The Distributional Effects of the Multi-Track Year-Round Calendar: A Quantile Regression Approach

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Abstract

Multi-track year-round school calendars are growing in popularity, in part because it is believed that they will aid low-achieving students by alleviating summer learning loss. Existing research however, is focused on estimating mean impacts or analyzing effects by subgroup. We instead use a quantile regression approach with school and grade-by-year fixed effects to estimate the distributional impact of year-round education in the context of a natural experiment setting in Wake County, NC. Our results suggest that while the average impact may be negligible, year-round education has a small positive impact on the achievement of the lowest-performing students. This finding supports the assertion that more frequent shorter school breaks may be beneficial for some students, while having little effect on the achievement of most students.

Keywords: quantile regression, achievement gaps, year-round schooling

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1. Introduction

It is well-documented that students lose valuable skills over summer (Alexander et al, 2007). This "summer learning loss" is particularly concerning because it has been shown to be a significant source of achievement gaps due to its disparate impact on low-achieving and disadvantaged students (Von Drehle 2010; Cooper et al. 1996; Jamar 1994; Alexander et al. 2007; O'Brien 1999; Heyns 1978; Downey et al. 2004). Alexander et al. (2007) estimate almost two-thirds of the socioeconomic achievement gap that exists at the end of the freshman year in high school can be traced back to disparities in summer learning loss. Downey, von Hippel and Broh (2004) also find that almost every achievement gap grows faster during summer than during school. The most common theory used to explain these differences in learning loss looks to the "quality" of the out-of-school environment. Reardon (2003) and Alexander et al (2001) find that socioeconomic status-based achievement gaps are particularly influenced by time spent outside of school. Students who have access to a learning-rich environment outside of school tend to maintain or even improve their achievement during the summer months. Those students with fewer resources and fewer out-of-school learning opportunities, however, often have significantly lower achievement after the summer break than before.

Given this evidence, it is not surprising that there has been increased interest in research that explores the effects of alternative school calendar models that shorten the long summer break. The multi-track year-round school (YRS) calendar has recently received particular attention in the empirical literature (Graves 2010, 2011; McMullen & Rouse 2012a, 2012b). Under the multi-track YRS calendar students attend school the same number of days as they would under the traditional calendar, but these days are dispersed more evenly across the school year. With a multi-track YRS calendar, each school building contains multiple tracks of students

each with their own unique schedule and one group of students (and their teachers) is "tracked out" at any point in time. This system allows a multi-track YRS to accommodate 20 to 33 percent more students than its traditional calendar counterpart, making it a financially desirable option in areas of high population growth.[2] The YRS calendar itself can vary. For example, in Wake County, NC the students follow a 45-15 calendar where they attend school for 45 days and then have a 15 day “track-out” break; while in California the most common model is a 60-20 model (CDE, 2012). The common attribute among all of these YRS calendars is the absence of the traditional summer break. Proponents of YRS argue that removing the lengthy summer vacation in favor of a more balanced calendar could help alleviate this summer learning loss (NAYRE, 2013). However, some recent research suggests that YRS generally has little effect on the average academic achievement of students (Cooper et al. 2003; McMillen 2001; McMullen and Rouse 2012a) and might even harm student achievement (Rasberry 1992, Graves 2010).

It is important to note that because YRS does not increase the number of school days, learning loss can only be alleviated (or worsened) if there are very specific non-linearities in the process of human capital accumulation and depreciation (Graves 2010; 2011; McMullen and Rouse 2012a). Otherwise, any academic benefits of YRS would have to be based on the merits of supplemental programs available during the breaks. Graves (2011) notes research has already indicated that disadvantaged students have different patterns of learning and forgetting than the average student. It is therefore plausible that different achieving students could be uniquely affected by YRS. Recognizing this possibility, prior studies on YRS have tried to examine the potential heterogeneous impacts of year-round schooling by estimating effects on sub-groups (Graves, 2011; McMullen and Rouse 2012b). Bitler, Gelbach and Hoynes (2006) note, however,

[2] http://www.wcpss.net/year-round-overview.html

that sub-group analyses may not be sufficient to capture heterogeneous policy effects because there may not be enough inter-group variation to identify effects. Graves (2011) uses aggregated data to draw some inferences about the distributional effects of year-round schooling and finds year-round schooling actually has a larger negative impact on the lower end of the test score distribution. However, because she does not have student-level data, she is unable to estimate directly the impact of year-round schooling on the distribution of student achievement.[3] According to Graves (2011, p. 1284), "one could learn much more about distributional effects by using quantile regression methods." While prior studies provide some insight into the academic impact of these calendars, because they have primarily focused on estimating the mean impacts of year-round schooling (Graves 2010; McMullen and Rouse 2012a,b) or the effects of year-round schooling on particular subgroups of students (Graves 2011; McMullen and Rouse 2012a), they cannot speak directly to the distributional question at the heart of the learning loss literature.

This paper provides an important contribution to our understanding of the effects of year-round schooling by focusing explicitly on the distributional impacts of YRS calendars. We investigate the differential impact that year-round schooling has on achievement for high and low performing students using quantile regression. Understanding the distributional impacts of YRS is warranted in light of the well-established literature showing summer learning loss to be particularly harmful for low-achieving at-risk students (Von Drehle 2010; Cooper et al. 1996; Jamar 1994; Alexander et al. 2007; O'Brien 1999; Heyns 1978; Downey et al. 2004). Furthermore, exploring the impacts of YRS at different points in the conditional test score distribution is important because relying on mean effects might mask significant heterogeneous effects of the policy. For example, using quantile regression methods, Bitler, Gelbach and

[3] She instead uses alternative dependent variables including the percent of students achieving at or above the national 25th percentile, at or above the national 50th percentile, and at or above the 75th percentile nationally to draw inferences regarding the distributional effects of YRS.

Hoynes (2006) find substantial heterogeneity in the impacts of welfare reform that goes undetected in mean effect estimates. It is therefore possible that the shorter more frequent breaks the YRS calendar creates could be effective in alleviating the detrimental impacts of summer learning loss for the lowest-performing students even if it has little impact on the average student. Alternatively, the YRS calendar could instead be more disruptive to low-achieving students, even if the average student is unaffected by change.

Using data from the North Carolina Research Data Center (NCERDC), we evaluate whether the school schedule differentially impacts students at different achievement levels using quantile regression methods. In addition, we take advantage of a 2007 policy change in Wake County, NC where the school system converted 22 of its schools from traditional to year-round schooling calendars to obtain plausible quasi-experimental evidence on these distributional effects of YRS. This policy change provides within-school variation in year-round schooling that allows including in the model both school and grade-by-year fixed effects to control for the non-random calendar change. Contrary to Graves' (2011) results, we find evidence that while the average impact of year-round schooling may be negligible, year-round schooling appears to have a small positive impact on the achievement of the lowest-performing group of students.

These results have important methodological and policy implications. First, given the concern in the education literature about the performance of low-achieving students, it is important for policy researchers to examine the possibility of different policy effects at different places in the achievement distribution. Our study is one example of a place where this emphasis could impact policy recommendations. Second, while the effects we find are small, our study does provide some modest support for year round schooling. This finding differs from that

found in other recent studies and is important especially in light of the other reasons for implementing the policy that are unrelated to achievement, such as cost savings.

The rest of this paper proceeds as follows. In the next section, we provide a more detailed discussion of the background and related literature on summer learning loss and year-round education. In the third section, we describe the data used in the analysis. Our quantile regression methodology is discussed in section 4. We present our results and discuss the policy implications in section 5. Section 6 concludes.

2. Background - Summer Learning Loss and Year-Round Schooling

There is a wide literature, dating back to 1906 with William White's simple study of math loss in seven students, documenting the negative academic effects of summer vacation. Much of the earlier literature on summer learning loss is reviewed by Cooper et al. (1996), which upon reviewing nearly 40 studies, documents a negative impact of summer vacation on learning. Using 13 of the most recent of those studies, the meta-analysis performed by these scholars suggests students lose one tenth of a standard deviation in test scores from spring to fall. This learning loss amounts to roughly one month of learning. Cooper et al. (1996) also provide evidence that summer learning loss is more pronounced for students from lower income families and suggest this finding is due to the differential learning opportunities available to students from different backgrounds and abilities.

The differential learning opportunities across socioeconomic backgrounds is further explored by Alexander, Entwisle, and Olson (2001). Studying students from Baltimore, they find the achievement gap between high and low income students increases during elementary school. They report this gap is primarily due to differences in summer gains across the two groups. The

high income students actually gain skill over the summer break (though at a slower rate than during the school year), while their lower income counterparts show flat growth. Downey, von Hippel and Broh (2004) examine a population of early elementary students, and find very similar results: high performing students tended to modestly improve their skills over the summer, while low achieving students performed worse after the summer break. More recently, Alexandar, Entwisle and Olsen (2007) show that early differences in achievement created by differential learning loss persist in upper grades. They find that the ninth grade SES achievement gap can be largely attributed to differing summer learning loss in elementary school. Furthermore, the study suggests early differences in summer learning opportunities contribute to SES-level differences in high school track placements, dropout rates, and four-year college attendance.

The results of these studies indicate the most important sources of achievement inequality are external to the school, and that achievement inequality actually decreases for young children during the school year (Downey, Von Hippel, & Broh, 2004; Alexander et al. 2007). This recognition has caused some policy-makers to support YRS as a way to prevent this loss of learning and decrease the disparities in learning outcomes. Indeed, over the past couple of decades, YRS calendars have been steadily gaining popularity. From 1986 to 2006, there was a 635 percent increase the number of year round schools operating in the United States as the number of U.S. students attending a YRS increased to just under 4% of the student population (Education Week, 2004; NAYRE, 2013).

As mentioned above, in contrast to the traditional academic calendar that typically consists of nine months of instruction followed by a three month summer break; a YRS calendar spreads instruction across all twelve months. Most generally, the YRS calendar can be separated into two distinct alternatives. The first alternative is the extended year calendar in which the

total number of schools days is increased. This study examines the second type of year-round calendar, the modified YRS calendar, where students attend school the same total number of days as the traditional calendar student, but these days are spread over an entire calendar year.

The modified version of the YRS calendar can either be implemented school-wide (SW) or as school-within-a-school (SWS) model. Under the SWS model, students may either be on a traditional or a year-round calendar. The teachers are typically placed into either the traditional school calendar or the year-round. Under this set-up, there are essentially two schools with two different groups of teachers and students housed in the same building (McMillen, 2001). With the SW setup, all of the students in the school are on a YRS calendar. In some cases, all students attend school on the same schedule. The type of calendar we are interested in here, however, is the "multi-track" system, where students are rotated through the building using a track system. Under this model, students are placed into a particular track that comes with its own unique schedule. At least one track (or, set of students), is always on vacation. This system allows one building to accommodate a larger number of students. The multi-track system has been advocated as a good solution to school over-crowding created by unanticipated or underestimated growth in population. Cooper et al. (2003) suggests the multi-track system becomes the most cost effective solution once a school's population reaches 115% of its capacity.

While many advocates of modified YRS calendars argue they are effective in addressing the summer learning loss problem, in order for this type of YRS calendar – one that re-distributes the school days (as opposed to adding to them) – to address summer learning loss, there must be specific non-linearities in the learning or learning loss process. If each day in school contributes equally to a student's learning and if a student loses the same amount of knowledge or skills each

day he is away from school, it shouldn't matter how these days are spread out across the year. It is, in fact, entirely possible for there to be a significant learning loss disparity between two groups of students and for year-round schooling to be ineffective as a remedy. The success or failure of year-round schooling thus depends critically on the acceleration or deceleration of learning and forgetting that may occur over the year, both in school and while out of school.

To illustrate the theoretical connection between year-round schooling and achievement, McMullen and Rouse (2012a) draw on the work of Graves (2010; 2011) and the learning loss literature to build a model of learning loss and YRS. This model outlines the specific assumptions that need to be made about the technology of learning and learning loss for year-round schooling to either aid or exacerbate the problem. Using this framework, for year-round schooling to remedy summer learning loss, at least one of two assumptions must hold:

1. The rate of learning declines the longer a student is in school without a break.
2. The rate of learning loss increases the longer a student is out of school.

The first assumption would justify more frequent breaks, while the second would justify shorter breaks. While both of these assumptions are, in principle, empirically verifiable, there is little evidence to justify either. Downey et al. (2004), in a study of students in kindergarten and first grade, claim that the rates of learning while in school are constant across the school year. To our knowledge, however, there is no direct evidence to be brought to bear on the second assumption. Nevertheless, those who argue that year-round schooling should be adopted in order to help low-achieving students must argue that either assumption (1) or (2) holds for those disadvantaged students but not for their peers. Because the focus in the literature has been on the out-of-school environment, assumption (2) is the more likely candidate.

On the other hand, for year-round schooling to exacerbate inequalities, as some have argued (Rasberry 1992; Graves 2010; 2011), at least one of two different assumptions must hold:

3. The rate of learning accelerates the longer a student is in school without a break.
4. The rate of learning loss decreases the longer a student is out of school.

As before, the direct empirical evidence on these assumptions is slim, though, as before, we can use these assumptions to clarify our thinking about the "disruption" thesis: that year-round schooling will exacerbate inequalities because the longer breaks disrupt the learning process. Particularly, for the disruption argument to exacerbate inequality, either assumption (3) or (4) must hold and be stronger for low-performing students than their high-performing peers.[4]

The limited literature on YRS on achievement inequalities remains mixed. Cooper et al. (2003) provide a thorough review of the earlier literature on the impact of YRS. This review of the early literature implies that, as the opponents argue, YRS has little impact on average student achievement. However, the review also suggests disadvantaged students are especially helped by YRS. There is also some evidence of this in North Carolina specifically. McMillen (2001) makes use of a large statewide dataset to evaluate the impact of YRS on achievement and finds YRS helps disadvantaged students, though it has little impact on others.

A more recent study found that at-risk students actually fare worse in a year-round calendar. Using data from California, Graves (2011) finds disadvantaged students perform worse under the YRS calendar. McMullen and Rouse (2012a) find that the average student is neither helped nor hurt by year-round schooling. They thus infer that none of the above assumptions hold, but that instead a simpler model in which both learning and learning loss are linear is a better approximation. Their study explores the impacts by race and does not find

[4] It is possible to consider combinations of assumptions that lead to ambiguous results. For example, assumption 1 and assumption 4 might both be true simultaneously, in which case year-round schooling might either help or hurt achievement, depending on the relative strength of the two effects.

significant differences, but does not look at the distributional effects. It is possible that the technology of learning differs substantially across students of varying performance levels; however, previous studies have not been designed to capture these effects. This study seeks to narrow this gap in the literature by estimating directly the distributional impacts of YRS, something that has not yet been done in this literature.

3. Data

Our study focuses on public school students in Wake County, NC. Currently, there are almost 150,000 students in the Wake County Public School System (WCPSS), making it the largest school district in the state and the 16th largest in the nation.[5] Over the past two decades, the school system has experienced tremendous growth. The number of students has nearly tripled since 1980 and the most recent projections suggest that the WCPSS will add another 40,000 by 2020. The school system first implemented the year-round academic calendar in the late eighties. Since then it has continued to increase the number of schools operating on the calendar. The largest policy change occurred in 2007-2008 when the school system converted 22 schools from traditional to year-round calendars and mandated that all new schools open on the year-round schooling calendar. This large conversion, which was largely enacted due to capacity and crowding concerns, more than doubled the number of YRSs operating in the district. The mandatory nature of the policy change was controversial and resulted in a parent-led court case against the school system. This court battle eventually made it to the State Supreme Court where the mandatory year-round schooling assignments were upheld.[6] The large-scale education policy change, while upsetting to parents, makes this school district a particularly good place to study

[5]http://www.wcpss.net/about-us/our-students/demographics/ (accessed May 2, 2013).
[6] http://www.wral.com/news/local/story/5063084/ (accessed May 2, 2013).

the impact of YRS because it creates a quasi-natural experiment to use to evaluate the effects YRS. Specially, we use the within-school variation in year-round schooling created by the policy change to identify the impact of the calendar on the distribution of student achievement. Our identification strategy is discussed in more detail in the next section.

The data used in this analysis primarily comes from the NCERDC. The NCERDC is an organization which holds and manages data on North Carolina schools. This large dataset, housed in the Center for Child and Family Policy at Duke University was created in 2000 through a joint partnership with the North Carolina Department of Public Instruction. The dataset contains information on every public school in the state of NC from the years 1995 to 2012. Data is available at the student, teacher, school, and district levels.[7] We merge this main data set with additional data on school crowding that was downloaded from the WCPSS website.[8] The crowding data allows us to control for one of the primary reasons the school district cited as motivation for the YRS policy change. The inclusion of this variable in our models should therefore capture the largest difference between the schools that were and were not selected for the policy change.

We focus our analysis on third through eighth graders enrolled in the WCPSS from 2006-2009. This restriction provides data from two years before the policy change through two years after the change. Our main identification strategy (discussed in detail in the next section) exploits the policy induced within-school variation across time using a school and grade-by-year fixed effects approach. This estimation method requires at least two consecutive years of achievement data for each student. In order to estimate math and reading score *gains*, however, we must also observe each student one additional, "baseline" year. This eliminates 3rd graders

[7] Our measures of student achievement come from end-of-grade math and reading scores, while school-level information comes from the School Report Card Files.
[8] See http://www.wcpss.net/about-us/our-students/demographics/school-data.html

from the gains samples, or whichever year the student is first observed in the data, and requires that we observe a student for three consecutive years to be included in our sample.[9]

A student's math and reading achievement test scores from their end-of-grade (EOG) tests are the main outcomes of interest. These tests, which are administered each spring, are multiple choice exams and are constructed so that they measure growth in achievement. Since scores are naturally expected to increase over time, we follow Bifulco and Ladd (2006) and McMullen and Rouse (2012a, 2012b) and normalize scores such that grade-by-year means are zero with a standard deviation of one. It is also important to note that test schedules are adjusted by calendar-type so that each student takes the EOG test at approximately the same point in their school year. This characteristic is important for this study because it makes test scores comparable across calendar type.

Table 1 presents the distribution of test scores by calendar status. This descriptive evidence suggests that students in year-round schooling score significantly higher than their traditional-calendar counterparts at each point in the achievement distribution. This result may indicate a positive impact of year-round schooling on student achievement. Importantly, however, it could also simply be a result of non-random calendar placement into high-achieving schools or non-random student selection of high-achievers into YRS. The table also suggests the difference in achievement is more pronounced at the low end of the test score distribution. Indeed, with both math and reading achievement, the descriptive evidence shows an inverse relationship between the gap in achievement between traditional and year-round schooling and the achievement percentile.

[9] Note that one of those three years can come in 2005, three years before the policy change.

Table 2 compares yearly achievement characteristics for the 22 traditional calendar schools that were switched to year-round calendars in 2007-2008 with those of the traditional and year-round calendar schools that were not forced to change calendars. The table demonstrates that observed across-school achievement differences are apparent even before the policy change. This evidence suggests that the achievement gap between traditional and year-round schools as shown in Table 2 is likely not solely due to year-round schooling itself. Instead, the data supports the possibility of non-random calendar implementation, where the year-round schooling calendar was implemented in primarily high-achieving schools. This observation underscores the importance of controlling for observed and unobserved school heterogeneity by including school and grade-by-year fixed effects, which is possible due to the variation induced by the large WCPSS 2007 policy change.

3. Quantile Regression Methodology

We use a quantile regression approach to estimate the distributional effects of YRS. As outlined in detail by Koenker and Bassett (1978), the basic quantile regression is performed by minimizing the following general equation:

$$Q_N(\beta_q) = \sum_{i:y_i \geq x_i'\beta}^{N} \alpha \left| y_i - x_i \beta_q \right| + \sum_{i:y_i < x_i'\beta}^{N} (1-\alpha) \left| y_i - x_i \beta_q \right| \tag{1}$$

where α is the quantile, y_i is the outcome of interest, the vector x_i includes observable characteristics, and β_q are the parameters to be estimated, which vary across quantile. The interpretation of a quantile regression parameter is similar to that found in traditional least squares linear regression; but rather than the estimation producing the conditional mean impact of the variable of interest, the impact of the variable is allowed to vary across the conditional

outcome distribution and thus measures the impact at different quantiles. Koenker and Hallock (2001) describe how quantile regression methods have been used widely in applied microeconomics research, including Levin's (2001) analysis of class size and Arias, Hallock, and Sosa-Escudero's (2001) examination of economic returns to education. Quantile regression approaches have also been used by Bitler, Gelbach and Hoynes (2006), among others.

Quantile regression estimation has a number of advantages for our purposes over traditional least-squares regression.[10] First, quantile regression, of which median regression estimates are a special case, enables us to estimate of the impact of year-round schooling across the conditional distribution of student achievement. This allows us to compare potential differences in the parameter of interest across and between groups. Moreover, we can also estimate directly the impact of year-round schooling on the inter-quartile range (the distance between the 25th and 75th percentiles of achievement), a direct measure of achievement inequality. Finally, quantile regression methods are less susceptible to the influence of outliers and use a different set of assumptions (Cameron and Trivedi 2005), and thus can operate as a robustness test of the OLS results found in earlier studies. While it is useful in exploring the potential of heterogeneous policy impacts of YRS, it is also important to also point out one drawback of the quantile regression methodology. As noted by Bitler, Gelbach and Hoynes (2006) and also discussed in Angrist and Pischke (2009), quantile regression estimates do not tell us how year-round schooling impacts individuals. While we can say something about how the students in a particular quartile fare under a YRS relative to a traditional calendar, with this method we are unable to say how a particular student in this group would perform under year-round schooling relative to a traditional school unless the policy is rank-preserving.

[10] For a detailed explanation of quantile regression techniques and comparisons with other methods see Cameron and Trivedi (2005) and Koenker and Hallock (2001).

The primary challenge in estimating the impact of YRS here arises from the fact that the placement of YRS calendars might not be random. That is, the set of students who attend the YRSs may differ in systematic ways from those who attend traditional calendar schools. For instance, the descriptive evidence provided above suggests YRS calendars were placed in primarily high achieving schools while their traditional calendar counterparts are composed of lower achievers. Failure to control for this difference may lead one to attribute the achievement difference to the calendar when, in fact, this difference may not be due to the calendar at all. Unless all differences in the schools or student populations are captured by the control variables in the model, the parameter estimates on YRS will be biased. Fortunately, because we have panel data, we are able to address this concern by including in the model a set of school fixed effects. These school fixed effects will capture any characteristics of the school that do not change over the time period of study. Because the 2007 WCPSS calendar change was mandatory and was imposed on schools (and the students within), it acts as a natural experiment where we are able to observe the same school under a traditional and a YRS calendar. The impact of year-round schooling is thus identified from within-school variation induced by the mandated calendar changes. Intuitively, our identification strategy is thus comparing student achievement at different quantiles in the same school before and after the YRS calendar change. To control for grade and year specific attributes that might differ, such as changes in tests across time or grade, we also include a set of grade-by-year fixed effects.

We model student achievement as a function of YRS, other observed student and school level characteristics that are thought to impact achievement, as well as the set of school and grade-by-year fixed effects:

$$y_{igst} = \lambda_q YRS_{st} + \mathbf{X}_i \beta_q + \mathbf{S}_{st} \delta_q + \varphi_s + \gamma_{gt} + \varepsilon_{igst} \quad , \tag{2}$$

where y_{igst} is the achievement outcome of interest (i.e. test scores) for student *i* in grade g at school *s* at time *t*, YRS_{st} is an indicator variable that set equal to one if school *s* is on a year-round calendar at time *t*, $\mathbf{X}_i$ is a vector of individual characteristics of student *i*, $\mathbf{S}_{st}$ is a vector of school level characteristics of school *s* at time *t*, φ_s is a school fixed effect, γ_{gt} is a set of grade-by-year fixed effects, and ε_{igst} is an error term. Here, the parameters to be estimated are indexed by q reflecting the fact that the quantile regression method allows their impact to vary across the conditional test score distribution. We estimate the general quantile regression model outlined in (1) above using the model described in equation (2). We measure achievement using both the level of achievement, y_{igst}, and the difference in achievement between two consecutive years, $y_{igst} - y_{ig-1st-1}$. We call this second measure our growth specification. The vector $\mathbf{X}_i$ includes controls for a student's gender, race, and parents' education. In the vector $\mathbf{S}_{st}$, we control for several school characteristics including percent crowding, student-teacher ratio, class size, enrollment, teacher licensure, teacher experience, and teacher turnover.

There is one additional drawback to using quantile regression methods here. Because the YRS policy was a school-wide change and was implemented as a mandatory change, the school fixed effects should capture any school selection effects. However, to the extent that students select non-randomly into the calendar, we are only able to capture student-level selection on those student characteristics that we can observe. If, for example, low income students select into YRS and this difference across students is not fully captured by the observed student characteristics included in the vector $\mathbf{X}_i$, the estimates on YRS may be biased. A solution to this problem would be to include in the model a set of student-level fixed effects, which is theoretically possible here because we have both student and school level variation in our data

set. However, while the use of individual fixed-effects estimators with quantile regression is possible (Koenker 2004), two issues prevent us from including student-level fixed effects in these models. For one, we have few observations on each student. When this is the case, the inclusion of student fixed effects in a quantile regression model can dramatically increase the variability of the estimates. Additionally, in practice, given the size of the data set, and the number of fixed effects to be estimated, the inclusion of these parameters in the model is computationally impossible with our current technology.

The result of these limitations is that we are not able to fully control for the student selection biases in the quantile regression model: we are able to include school and grade-by-year fixed effects, but no student fixed effects. While this concern is certainly problematic in theory, it is somewhat mitigated due to the school assignment process in the district. During the time period of study, the WCPSS used a strict student assignment process to assign students to schools based upon maintaining socioeconomic diversity across its schools. Students (or more likely, their parents) could appeal their schools assignments, however, this process was not easy and not all appeals were granted. According to the WCPSS website, in the 2008-2009 school year, only 4.7 percent of student assignments came from choice driven by the year-round calendar.[11] Moreover, anecdotal evidence suggests that many of the choices regarding academic calendar choice moves were driven by factors other than achievement, such as creating within-family calendar consistency or for optimal daycare arrangements. While there is some student-level 'choice' that is likely not accounted for by our models, these cases represent a small fraction of the student population and were likely not driven by anticipated achievement gains.

[11] http://www.wcpss.net/about-us/our-students/demographics/reports/tbl08AssignIndicator.pdf (accessed July 25, 2013).

Thus, compared to school-level selection, student selection should have much less impact on the estimates.

5. Results and Policy Implications

Table 5 shows a number of different quantile regression estimates of the impact of year-round schooling on achievement. Without school fixed effects (columns 1 and 3), nearly all of the estimates across different percentiles of achievement are estimated to be positive and often statistically significant. The estimates at the 50th percentile are very similar to the comparable OLS estimates (shown in the first row in each panel), indicating that the choice of using an OLS or a quantile estimator does not substantially change the results in this case. The pattern across quantiles for math achievement suggests the impact of year-round schooling on a student's math achievement level falls as students move along the achievement distribution. Estimates imply students who attend a year-round schooling and are at the 10th percentile of math achievement score 0.0861 standard deviations higher than their traditional calendar counterparts. The corresponding estimate for students at the 90th percentile of math achievement is 0.0573, a difference of roughly 0.03 standard deviations in achievement. The pattern is less clear with either math achievement growth or reading achievement.

Once school fixed effects are added to the specifications (columns 2 and 4) these results change. All estimates are lower in magnitude with school fixed effects than without, indicating that, as our brief examination of the descriptive data suggests, year-round schooling was implemented in slightly higher-quality schools. This same result is borne out in McMullen and Rouse (2012a,b). The pattern found in the baseline estimates for math achievement level remains. The estimates steadily fall in magnitude as one moves up the test score distribution,

though most of the estimates are not statistically significant at conventional levels. The results suggest year-round schooling does have a small, statistically significant, positive impact on the math achievement level of the lowest performers. The point estimate indicates year-round schooling students who are at the 10th percentile in math achievement score 0.0568 standard deviations higher than their traditional calendar peers. The pattern with reading achievement level is not quite as clear. However, a significant impact of year-round schooling is seen with students at the 25th percentile in reading achievement level. The results suggest these students score 0.0590 standard deviations higher in year-round schooling than traditional calendar school. The growth estimates for both reading and math imply year-round schooling has little impact on the growth in achievement at any point in the conditional test score distribution.

Table 5 also shows the results of a series of inter-quartile range regressions. This set of specifications uses quantile methods to ask more directly a question of interest: what is the impact of year-round schooling on the inter-quartile range of achievement or achievement growth? The results here suggest that when school fixed effects are included there is no evidence that the achievement gap between the 25th and 75th percentiles either widens or narrows. This evidence implies the policy has little impact on the middle range of student achievement.

Figure 1 shows the results of a more fine-grained analysis, showing the estimated impact of year-round schooling on achievement across 19 quantiles for each dependent variable, instead of the 5 quantiles reported in Table 5, with bands above and below showing the estimated 95% confidence interval. School fixed effects are included in each part. Figure 1 allows for an easy visual representation of the distributional impact of year-round schooling on achievement. If Graves' (2011) broad conclusions applied to the distribution of results here we would expect to

see upward sloping lines on this figure, indicating the low-achieving students fare worse under the policy than their high-achieving counterparts. Conversely, if the arguments of those who support year-round schools to counter learning loss were supported here we would see a downward sloping line, as the low achieving students disproportionately benefit from the policy. We see some evidence of this with math and reading achievement levels, where, at the tails of the distribution, we see positive impacts that appear to level out in the middle of the distribution and fall towards the end. With math achievement, there appears to be a small positive statistically significant impact on the level of math achievement up until about the 20th percentile of achievement.

Taken as a whole, this evidence suggests that while YRS has little impact on the average student, it may have a small positive impact on the lowest achieving students. This result offers modest support for YRS in terms of achievement. While these results are quite focused, they have an important role in policy debates surrounding the adoption of YRS calendars. Because of the focus on summer learning loss as a cause of achievement disparities, policy-makers are turning to two different types of policies as remedies. First, with support from the Obama administration, there have been calls for longer school years and longer school days. There is good evidence supporting the increase of in-school time as a way to improve achievement (Pischke 2007), but this tends to be an expensive policy (AP 2009). Second, many schools have adopted single or multi-track year-round schools as a way to address learning loss without additional expense.

The best evidence now indicates, however, that as a remedy for learning loss, year-round schooling has limited usefulness (McMullen and Rouse 2012a, Graves 2010), and Graves (2011) even argues that YRS calendars could exacerbate the inequalities caused by summer learning

loss. It is in this context that this study gives some limited evidence in favor of year-round calendars. It is worth noting, however, that our results do not suggest that this policy can entirely eliminate learning loss. On the contrary, Cooper et. al (1996) indicate that students lose a tenth of a standard deviation of achievement over the summer, on average. Our results indicate that even those students most helped by year round schooling only gain 0.05 to 0.06 standard deviations in achievement, perhaps less.

On the other hand, many schools, like Wake County, consider the multi-track year-round calendar for financial reasons, rather than academic. In that context, this study gives additional evidence that there is not likely to be a significant achievement cost associated with the switch. There may, however, be other costs or benefits not considered here that are worth considering. Moreover, there may be some demographic groups that react significantly differently to the policy. Graves (2011) found the year-round schooling calendar is especially harmful for some groups of at-risk and low-achieving students. Graves, McMullen and Rouse (2013) discuss the differences in study populations across the two samples and suggest that the differing results are likely associated with large demographic differences in Wake County, NC and California. This study focuses on YRS calendars in Wake County, NC where the majority of the students in year-round schooling are higher achieving white students. In contrast, Graves (2011) studies year-round schooling in California where the YRSs are placed in schools with large Hispanic populations. Thus, students in the tail ends of the two distributions are therefore also likely to be quite different.

7. Conclusion

Despite the connection between year-round schooling and learning loss in the literature, among recent studies on year-round schooling, there has been no evidence that year-round schooling can alleviate damaging seasonal learning patterns. The well-documented effects of summer learning loss have focused on the distributional impacts, however, while the year-round schooling literature has not. In this paper, we use a quantile regression approach with school and grade-by-year fixed effects to directly investigate the impact of the policy across the achievement distribution. Our results suggest that for most students, the impact of year-round schooling is negligible. However, year-round education appears to have a small positive impact on the achievement of the lowest-performing students. This finding supports the assertion that more frequent shorter breaks from school may be beneficial for at least the very tail end of the test score distribution. This is the first recent evidence that year-round schooling can partially alleviate some of the problems associated with summer learning loss.

This study uses standard policy-evaluation methods to evaluate a natural policy experiment. While this approach allows us to eliminate many possible measurement and inference problems, it does not allow us to directly measure the rate of learning over time. For this reason, additional research that measures student achievement many times over the school year would be essential to answer some of the underlying structural questions regarding summer learning loss and achievement disparities.

Table 1. Distribution of Achievement by Calendar Type

	Traditional	Year-Round	Difference
A. Math Scores			
10th Percentile	-1.222	-1.015	0.206
25th Percentile	-0.598	-0.422	0.176
50th Percentile	0.088	0.236	0.148
75th Percentile	0.764	0.868	0.104
90th Percentile	1.313	1.355	0.042
B. Reading Scores			
10th Percentile	-1.273	-1.131	0.142
25th Percentile	-0.578	-0.446	0.133
50th Percentile	0.100	0.187	0.087
75th Percentile	0.756	0.795	0.039
90th Percentile	1.248	1.289	0.041

Table 2. Comparison of Mean School-Level Achievement by Calendar Type and Year

	Math Scores				Reading Scores			
	2006	2007	2008	2009	2006	2007	2008	2009
Always Year-Round	0.153	0.103	0.139	0.145	0.128	0.086	0.106	0.098
	(0.966)	(0.987)	(0.967)	(0.941)	(0.967)	(0.976)	(0.969)	(0.942)
22 Converted Schools	0.046	0.061	0.094	0.043	0.026	0.025	0.049	-0.025
	(0.965)	(0.975)	(0.952)	(0.971)	(0.951)	(0.976)	(0.963)	(0.969)
Always Traditional	-0.052	-0.045	-0.061	-0.045	-0.040	-0.031	-0.041	-0.019
	(1.013)	(1.008)	(1.014)	(1.015)	(1.018)	(1.012)	(1.014)	(1.018)

Table 3. Impact of Year-Round School on Math and Reading Achievement

	Test Score Levels		Test Score Growth	
	(1)	(2)	(3)	(4)
A. Math Scores				
OLS estimates	0.0737*	0.026	0.026	-0.008
	(0.035)	(0.035)	(0.016)	(0.026)
Quantile Regression Estimates				
10th Percentile	0.0861***	0.0568*	0.0380***	0.006
	(0.011)	(0.026)	(0.006)	(0.015)
25th Percentile	0.0808***	0.030	0.0272***	-0.020
	(0.009)	(0.020)	(0.005)	(0.012)
50th Percentile	0.0769***	0.025	0.0341***	0.010
	(0.008)	(0.017)	(0.004)	(0.011)
75th Percentile	0.0731***	0.013	0.0240***	-0.010
	(0.007)	(0.018)	(0.004)	(0.014)
90th Percentile	0.0573***	-0.020	0.012	-0.028
	(0.009)	(0.024)	(0.007)	(0.022)
Inter-Quartile Range	-0.008	-0.017	-0.003	0.010
	(0.007)	(0.022)	(0.006)	(0.013)
B. Reading Scores				
OLS estimates	0.048	0.033	0.014	-0.002
	(0.026)	(0.031)	(0.010)	(0.018)
Quantile Regression Estimates				
10th Percentile	0.0356***	0.045	0.0318***	0.028
	(0.010)	(0.029)	(0.007)	(0.020)
25th Percentile	0.0587***	0.0590**	0.0139**	-0.006
	(0.007)	(0.021)	(0.005)	(0.015)
50th Percentile	0.0467***	0.025	0.0102*	-0.011
	(0.005)	(0.016)	(0.005)	(0.015)
75th Percentile	0.0472***	0.021	0.012	-0.013
	(0.007)	(0.022)	(0.008)	(0.016)
90th Percentile	0.0354***	0.004	0.008	-0.010
	(0.009)	(0.021)	(0.008)	(0.018)
Inter-Quartile Range	-0.012	-0.038	-0.002	-0.007
	(0.010)	(0.023)	(0.008)	(0.020)
School Fixed Effects	No	Yes	No	Yes
Number of Observations	154,969		128,834	
Number of Students	49,020		49,020	

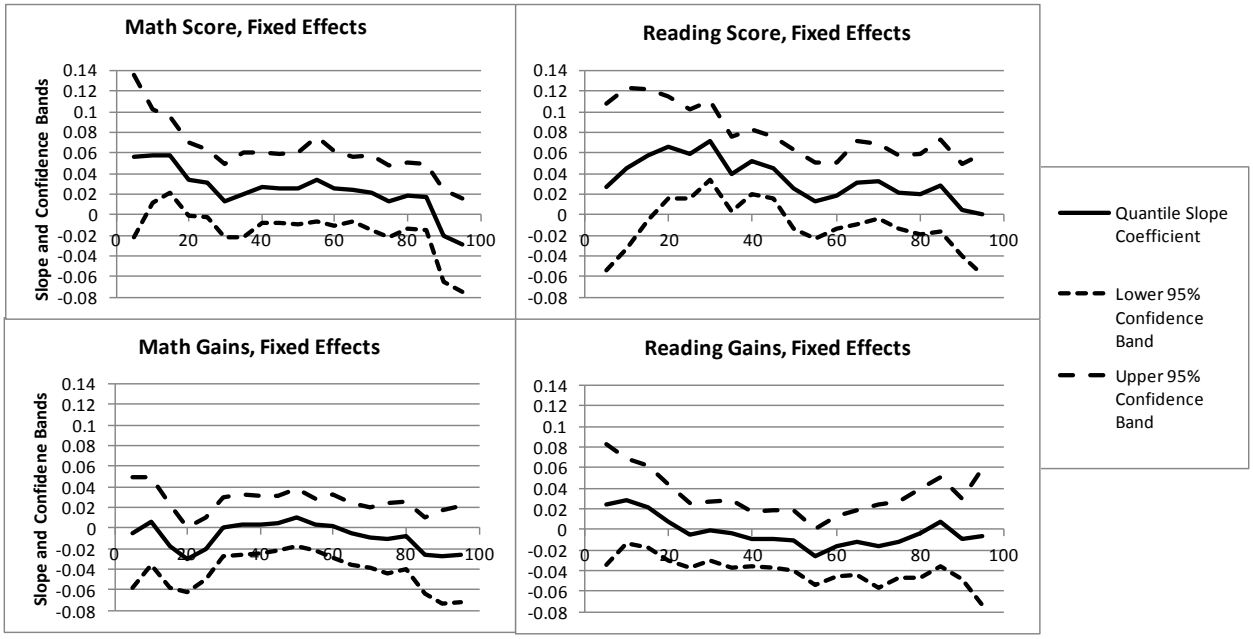
Notes:

a. Standard errors in parenthesis. * p<0.05, ** p<0.01, and *** p<0.001 denote statistical significance.

b. All models include grade/year fixed effects and time-varying school characteristics.

c. Models without individualized effects also include controls for gender, race, and parents' education.

Figure 1. Quantile Regression Estimates of the impact of YRS on Achievement



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