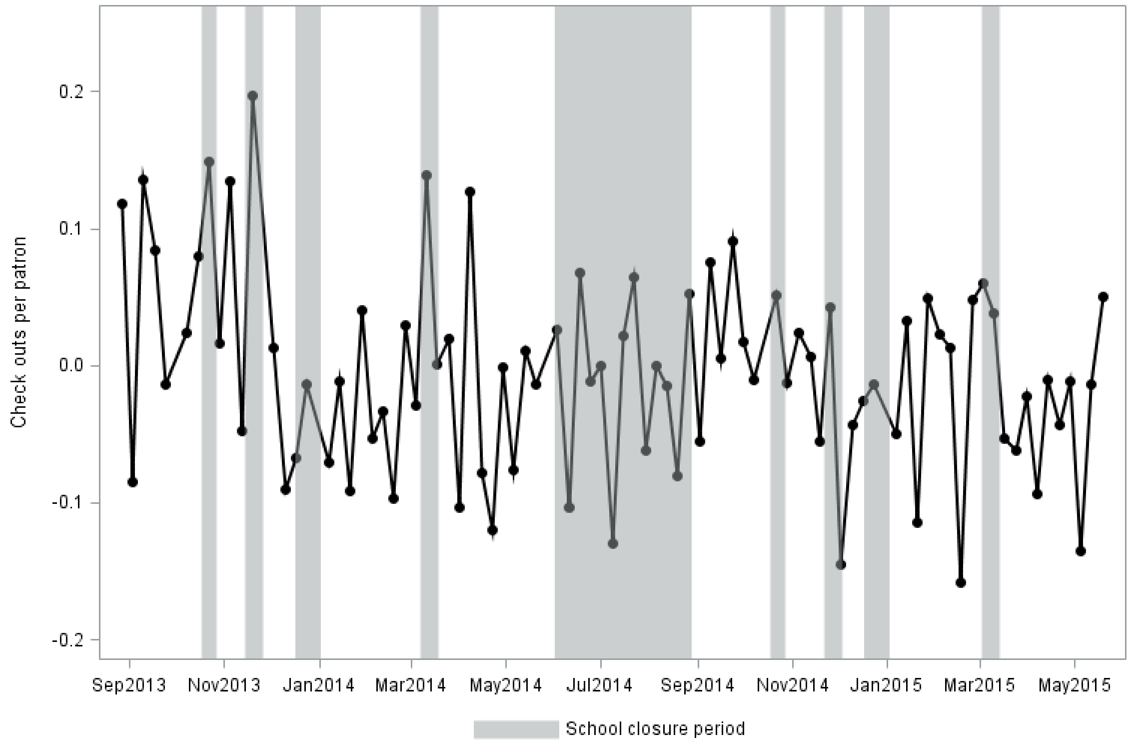


Figure 1: Similar Public Libraries and Communities Estimated Using Propensity Score Matching

(a) Checkouts, De-trended Weekly Average



(b) Checkouts, Monthly Averages Across Years

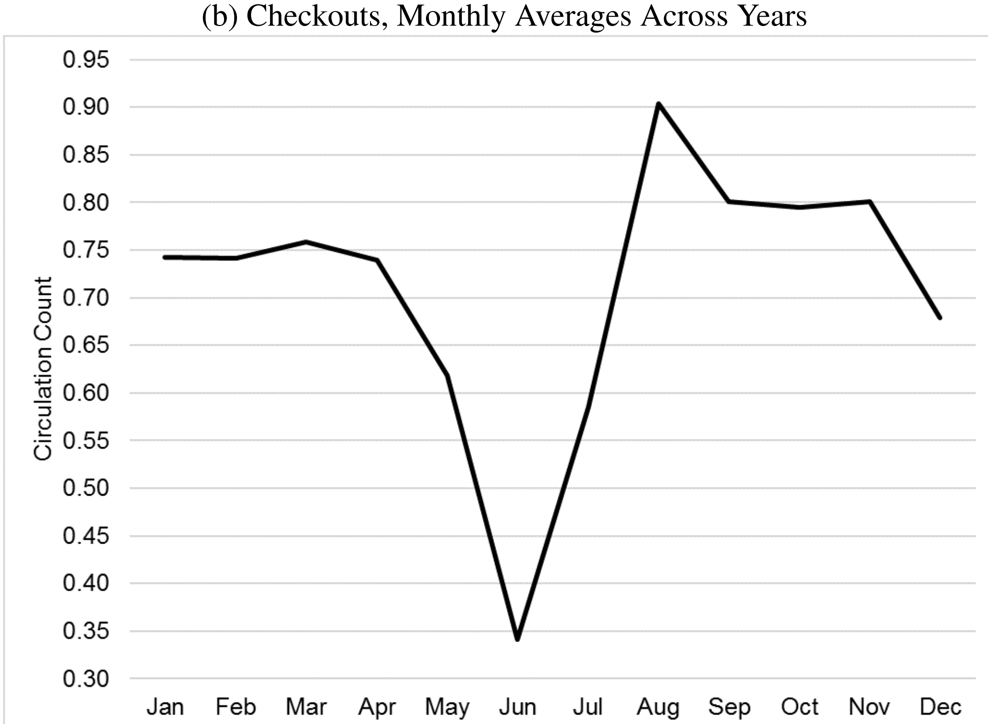
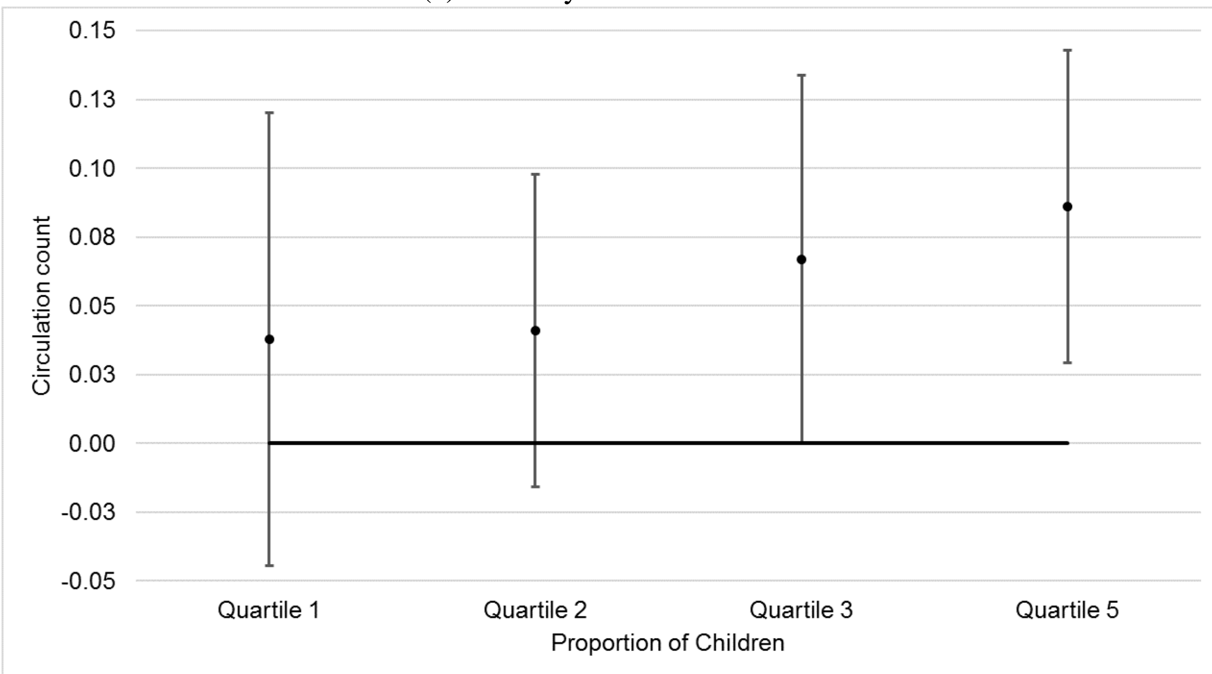


Figure 2: Checkouts per Patron, by Week Across Sample and by Monthly Average

Notes: Weekly average checkouts represented data that have been detrended by subtracting the mean per patron checkouts for each academic year.

(a) School-year Break Results



(b): Summer Break Results

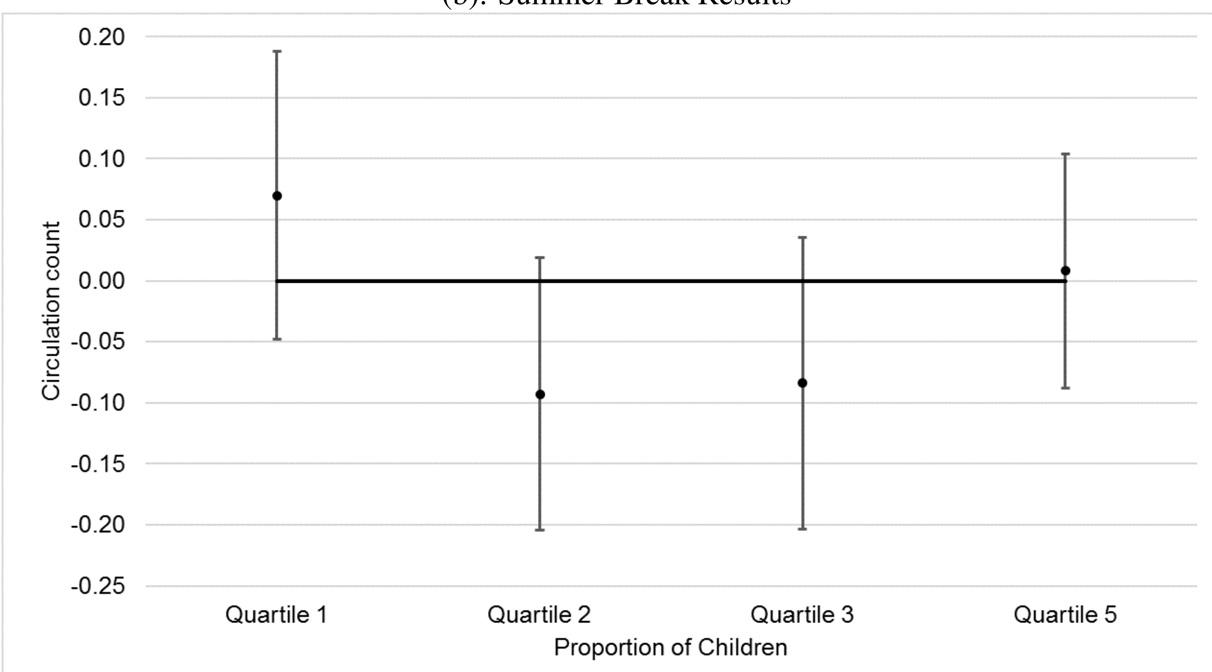


Figure 3: Estimation Results by Proportion of Children

Notes: Subsample estimation of Equation (1) by quartile of children per household's census block group. See Table 6 for results. Bootstrap standard errors with 500 replications. Only includes point estimates and 95% confidence interval on timing of school-year and summer breaks.

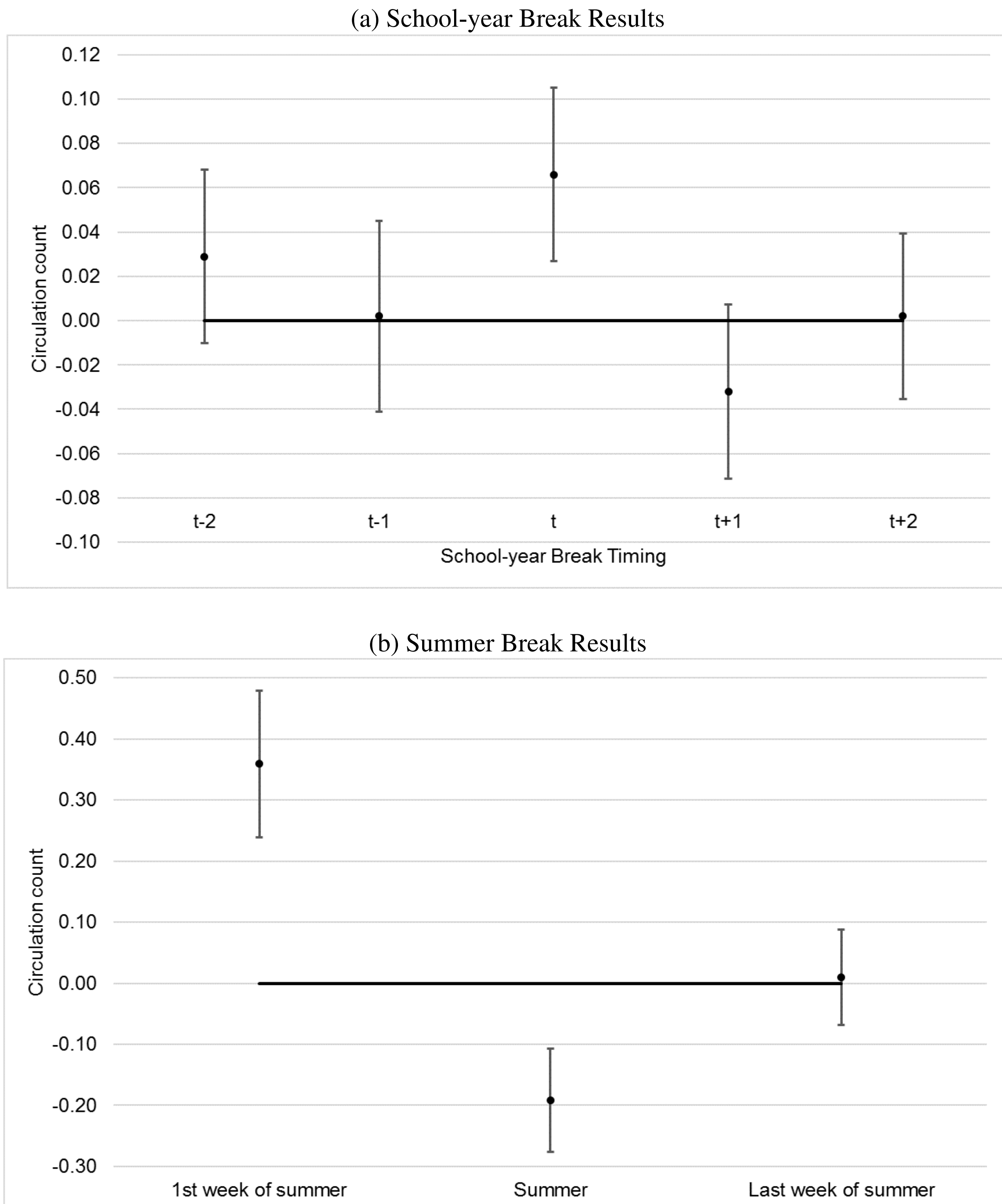


Figure 4: Estimation Results by Timing of School-year Break

Notes: Estimation of Equation (1) including two lead and lag indicators. See Table 8 for results. Bootstrap standard errors with 500 replications. Only includes point estimates and 95% confidence interval on timing of school-year and summer break transitions.

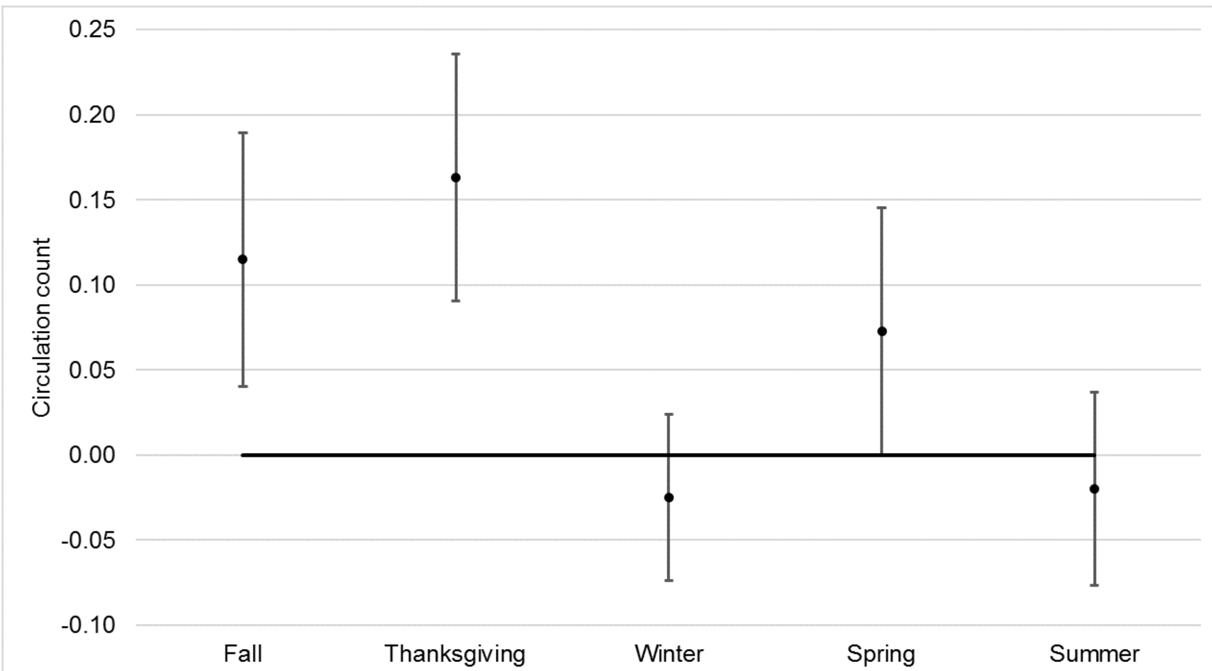
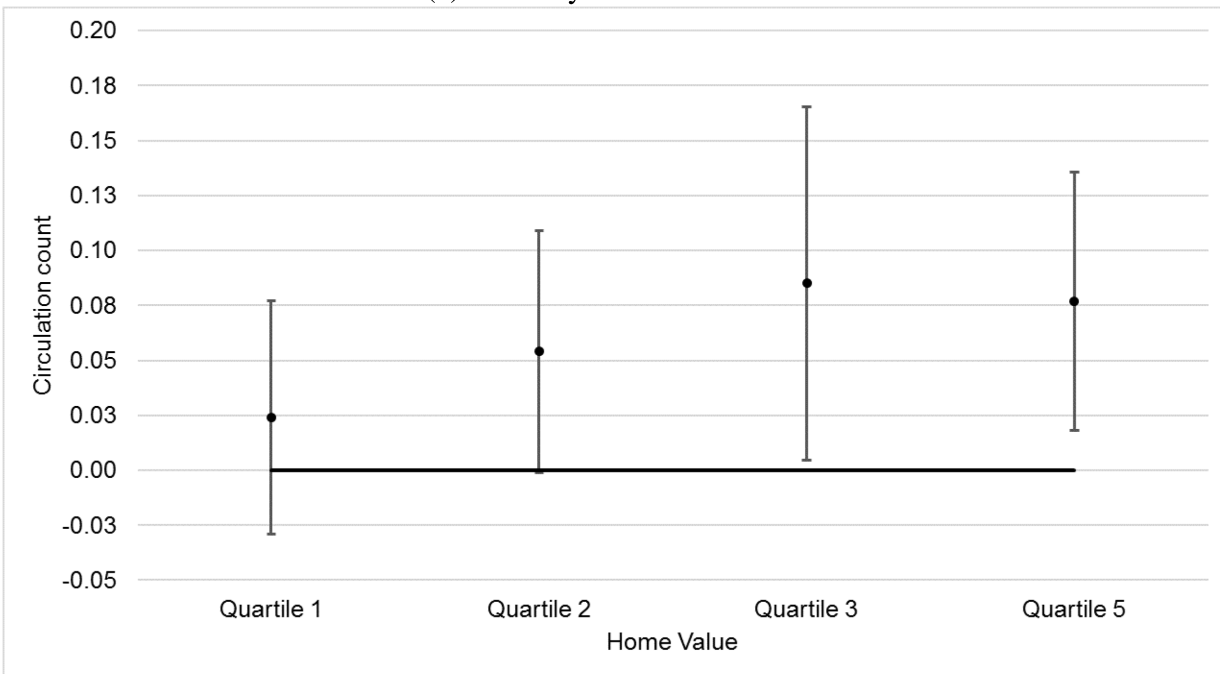


Figure 5: Estimation Results by Individual School Break

Notes: Estimation of Equation (1) with individual school-year breaks indicators. See Table 9 for results. Bootstrap standard errors with 500 replications. Only includes point estimates and 95% confidence interval on individual school-year and summer breaks.

(a) School-year Break Results



(b) Summer Break Results

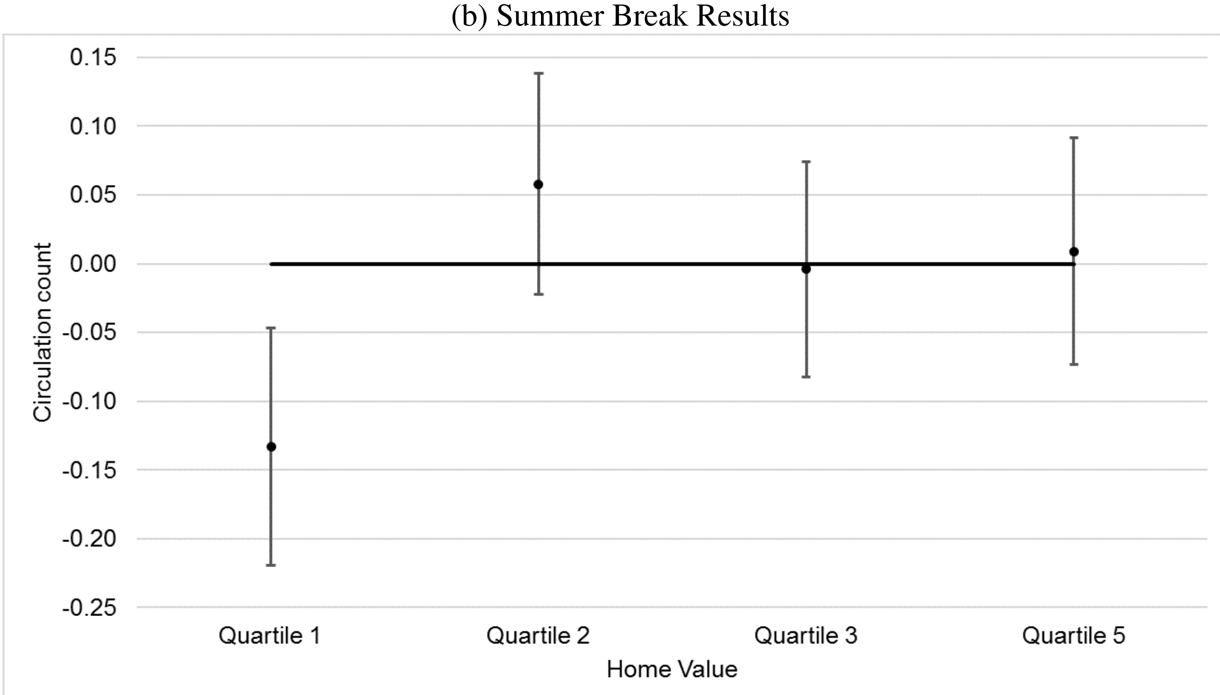
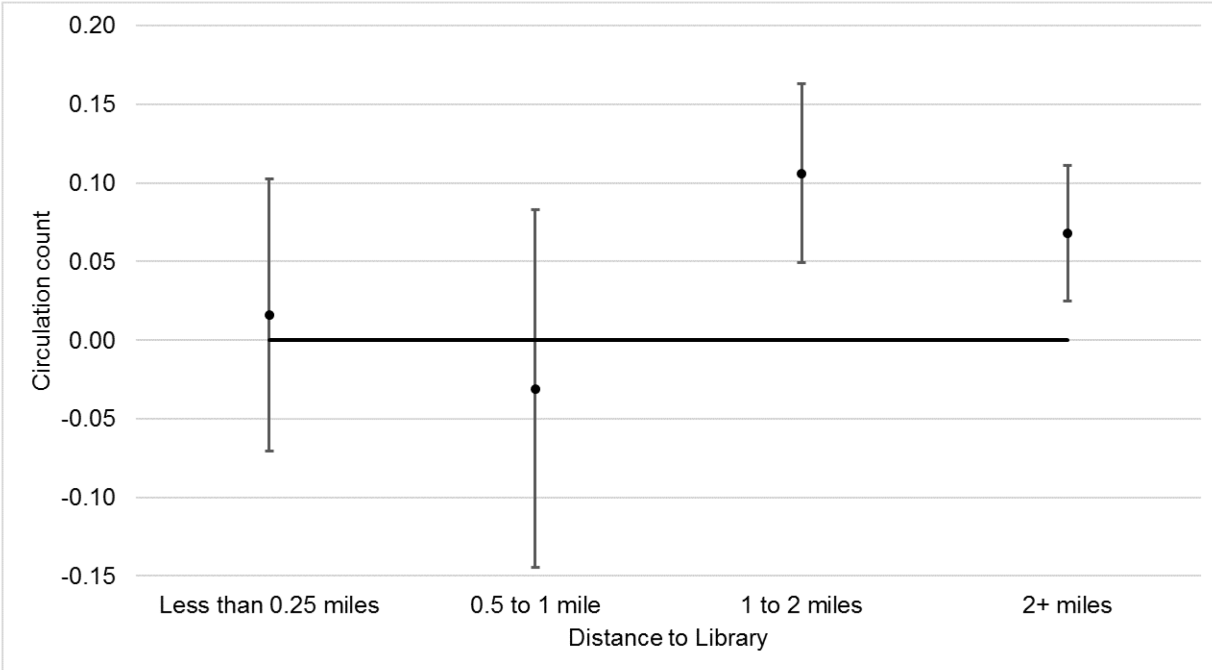


Figure 6: Estimation Results by Home Value

Notes: Estimation of Equation (2). See Table 11 for results. Bootstrap standard errors with 500 replications. Only includes point estimates and 95% confidence interval on home value quartile interaction variables.

(a) School-year Break Results



(b) Summer Break Results

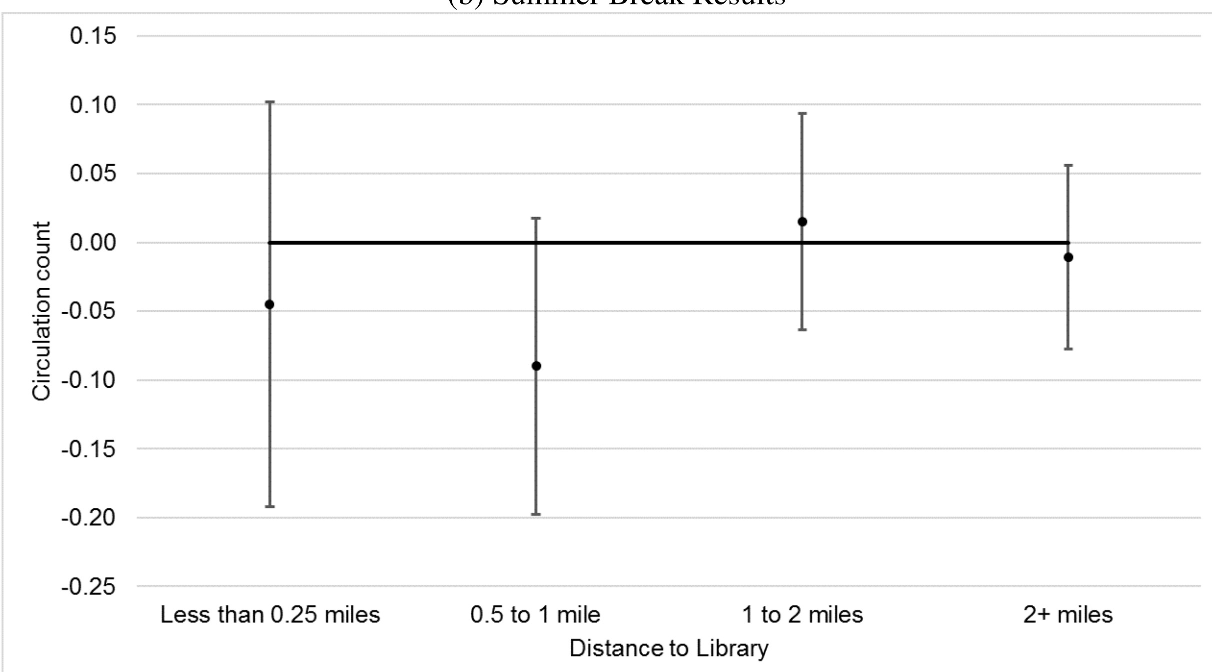


Figure 7: Estimation Results by Distance to Library

Notes: Estimation of Equation (3). See Table 11 for results. Bootstrap standard errors with 500 replications. Only includes point estimates and 95% confidence interval on distance to library interaction variables.

A Identification of Library Visit Behavior

In this section we outline a two-stage latent variable alternative modeling framework in which we first estimate patron-specific probabilities of visiting a public library and then use these probabilities in a reduced form second stage model of library demand. A patron decision to checkout items this week may be conditional on the patrons' previous library use behaviors. For example, a patron who has visited the library in week t may be less likely to visit the library in the following week $t+1$ because it is unlikely that the patron completely finished using the checked out items. However, in weeks—$t+2$, $t+3$, and so on—the probability of visiting the library and checking out new items is likely to increase. Therefore, visits are likely to occur intermittently rather than on a weekly basis.

We model each patron's probability of visiting a public library as a function of past visitation choices. That is, for patron i in week t, the binary decision to visit a library, V_{it}, is an AR(p) model of visits in preceding weeks; that is,

$$V_{it} = \gamma_i + \rho_{i1} V_{it-1} + \rho_{i2} V_{it-2} + \ldots + \rho_{ip} V_{it-p} + \eta_{it} \ , \tag{4}$$

where η_{it} is a white noise term.

There are several advantages of specifying a first-stage time series model of visitation behavior. First, the lagged dependent variables can be interpreted as a class of predetermined variables, which are exogenous to the error term in time t. That is, due to the intermittent nature of patrons' visit decisions, information about past visit behaviors is likely to be a primary source of information about the decision in week t. However, a patron's decision to visit a public library in week t will not affect the decision in any of the preceding weeks; that is, the term η_{it} is uncorrelated with the explanatory variables.

Second, the specification in equation (4) is based on theoretically and empirically valid exclusion restrictions, which are not used in the second stage library demand model. Intuitively, a patron's binary choice to visit a library in a preceding week is not likely to affect that patron's decisions about the number of items to check out during the week when that patron visits the library. We also assess this relationship by calculating the correlation between lagged visitation decisions and contemporaneous level of checkouts. We find that the correlation is approximately 0.22 and there were no detectable temporal patterns across different visit lags (see Table 12).

Table 12: Correlation Table

	$Checkouts_t$	$Visit_t$	$Visit_{t-1}$	$Visit_{t-2}$	$Visit_{t-3}$
$Visit_t$	0.55				
$Visit_{t-1}$	0.22	0.36			
$Visit_{t-2}$	0.22	0.32	0.36		
$Visit_{t-3}$	0.22	0.32	0.32	0.36	
$Visit_{t-4}$	0.23	0.35	0.32	0.32	0.36

We estimate the visit probability model for each patron in the data set over sample window because the objective of the estimation is to identify the probability of visiting a library for each patron. Therefore, we are able to evaluate the model that best fits the data at the patron level.

We do so by comparing the Bayesian information criterion (BIC) across the different time series model specifications. Overall, the model selection results indicate that an AR(1) model is optimal for 60.0% of patrons, a two-lag model for 16.7% of patrons, three lags for 10.4% of patrons, and four lags for the remaining 12.9% of patrons. The average estimates and standard errors by BIC preferred lag specification are provided in Table 13. Using these estimates, the average predicted probability of visiting the library during any given week is 0.42 with substantial variation at the patron-level.

After identifying the patron-level visits variable, we estimate a reduced form model of library demand. Specifically, we estimate the number of library item checked out, C_{it}, by patron i during week t:

$$C_{it} = \alpha + \beta_1 \hat{V}_{it} + \beta_2 \text{Schl\_brk}_t + \beta_3 \text{Sum\_brk}_t + \beta_4 \text{Comm}_t + \delta_i + \delta_m + \delta_y + \varepsilon_{it} \tag{5}$$

The term $\hat{V}_{it}$ represents the predicted values of patron i's probability of visiting the library in week t obtain from the first stage, Schl_brk_t is an indicator for whether a school break occurred during week t, Sum_brk_t is an indicator for whether summer break occurred during week t, Comm_t is a vector of community-level characteristics, δ_m adn δ_y are month and year fixed effects that account for seasonality effects, δ_i are individual fixed effects, and ε_{it} is the idiosyncratic error term.

The results of this alternative specification are provided in column ‘Model 10’ of Table 4 and indicate that the main coefficients of interest remain unchanged.

Table 13: First-stage Regression Coefficient Statistics, by BIC Preferred Lag Specfication

Preferred	$\hat{V}_{it}$		$\hat{\gamma}$		$\hat{\rho}_1$		$\hat{\rho}_2$		$\hat{\rho}_3$		$\hat{\rho}_4$	
Number of Lags	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1	0.431	0.228	0.401	0.230	0.111	0.210	—	—	—	—	—	—
2	0.401	0.265	0.358	0.27	0.108	0.23	0.067	0.278	—	—	—	—
3	0.388	0.297	0.349	0.34	0.121	0.3	-0.019	0.269	0.113	0.287	—	—
4	0.391	0.322	0.286	0.3	0.094	0.25	-0.011	0.185	0.041	0.261	0.231	0.261