Impacts of the four-day school week on early elementary achievement

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Abstract: This study explores the impact of four-day school weeks on early elementary achievement. Using covariate adjusted regression analyses and data on all students who entered kindergarten in Oregon, USA between 2014 and 2016, we examine differences in 3rd grade math and English Language Arts test scores (i.e., achievement) for students enrolled in a four-day school week versus a five-day school week at kindergarten entry. On average, we find minimal differences between 3rd grade test scores of four-day and five-day students, but there are notable differential effects across the spectrum of these students' kindergarten readiness scores and educational program participation. We find that above median performers on kindergarten assessments, White students, general education students, and gifted students – student groups that make up more than half our sample – are the most negatively impacted by the four-day school week during the early elementary period. We generally find no statistically significant evidence of detrimental four-day school week achievement impacts for students who were below median performers on kindergarten assessments, minority students, economically disadvantaged students, special education participants, and English as a second language students.

Keywords: four-day school weeks; kindergarten assessment; achievement

Introduction

Children experience significant growth in their cognitive and socioemotional skills prior to attending formal schooling, and this early learning and skill development is associated with later grade academic achievement (Duncan, et al., 2007; Pace, et al., 2019) and subsequent adult outcomes, such as college completion, home ownership, and earnings (Chetty, et al., 2011; McClelland, et al., 2013). However, differences in socioeconomic status often lead to differential learning opportunities during preschool years – in part due to fewer home resources and caregivers having less time or tools to promote early learning opportunities (Guryan, Hurst, and Kearney, 2008; Kalil, Ryan, and Corey, 2012; Korat, Klein, and Segal-Drori, 2007; Blau, 1999; Najman, et al., 2004) – resulting in skill development and content knowledge that lags behind that of higher resourced peers (Duncan and Murnane, 2011). To address these inequities, policymakers have focused their attention on increased investments in pre-kindergarten (pre-K) programming for low-income families. Over the past decade, funding for state preschool programs increased by nearly $4 billion (inflation-adjusted), and the percentage of four-year-olds enrolled in state-funded pre-K programs rose from 9 to 33 percent (Friedman-Krauss, et al., 2018; Pitts and Kuhfeld, 2020). Recent evidence suggests these efforts have reduced but not eliminated gaps in achievement upon entering kindergarten (Kuhfeld, et al., 2020a). For example, as noted by Kuhfeld, et al. (2020a), between 2010 and 2017, the Black-White gap at school entry fell from 0.66 to 0.54 standard deviations (SD) in math and fell from 0.53 to 0.42 SD in reading.

The K-12 school environment is another critical setting for further closing these achievement gaps once children reach school age and has been viewed as a critical component to child development by providing stability and universal academic instruction, regardless of a child's home environment. A wealth of literature demonstrates that the quality of educational inputs, such as teacher quality (Rockoff, 2004; Rivkin, Hanushek, and Kain, 2005; Figlio and Kenny, 2007;

Eren, 2019), class size (Angrist and Lavy, 1999; Krueger, 1999), and school infrastructure investments (Neilson and Zimmerman, 2014; Conlin and Thompson, 2017; Lafortune and Schönholzer, 2019), and the quantity of exposure to the K-12 school environment (Taylor, 2014; Cortes, Goodman, and Nomi, 2015; Lavy, 2015; Rivkin and Schiman, 2015; Huebener, Kuger, and Marcus, 2017; Cattaneo, Oggenfuss, and Wolter, 2017) positively impact achievement. Further, these increased educational inputs also positively impact students' socioemotional and non-cognitive skill development (Dee and West, 2011; Gershenson, 2016; Jennings and DiPrete, 2010; Ruzek, et al., 2014; Blazar and Kraft, 2015; Villaseñor, 2017) and may be most critical for students experiencing economic disadvantage (Jackson, et al. 2020).

Given these benefits, worries abound over the implications of lost exposure to the in-person school environment due to the COVID-19 pandemic. Recent evidence suggests that the change in educational modality has only further disadvantaged low-income and minority students (Dorn, et al., 2020), lowered engagement with online resources among these student groups (Barnum and Bryan, 2020; Bacher-Hicks, Goodman, and Mulhern, 2021) due to differential access to technological devices/internet needed for online learning. Although smaller in impact than the COVID-19 pandemic, alternative school schedules also influence exposure to these educational environments. Of interest to this study is the four-day school week, which reduces the school week from a traditional five-day week to a four-day week with longer hours on the remaining four school days. This alterative schedule has been in use in some districts for over two decades, and use of this model had increased steadily over the decade preceding the COVID-19 pandemic (Thompson et al., 2021a).

A growing literature using two-way fixed effects difference-in-differences approaches (Anderson and Walker, 2015; Morton, 2021; Morton, 2022; Thompson, 2021a; Thompson, et al.,

2021b; Kilburn, et al., 2021; Thompson and Ward, 2022; Morton, Thompson, and Kuhfeld, 2022) has considered the academic impacts of four-day school weeks for older elementary, middle, and high school students, often finding detrimental achievement impacts. How the four-day school week model impacts the academic achievement of early elementary students, however, has not been explored. Thus, we examine the academic impacts of this four-day school week schedule for early elementary students – a critical age for student growth and development during which educational interventions have been shown to have lasting impacts into adolescence and adulthood (Chetty, Friedman, and Rockoff, 2014; Chetty, et al., 2011).

Specifically, we examined the impact of four-day school week exposure beginning at kindergarten entry – usually between ages 5 and 6 – on 3rd grade math and English Language Arts (ELA) test scores among students who entered kindergarten in Oregon, USA between 2014 and 2016. In addition to these average effects, access to detailed student demographic and educational program participation information and academic and social-emotional kindergarten readiness assessment scores enabled an examination of whether different student subgroups are affected differentially by this school schedule and whether academic and social-emotional readiness for kindergarten influences these four-day week effects when the same children were assessed in 3rd grade. Several previous studies have examined heterogeneity in four-day school week impacts across student demographic groups and educational program participation. Thompson (2021a) found that among upper elementary and middle school students in Oregon, special education students exhibit smaller negative four-day school week achievement impacts than general education students under a four-day school week schedule and students in the English as a Second Language (ESL) curriculum were found to have larger negative four-day school week achievement impacts than their non-ESL counterparts. Although these differences across educational program

participation were observed, that study found no statistically significant evidence that different demographic student subgroups fared any better or worse following the implementation of the four-day school week. A national study of elementary and middle school students (Morton, Thompson, and Kuhfeld, 2022) found that the academic achievement of female students and Hispanic students was more negatively impacted by the four-day school week than male and White students, respectively.

We build on this previous research by assessing heterogeneity in four-day school week achievement effects by educational program participation and student demographics for the early elementary age group and also consider differential four-day school week achievement effects by baseline kindergarten assessment score group. Although loss of access to school is thought to be problematic for at-risk students (Dorn, et al., 2020; Jackson, et al. 2020), differential access to non-school weekday services among low performing students compared to higher performing peers and a more constrained curriculum that focuses on core skills may lead the four-day school week to be less detrimental to lower achievers than high achievers, relative to similar achieving or emotionally regulated peers on a five-day school week schedule. Understanding how these four-day school weeks impact students of different demographic groups, skill levels, and educational programmatic needs will inform school policymakers about the important equity considerations when choosing to implement four-day school week schedules.

Background and prior literature
Four-day school weeks

The four-day school week, which is predominantly used in rural contexts, eliminates one required school day per week — typically a Friday in Oregon — with longer school hours on the remaining four school days. While use of the four-day school week dates back to the 1970s in the

United States, the number of four-day school weeks grew substantially from 108 districts to 662 school districts between 1999 and 2019. Historically, school districts often adopted these school schedules for financial, attendance, and rural-related reasons (e.g., transportation challenges, staff recruitment and retention) (Thompson et al., 2021a), but since the pandemic, a new wave of four-day school week schedules have been adopted as a potential mechanism to alleviate teacher burnout. When used, these school schedules are nearly universally applied districtwide (Thompson, 2021b). These school schedules are facilitated through state policy that allows for schools to meet minimum instructional hours requirements instead of traditional minimum required instructional days. Although longer school hours on the remaining four school days help schools adhere to these state-mandated minimum instructional hours requirements, the resultant effect in many schools, especially in Oregon, is an overall reduction in school exposure upon switching to the four-day school week. Nationally, the average school day lasts seven hours and 45 minutes under a four-day school week model and six hours and 54 minutes under a five-day school week model (Thompson, et al., 2021a). This difference in school day length, along with the differences in instructional days per year – an average of 148 on a four-day schedule and 179 on a five-day schedule – lead four-day school week students to attend school for an average of 1,150 hours per year compared to an average of 1,235 yearly hours for five-day school week students.

Four-day school week achievement effects

Much of the previous research on four-day school week effects has focused on student achievement impacts: a growing literature – all of which used a version of the two-way fixed effects difference-in-differences estimator – has demonstrated the time in school reductions associated with four-day school week adoption to be detrimental to achievement for students in upper elementary school, middle school, (Kilburn, et al., 2021; Morton, 2021; Thompson, 2021a;

Thompson and Ward, 2022; Morton, Thompson, and Kuhfeld, 2022) and high school (Thompson, et al., 2021b; Morton, 2022).

Many of these studies have focused on several specific states, including Colorado, Oklahoma, and Oregon. In Oklahoma, Morton (2021) found negative, but not statistically significant, impacts of four-day school weeks on achievement in grades 3 through 8. These effects are on the order of a 0.052 SD reduction in math achievement and a 0.032 SD reduction in reading achievement. A subsequent study of high schoolers in Oklahoma (Morton, 2022) found minimal and not statistically significant impacts of the four-day school week on ACT test scores. Thompson (2021a) found similarly sized reductions in grade 3 through 8 achievement in Oregon of between 0.037 and 0.059 SD in math and between 0.033 and 0.042 SD in reading. A subsequent study of high schoolers in Oregon (Thompson, et al., 2021b) found reductions in high school achievement for non-rural four-day school week students but minimal impacts for rural four-day school week students. A notable exception to these studies is Anderson and Walker (2015), which found positive impacts of the four-day school week in Colorado on 4th grade reading and 5th grade math achievement. Previous research (Thompson 2021a; Thompson, et al., 2021a) posits that these mixed findings may be related to differences in four-day school week implementation, most notably differences in time in school (Thompson and Ward 2022).

A couple of other studies have conducted multi-state analyses that also find negative four-day school week achievement effects. Kilburn et al. (2021) examined four-day school week achievement effects among 3rd to 8th graders across five states. They found that eight years after adoption, four-day school week ELA achievement was between 0.145 and 0.229 SD lower and math achievement was between 0.144 and 0.189 SD lower than in comparable five-day school week districts. Thompson and Ward (2022) found smaller, but still negative, four-day school week

achievement effects among 3rd to 8th graders across twelve states (which included the five states used in the Kilburn et al., 2021 study), a reduction in achievement on the order of 0.015 to 0.026 SD. Thompson and Ward (2022) also found that school districts that switch to the four-day school week and are in the lower third of the time-in-school distribution have the largest negative four-day school week achievement effects, with achievement reductions on the order of 0.034 and 0.056 SD.

Beyond assessing the average effects of these school schedules, a few studies (Thompson, 2021a; Morton, Thompson, and Kuhfeld, 2022) have examined heterogeneity across student demographic groups and educational program participation. Thompson (2021a) examined heterogeneous impacts among upper elementary and middle school students in Oregon and found that special education students fared 0.026 SD better in math than general education students under a four-day school week schedule. Four-day school week students in the English as a Second Language (ESL) curriculum were found to score 0.041 SD below their non-ESL counterparts in reading. Despite these notable differences across educational program participation, Thompson (2021a) found no statistically significant evidence that different demographic student subgroups scored differently in reading or math following the introduction of the four-day school week. A national study of elementary and middle school students (Morton, Thompson, and Kuhfeld, 2022) found that female students scored 0.04 SD below that of male students in reading and math after the implementation of the four-day school week. Compared to White students, Hispanic students scored 0.07 SD lower in math and American Indian students scored 0.12 SD higher in math following the introduction of the four-day school week.

Non-academic impacts of the four-day school week

Other literature also has focused on non-academic outcomes related to the adoption of four-day school weeks, including school district cost savings, student health, and juvenile crime. Several studies have found modest cost savings as a result of the four-day school week. Griffith (2011) projected that the switch to a four-day school week produced savings of between 0.4 and 2.5 percent, while Morton (2021) found cost savings of 1.36 percent in Oklahoma. A nationwide study (Thompson, 2021b) also found a similar magnitude impact – on the order of a one to two percent reduction in per-pupil expenditures. Thompson (2021b) also reported that the four-day school week is often used in conjunction with pre-existing instructional expenditure reduction policies, possibly as a form of non-monetary benefit to recruit and retain teachers in periods of budgetary uncertainty.

Another set of literature has examined the impacts of the four-day school week on nutrition, physical activity, risk behaviors, and juvenile crime. In terms of nutrition and physical activity, among adolescent students, Israel et al. (2020) conducted a cross-sectional analysis and determined that four-day school weeks in Colorado were related with increased physical activity, decreased non-school screen time, and decreased breakfast consumption. Tomakyo et al. (2021) conducted a repeated cross-sectional analysis with school fixed effects and found that four-day school weeks in Oregon were associated with increased sugar sweetened beverage consumption, decreased water consumption, increased food insecurity, and fewer days of access to physical education. Tomayko et al. (2020) conducted an analysis of longitudinal data on physical education provision in Oregon and noted that while days of physical education were lower in four- versus five- day schools, physical education exposure (i.e., minutes of physical education) increased following the switch to the four-day school week. However, this increased exposure was not associated with noticeable differences in body mass index among early elementary students, and little is known about the

quality of the exposure. In terms of health behaviors, Israel et al. (2020) reported mixed findings among four-day school weeks in Colorado, including decreased sleep, decreased substance use behaviors, increased bullying, and increased sexual activity. Conversely, Tomakyo et al. (2021) demonstrated that four-day school weeks in Oregon were associated with increased incidence of drug and marijuana use. Another study of adolescent behaviors by Fischer and Argyle (2018) found using a two-way fixed effects difference-in-differences estimator that an increase in four-day school week prevalence in the local area was associated with an increase in juvenile crime by nearly 20 percent.

The current study

Our study aims to examine how the four-day school week and school readiness impact achievement for early elementary students, an aspect that has been previously unexplored in the four-day school week achievement literature. Specifically, we ask the following research questions:

(1) How does attending a four-day school week starting in kindergarten impact 3rd grade math and ELA achievement?

(2) Are there differential four-day school week impacts on 3rd grade math and ELA achievement across the distribution of baseline pre-K academic and social-emotional skill development (as measured by academic and social-emotional kindergarten readiness assessment scores), student demographics, and educational program participation?

Similar to older students, we expect early elementary students to experience negative achievement impacts as a result of lost time in school related to adoption of these four-day school

weeks. Moreover, there are several reasons suggesting these negative achievement effects could be exacerbated for younger elementary school students. First, for this younger student group, in-person interactions with teachers and peers are critical for fostering academic and socioemotional skill development (Brown and Saks, 1986; Croninger, et al., 2007; Palardy and Rumberger, 2008; Blank, 2012; Boonen, Van Damme, and Onghena, 2014; Arujo, et al., 2016; Bingley, et al., 2018), especially for those at-risk for on-time grade progression (Simmons, et al. 2007; Harn, Linan-Thompson, and Roberts, 2008; Ecalle, et al., 2021). Second, the non-school weekday (typically Friday) is likely to present challenges for student learning and skill development, especially for families with younger school-age children. For example, while educational content for early elementary students may be more easily supplemented at home than in later grades, the ability to facilitate home instruction is likely more difficult for families with early elementary children where more direct parent involvement is often required. These effects may be similar to "learning losses" observed during summer break (Atteberry and McEachin, 2021; Kuhfeld, et al., 2021; Alexander, Entwisle, and Olson, 2007; Downey, von Hippel, and Broh, 2004) or during the COVID pandemic school closures (Kuhfeld, et al., 2020b; Kuhfeld and Tarasawa, 2020), where younger and more at-risk students were found to display higher rates of learning loss. While the non-school weekday is free of traditional academic instruction, some school districts offer remedial or enrichment services, although these are often primarily for middle and high school students. According to Thompson, et al. (2021a), 38.7 percent of four-day school week districts in Oregon offer some type of student services on the non-school weekday. In Oregon many of these are "remedial services" or help sessions for students who are struggling academically. Thus, few districts, if any, have services for all students on the non-school weekday.

Additionally, supervision remains a pressing issue for this early elementary age group. Few schools offer non-school weekday childcare or supplemental instruction for early elementary school children (Thompson, et al., 2021a). Thus, parents of early elementary students likely must choose between reducing work commitments or devoting greater family resources to childcare. To this point, Ward (2019) finds that maternal labor hours and employment were reduced as four-day school week prevalence in the local area increased. In addition to potential reductions in household financial resources as a result of parental work decisions in response to the four-day school week, the loss of school meals and physical education opportunities one day a week may impact child nutrition, socioemotional development, and overall child well-being more broadly, which may indirectly impact early elementary school achievement.

Although it is generally thought that loss of access to school may be particularly problematic for students at-risk academically and those from disadvantaged backgrounds (Dorn, et al., 2020; Jackson, et al. 2020), there are several reasons to suspect that low achievers may be less impacted by these school schedules than high achievers. First, remedial services during the non-school weekday are generally offered to low performing students but not the entire student body. Given these differences in access to non-school weekday services, there may be reason to suspect that these lower scoring students may not feel the full effects of lost instructional time that results from the switch to the four-day school week. This may also be true for students with specialized education plans, including those in special education programs or the ESL program. Second, the compressed schedule also may lead to a more constrained curriculum that focuses more on core skills – instead of a broader set of content that might benefit high-achievers; this curricular approach also would benefit lower achievers. Higher achievers may miss out on

specialized instruction – such as gifted and enrichment activities – that they would have had time to receive under a five-day school schedule.

Method

Data

We obtained kindergarten readiness assessment scores, 3rd grade math and reading test standardized test scores, and demographic information for students entering kindergarten in the state of Oregon between 2014 and 2016 from the Oregon Department of Education. Using all students who were kindergartners between 2014 and 2016, the analytic sample included a total of 95,221 students. The total analytic sample includes 90,897 five-day students and 4,324 four-day students. These data include scores from the Early Literacy, Early Math, and Approaches to Learning Assessments conducted during the beginning months of kindergarten. We linked these kindergarten assessment scores to students' 3rd grade math and ELA standardized test scores from 2017 to 2019, also from the Oregon Department of Education. This database also includes student demographic information such as student's sex, race/ethnicity, socioeconomic status, and program participation (e.g., special education, gifted/talented, English as a Second Language).

Measures

Achievement Outcome Measures. As our main outcomes we use students' 3rd grade math and ELA standardized test scores. These scores come from Oregon's statewide accountability assessment that is required of all 3rd graders. In our sample, of the 103,258 students that entered kindergarten over this period who had valid kindergarten assessment scores, only around 6,000 students had missing 3rd grade assessment scores. Among the group with non-missing 3rd grade test scores, the standardized math scores ranged from -2.00 SD to 2.83 SD and standardized reading scores ranged from -1.42 SD to 1.48 SD.

Academic Math Readiness Measures. The Early Math assessment is an untimed assessment containing 16 items that include counting, simple addition, simple subtraction, and recognizing number patterns. This assessment is multiple choice, with students pointing to or verbalizing their answer from three possible answers. The Early Math assessment is scored as the number of correct answers given from this 16-item assessment (0-16 possible raw score).

Academic Language Readiness Measures. The Early Literacy assessment includes two measures: (a) English letter names assessment that consists of students looking at a chart with 100 upper and lowercase letters and is scored as the number of letters students can identify correctly in 60 seconds (0-100 possible raw score); (b) English letter sounds assessment that consists of students looking at a chart with 100 upper and lowercase letters and some letter blends and is scored as the number of letter sounds students can make correctly in 60 seconds (0-100 possible raw score).

Social-Emotional Readiness Measures. The Approaches to Learning Assessment is modeled after a research-based measure called the Child Behavior Rating Scale (CBRS) that includes teacher ratings of children's self-regulation and social-emotional skills (Bronson, et al., 1990). It includes two subscales: self-regulation and interpersonal skills. The self-regulation subscale consists of 10 items and includes questions such as "Observes rules and follows directions without requiring repeated reminders" and "Completes tasks successfully." The interpersonal skills subscale consists of 5 items and includes questions such as "Willing to share toys or other things with other children when playing" and "Takes turns in a game situation with toys, materials, and other things without being told to do so." Overall, the CBRS includes 15 items that teachers score on a five-point scale – ranging from never exhibits the behavior (score of 1) to always exhibits the behavior (score of 5) – based on observation of the student in the classroom during regular classroom activities and routines. This rating scale has demonstrated reliability and validity in diverse samples of children

(Matthews, Ponitz, and Morrison, 2009; Wanless, et al., 2011). For example, previous research has consistently found that the CBRS has high internal reliability α = .95 (McClelland & Morrison, 2003) and ranges of α = .94 - .95 across multiple samples in different countries for the self-regulation subscale (Wanless, et al., 2011). Other research using the Kindergarten Assessment data in Oregon found that the CBRS had an internal reliability of α = .95 (Tindal et al., 2015). Evidence of validity with direct assessments of self-regulation also has been found with a correlation between the self-regulation subscale of the CBRS with a direct assessment of self-regulation (the Head-Toes-Knees-Shoulders) of *r* = .35 (Schmitt, Pratt & McClelland, 2014).

The self-regulation and early math assessments have been shown to be the most predictive of later outcomes for students (McClelland, et al., 2013; Robson, Allen, and Howard, 2020; Schmitt, et al., 2017; Burchinal, et al., 2020; Duncan, et al., 2007; Nguyen, et al., 2016). For more information on these kindergarten assessment measures, see:

www.oregon.gov/ode/educator-resources/assessment/Pages/Kindergarten-Assessment.aspx.

Analytic Strategy

Simple comparisons of 3rd grade achievement between four-day and five-day students could potentially be biased due to differences in educational inputs across school districts that adopt and do not adopt the four-day school week and unobservable student input differences across students in four- and five-day schools. Thus, to control for these aspects, we included student and school district observable characteristics and the various kindergarten assessment scores as control variables in the following Ordinary Least Squares model specification:

$$A_{i3st} = \alpha + \lambda KA_{iKs,t-3} + \beta \, \text{fourday}_{s,t-3} + \delta \boldsymbol{X}_{igst} + \theta_t + \epsilon_{igst} \qquad (1)$$

where A_{i3st} is the outcome of interest, either 3rd grade math or reading achievement. The fourday$_{s,t-3}$ variable is an indicator for whether the student was in a four-day school week starting

in kindergarten and is the key variable of interest in this study. $KA_{iKs,t-3}$ includes a set of kindergarten readiness assessment scores for student i from the year of kindergarten entry, including scores on early math, letter names, letter sounds, and Approaches to Learning assessments. Based on the educational production function (Todd and Wolpin, 2003), these kindergarten assessment scores serve to capture student, neighborhood, and family inputs prior to entering kindergarten. This creates an estimator that provides a better matched comparison across four- and five-day students in the absence of a robust set of fixed effects. As we are looking at repeated cross-section in the outcome achievement variables during a time span when four-day school week use was stable – there were no adoptions or removal of the four-day school week during the time period we examined – we were unable to include school or school district fixed effects in these models because there is no variation in the four-day school week indicator at the school/district level. As we also only observed each student once in our outcome data, we are unable to include a student fixed effect. We also added a set of student covariates, including student demographics (race, sex, socioeconomic status), student 3rd grade program participation (special education, English as a Second Language, or gifted and talented programming), and school district covariates (total enrollment, fraction of the student body who is White, fraction of the student body who receives free and reduced priced lunch, and rurality), and school year fixed effects (θ_t). The idiosyncratic error term, ϵ_{igst}, is clustered at the school level.

While the main analysis includes students in all five-day school week districts in the comparison group, as noted in Table 1, four-day school week districts tend to be more concentrated in rural areas and have smaller enrollment than five-day school week districts. Thus, we used several alternative comparison groups that may more accurately reflect the composition of districts using these four-day school weeks. First, we separately estimated equation (1) using stratified rural

and non-rural samples. The rural sub-sample contains 13,869 students in 82 school districts, and the non-rural sub-sample contains 81,352 students in 76 school districts. Of these, 3,176 students in 48 school districts were on a four-day schedule in the rural sub-sample and 4,181 students in nine school districts were on a four-day schedule in the non-rural sub-sample. Second, we separately estimated equation (1) for the full, rural, and non-rural samples using only districts with below median enrollment to capture the set of districts that have similar student populations to the majority of the four-day school week school districts.

Beyond assessing the overall effects of the four-day school week on 3rd grade achievement, we also consider heterogeneity in these effects across student demographic groups, educational program participation, and across students in different parts of the distribution of kindergarten assessment scores. To do this for the kindergarten assessment scores, we stratified the sample into two different groups for each of the assessment types and separately estimated equation (1) using each of these stratified samples, as well as again stratifying these further using the rural and non-rural samples. The two groups are the following: (a) above median scorers – students scoring in the top 50 percent of the score distribution; (c) below median scorers – students scoring in the bottom 50 percent of the score distribution. As a robustness check, and to observe whether the differences in effects across groups are significantly different from one another, we also estimate a version of equation (1) where we interact these group indicators with the four-day school week indicator. The results of this interacted model may differ slightly from the stratified sample approach, as the interacted model is a test of the difference in four-day school week effect sizes across the two stratified groups, while the stratified sample approach conducts a test of differences between four-day and five-day school week achievement within the stratified groups.

One concern with these types of analyses is whether the results are driven by differences related to the four-day school week or compositional differences across these kindergarten assessment scoring groups. We examined compositional differences across these various scoring groups in Appendix Table A2 and found that students in the below median social-emotional assessment scoring groups are more likely to be boys, participate in special education, and be economically disadvantaged. Students in the below median academic assessment scoring groups are more likely to be non-White, participate in special education or in English as a Second Language programming, and be economically disadvantaged.

Results

Descriptive Statistics

Table 1 describes student and school district characteristics by whether they are on a four- or five-day schedule. Columns (3) and (6) present the differences in the means and results of t-tests for statistical significance. As noted in Panel A, four-day students have slightly lower 3rd grade achievement scores, on average, compared to five-day students despite the fact that four-day students generally have higher early math kindergarten assessment scores. As noted in Panels B and C, students in four-day school week districts are more likely to be White, less likely to be Hispanic, and less likely to participate in English as a Second Language and/or gifted/talented programming by 3rd grade. As noted in Panel D, four-day school week districts also tend to have smaller overall enrollment and are more concentrated in rural areas than five-day school week districts.

[INSERT TABLE 1 HERE]

Main Regression Results

Overall, we found minimal statistically significant differences in 3rd grade achievement scores between students who started kindergarten on a four-day week schedule and those who started kindergarten on a five-day week schedule. The differences are perhaps most prominent among students in the full sample where four-day school week students have math test scores that are 0.024 SD lower than five-day school week students, but this effect is only marginally statistically significant (p<0.1). We also did not find any statistically significant differences when comparing four-day and five-day students in non-rural and rural areas separately. When we considered only small enrollment school districts (Panel B) the point estimates fall slightly and the smaller sample sizes led to even less precision in the estimates. Thus, these average effects suggest that the four-day school week has minimal impacts on early elementary school achievement overall.

[INSERT TABLE 2 HERE]

Heterogenous Effects

While the main regression results suggest a minimal impact of the four-day school week on 3rd grade achievement after controlling for these kindergarten assessment scores, these average effects may be masking interesting heterogeneity across student demographic groups, educational program participation, and the spectrum of student readiness for kindergarten. Specifically, we are interested in whether there are differential effects of the four-day school week across student subgroups defined by race, sex, socioeconomic status, and educational program participation (e.g., special education, ESL program, gifted program). We are also interested on heterogeneity across the spectrum of social-emotional skill development and academic skill development, as measured by scores on the various kindergarten assessments. The following three subsections cover each of

these separately. Given the number of regressions we estimate, there may be concern around whether the results we find here are spurious as a result of lower sample sizes and the multiple comparisons being made in this section. However, across these specifications we notice a common thread emerge – the students least academically at-risk and most advantaged (e.g., the above median scorers on both the social-emotional and early academic skill assessments; White students; general education and gifted students) are the ones most negatively impacted by the four-day school week during the early elementary period. We generally find no statistically significant evidence of detrimental four-day school week achievement impacts, and even some positive impacts, for below median performers on kindergarten assessments, minority students, economically disadvantaged, special education, and ESL students.

Socioemotional Readiness

When we stratified the sample by the pre-kindergarten Approaches to Learning assessment total score bins, we found detrimental effects for above median scorers and no statistically significant impacts for below median scorers. In the full sample (see Panel A of Table 3), we found 3rd grade math and reading test scores are statistically significantly lower – on the order of 0.032 SD in math and 0.038 SD in reading – for four-day school week students among the above median scoring group. We did not find statistically significant overall differences for students among the below median scoring group. The interacted model (see columns (1) and (2) of Appendix Table A1), however, showed that there is no statistically significant difference in the impact of the four-day school week between above median and below median scorers on the Approaches to Learning assessment.

Among the rural subsample (see Panel A of Table 4), we found that four-day school week students in the above median scoring group have 3rd grade reading test scores that are 0.036 SD

lower (p < 0.1) than five-day school week students. Just as in the full sample, we did not find statistically significant differences in achievement for students among the below median scoring group in the rural subsample. Among the non-rural subsample (see Panel A of Table 5), we found no statistically significant differences in achievement for either the above median or below median scoring groups.

[INSERT TABLE 3 HERE]

Academic Readiness

Similar to the social-emotional heterogeneous effect results, we also demonstrated detrimental effects for the above median scoring group when we stratified the sample by the pre-kindergarten early math, letter sounds, and letter names assessment scoring groups. In the full sample (see Panel A of Table 3), we found 3rd grade math and reading scores are statistically significantly lower – on the order of 0.035 SD in math and 0.040 SD in reading – for four-day school week students among the above median early math scoring group. Using the letter names assessment score, we found that four-day school week students in the above median scoring group have 3rd grade math and reading test scores that are 0.033 SD lower and 0.037 SD lower (p < 0.05), respectively, than five-day school week students. Using the letter sounds assessment score, we found that four-day school week students in the above median scoring group have 3rd grade math and reading test scores that are 0.043 SD lower (p < 0.05) than five-day school week students. We did not find statistically significant overall differences for students among the below median scoring group using the early math assessment score, letter sounds assessment score, or letter names assessment score. The interacted model (see columns (9) to (14) of Appendix Table A1) also showed statistically significant differences in the impact of the four-day school week between

high and low scorers on the early math, letter sounds, and letter names assessments, particularly in the case of math achievement.

[INSERT TABLE 4 HERE]

Among the rural subsample (see Panel A of Table 4), we found that four-day school week students in the above median scoring group on these academic readiness assessments have 3rd grade math and reading test scores that are between 0.038 SD lower and 0.048 SD lower than five-day school week students. Just as in the full sample, we did not find statistically significant differences in achievement for students among the below median scoring groups on these academic readiness assessments in the rural subsample. Among the non-rural subsample (see Panel B of Table 5), we found no statistically significant or only marginally significant differences in achievement for the above median scoring groups on the early math and letter names assessments. The above median scoring group on letter sounds assessment, however, was found to have 3rd grade math and reading test scores that are 0.034 SD lower and 0.042 SD lower ($p < 0.05$), respectively, than five-day school week students. We continued to find no statistically significant differences in achievement for students among the below median scoring groups on these academic readiness assessments in the non-rural subsample.

Student Demographics and Educational Program Participation

When we looked at heterogeneity across student demographic subgroups and educational program participation (see Panel B of Table 3), the results also generally aligned with the kindergarten readiness results – minority students and those in non-general education programs were less likely to be affected negatively by the four-day school week. When we considered

student sex or socioeconomic status, much of the stratified results were not statistically significant. We did find that boys attending school on a four-day school week scored 0.028 SD below (p < 0.05) that of boys attending school on a five-day school week in math. The results of the interacted model (see Appendix Table A1) also showed that boys fare worse than girls in math as a result of the four-day school week. The interacted model also found that economically disadvantaged students scored 0.033 SD higher in math and reading (p < 0.05) than non-economically disadvantaged students. Looking at heterogeneity across student race, we found that White four-day school week students have 3rd grade math and reading test scores that are 0.029 SD lower and 0.030 SD lower (p < 0.05), respectively, than White five-day school week students. We did not find statistically significant differences in achievement for non-White students. Using the interacted model, we found that White students scored 0.043 to 0.059 SD lower in math and reading (p < 0.01), respectively, compared to non-White students. When stratifying the sample into rural and non-rural subsamples (see Panel B of Tables 4 and 5), almost all of the results are no longer found to be statistically significant or only remain marginally significant (p < 0.1).

[INSERT TABLE 5 HERE]

In terms of educational program participation, students not participating in special education or ESL program and those participating in the gifted program appear to be negatively impacted by the four-day school week. While the sample sizes in these groups are quite small, leading to some results to not be statistically significant or only marginally significant, we do find several notable results. In terms of reading achievement, gifted students attending school on a four-day school week score 0.094 SD below that of gifted students attending school on a five-day school

week. ESL students attending school on a four-day school week were found to score 0.083 SD above ESL students attending school on a five-day school week ($p < 0.05$). These same results hold for the gifted and ESL students when we examine the rural and non-rural subsamples. The interacted model also shows large positive effects of the four-day school week for students in the ESL program, with ESL students scoring 0.064 ($p < 0.05$) to 0.12 SD ($p < 0.01$) higher in math and reading, respectively, compared to non-ESL students.

Discussion

Prior research has established that reduced time in school as a result of the four-day school week leads to achievement reductions for upper elementary, middle, and high school students. We build on this literature by examining a previously unexplored student group in the four-day school week achievement literature – students who were exposed to the four-day school week during the early elementary years. Using kindergarten readiness scores as proxies for baseline pre-K skill development, we compared 3rd grade math and ELA achievement of students who started kindergarten on a four-day week schedule and those who started kindergarten on a five-day week schedule.

Our main regression results suggest minimal and non-significant differences in 3rd grade achievement scores, on average, between students who started kindergarten on a four-day week schedule and those who started kindergarten on a five-day week schedule. We did find marginally statistically significant impacts ($p < 0.1$) on math test scores for students in the overall sample, where four-day school week students have math test scores that are 0.024 SD lower than five-day school week students. Thus, we might be tempted to conclude based on these results that the four-day school week has little impact on 3rd grade achievement and that the four-day school week yields similar achievement outcomes to five-day school weeks for most children. This is not the

case, however, as these main regression results appear to mask interesting heterogeneity across the spectrum of student readiness for kindergarten, which tells a more nuanced story of the impacts of the four-day school week in these early grades.

Our heterogeneous effects results suggest that the students least academically at-risk and most advantaged – a group of students that makes up more than half our sample – are the ones whose math and ELA test scores are most negatively impacted by exposure to the four-day school week during the early elementary period. Above median scorers on kindergarten assessments, male students, White students, non-ESL students, and non-economically disadvantaged students in four-day school week districts are found to score between 0.022 and 0.043 SD lower than five-day school week students on 3rd grade math and ELA tests. We generally find no statistically significant evidence of detrimental four-day school week achievement impacts, and even some positive impacts, for below median performers on kindergarten assessments, minority students, economically disadvantaged, special education, and ESL students.

The magnitudes of these effects align with previous estimates of four-day school week achievement impacts in upper elementary and middle school grades (Kilburn, et al., 2021; Morton, 2021; Thompson, 2021a; Thompson and Ward, 2022), suggesting that these more skilled and more advantaged early elementary students are impacted similarly to older students in terms of level scores following the introduction of the four-day school week. However, given the greater annual gains observed for younger elementary students (see Bloom, et al., 2008), these effect sizes would be considered "small" (Kraft, 2020) – only representing about one-twentieth of the estimated impact of a year of school on achievement in 3rd grade (Bloom, et al., 2008; Lipsey, et al., 2012) or the equivalent of about two weeks of learning.

While more work is needed to understand the mechanisms driving these heterogeneous effects, one potential explanation here is that floor effects may limit the negative impacts of the four-day school week for the below median scorers on these kindergarten assessments. While stable pre-K supports (e.g., high quality home environments, daycares, and/or preschool opportunities) have been found to contribute to increased cognitive, language, and social development (Burchinal et al., 2002; Howes et al., 2008; Mashburn et al., 2008; Pinto, Pessanha, and Aguiar, 2013), few analogous supports exist for school-age children. Thus, for the students most likely to fully take advantage of the education being offered in these early grades, there is likely to be a noticeable drop-off in achievement from not attending school one day a week. While there may still be a drop-off in achievement for the four-day students relative to five-day students in the below median scoring group, it may be less noticeable, both in terms of magnitude and statistical significance, due to lower baseline skill development these students possess when entering kindergarten. A second potential mechanism is that differential access/availability of student services on the non-school weekday or a more constrained curriculum focused on core skills that favors struggling students helps mitigate the negative achievement effects for the below median scoring group. As noted previously, a little over a third of schools in Oregon provide non-school weekday services for students, and a majority of these services are for remedial instruction – an intervention targeted at moving students' ability to the expected grade level standard. Thus, students performing above the median would be unlikely to need or be eligible for such supplemental instruction. Access to these critical services on the non-school weekday may also explain why non-ESL and non-special education students also fare worse under the four-day school week schedule.

In addition to a lack of available data to disentangle these mechanisms, there are a few other notable limitations of this analysis. First, the choice of four-day school week adoption at the school district level is non-random. While we did control for school district factors in our regression analyses, the fact that four-day school week adoption was stable during the time period we examined means we were unable to include school district fixed effects in these analyses. Future work that examines other time periods and settings may better account for fixed differences across different school districts using these types of fixed effects to provide better comparison between four- and five-day school districts. Second, given that we first observed the residence of students when they enter kindergarten, we are unable to fully account for selection of families into or out of these four-day school weeks prior to their child's kindergarten entrance. Families that remain in four-day school week districts may be different than those who move to nearby five-day school week districts, which could also bias our estimates. Thus, we cannot conclude with certainty that our estimates are causal. Third, while we have cross-sectional information on the availability of supplemental or remedial services for students on the non-school weekday, we lack longitudinal information on their availability and utilization, which limits our ability to directly test whether these programs are fully driving the differences we observe here. Fourth, while not likely an issue with the academic assessments, the Assessment of Learning Approaches metrics are based on teacher ratings that could be biased towards White students and students from more advantaged backgrounds (Grissom and Bartanen, 2022), which could limit the use of these measures as key predictors of school performance and our heterogeneous groups based on these metrics. Finally, we only consider one state setting. Previous literature (Thompson, 2021a; Thompson, et al., 2021a) has noted that the larger and statistically significant negative four-day school week achievement impacts found in Oregon compared to those found in other states studied (i.e., Oklahoma and

Colorado) may, in part, be attributable to lower amounts of time in school and less frequent use of non-school weekday activities in Oregon relative to these other states. Thus, we may expect these results to be toward the lower bound of four-day school achievement effects across the spectrum of states that allow this school schedule.

Despite these limitations, our results suggest that while the four-day school week may help reduce pre-existing achievement gaps between the students least academically at-risk or most advantaged and the students most academically at-risk or least advantaged, it comes at a cost for these least academically at-risk and most advantaged students. Leveling-down effects for these least academically at-risk and most advantaged students is something that school districts should be cognizant of and may want to attempt to mitigate when considering these school schedules. The lack of impacts on the students most academically at-risk or least advantaged may suggest smaller, less detectible impacts for this group or may suggest that remedial or supplemental instruction is an effective tool in mitigating detrimental impacts of lost instructional time as a result of the four-day school week for struggling students. It could also suggest that the shortened schedule is leading to a more core skill-focused curriculum that would benefit lower achievers, with the lack of a broader, more enriching curriculum ultimately slowing the growth potential of the higher achieving students. Little current data exist on these mechanisms, and thus, future work that assesses what school districts are doing in practice to maintain instructional time and the overall curriculum and provide non-school weekday instructional opportunities to at-risk students versus the student body at large will better explain the mechanisms driving these results.

While school districts have continued to turn to these school models for positive benefits related to financial flexibility, alleviating teacher burnout, and practical considerations related to the rural setting of many of these districts, the findings of this study and that of previous research

suggests that student learning, for a majority of students in these districts, may be negatively impacted by these decisions – particularly when instructional time is not adequately maintained. Thus, school districts should be cognizant of balancing the tradeoff between these intended benefits and the negative implications these school schedules may have for student learning and achievement. School districts should also consider non-academic impacts on student health and wellbeing due to lost access to support, like school meals and physical education one day per week. Unlike other early elementary interventions, which are often short-duration interventions that see the policy effects fade out after the intervention ends [e.g., Perry preschool; see Schweinhart, et al. (2005); Head Start; see Puma, et al. (2012); Building Blocks pre-K math intervention; see Clements, et al. (2013)], the four-day school week represents a longer-term intervention – as many school districts never return to the five-day school week schedule. Thus, students harmed by the changes related to instructional time, the curriculum, etc. that result from the switch to the four-day school week may be unlikely to recover these losses if they remain in the four-day school week setting. Ultimately, finding low-cost ways – in terms of financial obligations for school districts and effort for teachers – to better maintain instructional time for all students seems critical for eliminating the leveling down of the achievement trajectories associated with this school schedule. Possible approaches include supplemental in-person or asynchronous learning on the non-school weekday or by further lengthening the remaining school days. However, for districts with high populations of advantaged students, our results suggest that a switch back to the five-day school week may be warranted if academic achievement is a primary motivator for determining school schedules.

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Tables

Table 1: Mean and SDs for study variables by 4-day and 5-day school samples

	(1)	(2)	(3)		(4)	(5)	(6)
	Five-Day	Four-Day	Col. (1) – Col. (2)		Five-Day	Four-Day	Col. (4) – Col. (5)
Panel A: Assessment Scores				**Panel B: Student Demographics**			
Std. 3rd Grade Math Score	0.04	0.01	0.028	Female	0.49	0.49	0.003
	(0.85)	(0.79)	[0.037]		(0.50)	(0.50)	[0.654]
Std. 3rd Grade Read Score	0.04	0.02	0.018	White	0.61	0.79	-0.183
	(0.85)	(0.77)	[0.157]		(0.49)	(0.41)	[<0.001]
Approaches to Learning Score (out of 5)	3.70	3.71	-0.013	Black	0.02	0.01	0.016
	(0.80)	(0.78)	[0.311]		(0.14)	(0.07)	[<0.001]
Early Math Score (out of 16)	8.18	8.38	-0.200	Hispanic	0.25	0.15	0.105
	(3.20)	(2.89)	[<0.001]		(0.43)	(0.35)	[<0.001]
Early Letter Names (out of 100)	18.45	17.84	0.609	Asian	0.04	0.01	0.036
	(16.72)	(15.21)	[0.019]		(0.20)	(0.08)	[<0.001]
Early Letter Sounds (out of 100)	6.89	6.87	0.023	American Indian	0.01	0.01	0.003
	(9.84)	(9.33)	[0.879]		(0.11)	(0.10)	[0.091]
				Economically Disadvantaged	0.62	0.63	-0.017
					(0.49)	(0.48)	[0.021]
Panel C: Educational Program Participation				**Panel D: School District Characteristics**			
Special Ed	0.15	0.16	-0.007	Enrollment	459.53	335.50	124.04
	(0.36)	(0.36)	[0.190]		(140.37)	(216.64)	[<0.001]
ESL Program Participant	0.07	0.03	0.042	Fraction White	0.60	0.78	-0.181
	(0.26)	(0.17)	[<0.001]		(0.21)	(0.17)	[<0.001]
Gifted/Talented Reading	0.02	0.00	0.013	Fraction FRL	0.54	0.60	-0.056
	(0.13)	(0.06)	[<0.001]		(0.24)	(0.17)	[<0.001]
Gifted/Talented Math	0.02	0.00	0.014	Rural	0.12	0.67	-0.546
	(0.13)	(0.06)	[<0.001]		(0.33)	(0.47)	[<0.001]

Notes: Panel A includes means and standard deviations (in parentheses) for scores on 3rd grade math and reading assessments and the five kindergarten readiness assessments. Among the group with non-missing 3rd grade test scores, the standardized math scores ranged from -2.00 standard deviations to 2.83 standard deviations and standardized reading scores ranged from -1.42 standard deviations to 1.48 standard deviations. Panels B, C, and D includes means and standard deviations (in parentheses) 3rd grade students demographics, 3rd grade program participation, and school district characteristics respectively. Columns (3) and (6) present the difference in mean outcomes between the respective five-day and four-day columns, with the associated p-value in brackets. The total analytic sample includes 90,904 five-day students and 4,324 four-day students.

Table 2: Overall effects of 4-day school outcomes on 3rd grade math and reading scores

	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample		Rural Only		Non-rural Only	
	Math	Read	Math	Read	Math	Read
Panel A: All districts						
Four-day	-0.024*	-0.023	-0.023	-0.023	-0.012	-0.016
	(0.013)	(0.015)	(0.017)	(0.018)	(0.018)	(0.023)
Observations	94,470	94,497	13,780	13,785	80,690	80,712
R-squared	0.454	0.430	0.396	0.374	0.463	0.440
Panel B: Small Enrollment districts only						
Four-day	-0.013	-0.015	-0.010	-0.010	-0.015	-0.020
	(0.012)	(0.014)	(0.016)	(0.018)	(0.022)	(0.027)
Observations	47,590	47,592	10,027	10,035	37,563	37,557
R-squared	0.432	0.407	0.388	0.362	0.443	0.418

Notes: Each cell of the table presents results for the $fourday_{dt}$ variable from a separate regression containing the specified dependent variable (listed along the rows of the table), controls for student demographics and program participation, school district characteristics, and kindergarten assessment scores. Panel A includes all districts in the sample, while Panel B only includes districts with less than or equal to 450 students. The "Full Sample" analyses include all 3rd grade students. The "Rural" analyses include all 3rd grade students from rural school districts. The "Non-rural" analyses include all 3rd grade students from non-rural school districts. Robust standard errors, clustered at the school district-level are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Heterogeneous effects of 4-day school outcomes on 3rd grade math and reading scores, full sample

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
	Panel A: Kindergarten Readiness Measures								
	3rd Grade Math Achievement		3rd Grade Reading Achievement			3rd Grade Math Achievement		3rd Grade Reading Achievement	
	Above Median Scorers	Below Median Scorers	Above Median Scorers	Below Median Scorers		Above Median Scorers	Below Median Scorers	Above Median Scorers	Below Median Scorers
	Approaches to Learning Assessment					Letter Names Assessment			
Four-day	-0.032**	-0.015	-0.038**	-0.007	Four-day	-0.033**	-0.016	-0.037**	-0.011
	(0.015)	(0.014)	(0.016)	(0.015)		(0.015)	(0.013)	(0.016)	(0.017)
Observations	48,540	45,930	48,577	45,920	Observations	47,715	46,755	47,745	46,752
R-squared	0.410	0.398	0.387	0.368	R-squared	0.364	0.289	0.321	0.252
	Early Math Assessment					Letter Sounds Assessment			
Four-day	-0.035**	-0.012	-0.040***	-0.008	Four-day	-0.043***	-0.006	-0.043**	-0.006
	(0.014)	(0.014)	(0.015)	(0.017)		(0.016)	(0.012)	(0.017)	(0.016)
Observations	41,842	52,628	41,865	52,632	Observations	45,420	49,050	45,439	49,058
R-squared	0.365	0.309	0.348	0.306	R-squared	0.380	0.315	0.337	0.275
	Panel B: Demographic and Educational Program Participation								
	3rd Grade Math Achievement		3rd Grade Reading Achievement			3rd Grade Math Achievement		3rd Grade Reading Achievement	
	Student Gender					Economically Disadvantaged			
	Male	Female	Male	Female		High-income	Low-income	High-income	Low-income
Four-day	-0.028**	-0.019	-0.026	-0.020	Four-day	-0.023	-0.022*	-0.022	-0.021
	(0.014)	(0.014)	(0.017)	(0.015)		(0.020)	(0.013)	(0.021)	(0.016)
Observations	47,999	46,471	47,983	46,514	Observations	36,423	58,047	36,455	58,042
R-squared	0.457	0.450	0.415	0.437	R-squared	0.406	0.369	0.362	0.349
	Student Race					Gifted Program Participation			
	White	Non-White	White	Non-White		Gifted	Non-Gifted	Gifted	Non-Gifted
Four-day	-0.029**	0.005	-0.030**	0.015	Four-day	0.035	-0.024*	-0.095**	-0.022
	(0.013)	(0.016)	(0.015)	(0.020)		(0.040)	(0.013)	(0.046)	(0.015)
Observations	58,304	36,166	58,305	36,192	Observations	2,379	92,091	2,392	92,105
R-squared	0.420	0.457	0.391	0.431	R-squared	0.262	0.426	0.239	0.405
	ESL Program Participation					Special Education Status			
	ESL	Non-ESL	ESL	Non-ESL		Special Ed	Non-Special Ed	Special Ed	Non-Special Ed
Four-day	0.035	-0.025*	0.083**	-0.026*	Four-day	-0.023	-0.024*	-0.007	-0.026
	(0.030)	(0.013)	(0.034)	(0.015)		(0.016)	(0.014)	(0.019)	(0.016)
Observations	6,634	87,836	6,619	87,878	Observations	13,538	80,932	13,490	81,007
R-squared	0.240	0.443	0.185	0.410	R-squared	0.394	0.413	0.359	0.391

Notes: Each cell of the table presents results for the $fourday_{dt}$ variable from a separate regression containing the specified dependent variable, controls for student demographics and program participation, school district characteristics, and kindergarten assessment scores. The "Above Median Scorers" group includes students who scored in the top 50 percentile of the score distribution (50-100 percentile). The "Below Median Scorers" group includes students who scored in the bottom 50 percentile of the score distribution (0-49 percentile). Robust standard errors, clustered at the school district-level are given in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Heterogeneous effects of 4-day school outcomes on 3rd grade math and reading scores, rural subsample

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
Panel A: Kindergarten Readiness Measures									
	3rd Grade Math Achievement		3rd Grade Reading Achievement			3rd Grade Math Achievement		3rd Grade Reading Achievement	
	Above Median Scorers	Below Median Scorers	Above Median Scorers	Below Median Scorers		Above Median Scorers	Below Median Scorers	Above Median Scorers	Below Median Scorers
Approaches to Learning Assessment					**Letter Names Assessment**				
Four-day	-0.030	-0.015	-0.036*	-0.009	Four-day	-0.038*	-0.010	-0.039**	-0.009
	(0.018)	(0.018)	(0.019)	(0.019)		(0.020)	(0.017)	(0.019)	(0.019)
Observations	7,005	6,775	7,014	6,771	Observations	6,929	6,851	6,931	6,854
R-squared	0.334	0.354	0.319	0.323	R-squared	0.312	0.261	0.275	0.216
Early Math Assessment					**Letter Sounds Assessment**				
Four-day	-0.048**	0.002	-0.044**	-0.003	Four-day	-0.043**	-0.004	-0.040*	-0.007
	(0.020)	(0.017)	(0.019)	(0.019)		(0.021)	(0.015)	(0.020)	(0.018)
Observations	6,242	7,538	6,238	7,547	Observations	6,841	6,939	6,842	6,943
R-squared	0.318	0.270	0.301	0.268	R-squared	0.324	0.286	0.292	0.236
Panel B: Demographic and Educational Program Participation									
	3rd Grade Math Achievement		3rd Grade Reading Achievement			3rd Grade Math Achievement		3rd Grade Reading Achievement	
Student Gender					**Economically Disadvantaged**				
	Male	Female	Male	Female		High-income	Low-income	High-income	Low-income
Four-day	-0.026	-0.019	-0.026	-0.020	Four-day	-0.035	-0.013	-0.022	-0.022
	(0.017)	(0.018)	(0.019)	(0.019)		(0.024)	(0.016)	(0.022)	(0.019)
Observations	7,110	6,670	7,115	6,670	Observations	5,716	8,064	5,710	8,075
R-squared	0.409	0.382	0.369	0.366	R-squared	0.361	0.349	0.330	0.332
Student Race					**Gifted Program Participation**				
	White	Non-White	White	Non-White		Gifted	Non-Gifted	Gifted	Non-Gifted
Four-day	-0.029*	0.006	-0.027	0.003	Four-day	0.020	-0.023	-0.128***	-0.023
	(0.017)	(0.022)	(0.018)	(0.022)		(0.033)	(0.017)	(0.038)	(0.018)
Observations	10,245	3,535	10,251	3,534	Observations	1,593	13,596	1,601	13,601
R-squared	0.383	0.408	0.351	0.400	R-squared	0.310	0.378	0.222	0.357
ESL Program Participation					**Special Education Status**				
	ESL	Non-ESL	ESL	Non-ESL		Special Ed	Non-Special Ed	Special Ed	Non-Special Ed
Four-day	0.053	-0.024	0.080*	-0.024	Four-day	-0.005	-0.026	0.010	-0.029
	(0.051)	(0.017)	(0.045)	(0.018)		(0.020)	(0.018)	(0.024)	(0.019)
Observations	529	13,251	527	13,258	Observations	1,885	11,895	1,871	11,914
R-squared	0.255	0.391	0.201	0.362	R-squared	0.323	0.343	0.296	0.330

Notes: Each cell of the table presents results for the $fourday_{dt}$ variable from a separate regression containing the specified dependent variable, controls for student demographics and program participation, school district characteristics, and kindergarten assessment scores. The "Above Median Scorers" group includes students who scored in the top 50 percentile of the score distribution (50-100 percentile). The "Below Median Scorers" group includes students who scored in the bottom 50 percentile of the score distribution (0-49 percentile). Robust standard errors, clustered at the school district-level are given in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Heterogeneous effects of 4-day school outcomes on 3ʳᵈ grade math and reading scores, non-rural subsample

	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
	Panel A: Kindergarten Readiness Measures								
	3rd Grade Math Achievement		3rd Grade Reading Achievement			3rd Grade Math Achievement		3rd Grade Reading Achievement	
	Above Median Scorers	Below Median Scorers	Above Median Scorers	Below Median Scorers		Above Median Scorers	Below Median Scorers	Above Median Scorers	Below Median Scorers
	Approaches to Learning Assessment					Letter Names Assessment			
Four-day	-0.018	-0.008	-0.030	-0.003	Four-day	-0.018	-0.010	-0.032	-0.006
	(0.022)	(0.018)	(0.025)	(0.022)		(0.016)	(0.022)	(0.021)	(0.029)
Observations	41,535	39,155	41,563	39,149	Observations	40,786	39,904	40,814	39,898
R-squared	0.423	0.406	0.399	0.376	R-squared	0.372	0.295	0.329	0.259
	Early Math Assessment					Letter Sounds Assessment			
Four-day	-0.012	-0.011	-0.034*	-0.003	Four-day	-0.034**	0.003	-0.042**	0.001
	(0.014)	(0.022)	(0.020)	(0.028)		(0.015)	(0.021)	(0.018)	(0.030)
Observations	35,600	45,090	35,627	45,085	Observations	38,579	42,111	38,597	42,115
R-squared	0.372	0.317	0.356	0.313	R-squared	0.389	0.321	0.345	0.282
	Panel B: Demographic and Educational Program Participation								
	3rd Grade Math Achievement		3rd Grade Reading Achievement			3rd Grade Math Achievement		3rd Grade Reading Achievement	
	Student Gender					Economically Disadvantaged			
	Male	Female	Male	Female		High-income	Low-income	High-income	Low-income
Four-day	-0.017	-0.006	-0.019	-0.013	Four-day	-0.009	-0.015	-0.035	-0.011
	(0.018)	(0.019)	(0.024)	(0.023)		(0.021)	(0.021)	(0.040)	(0.027)
Observations	40,889	39,801	40,868	39,844	Observations	30,707	49,983	30,745	49,967
R-squared	0.465	0.461	0.424	0.448	R-squared	0.411	0.372	0.365	0.352
	Student Race					Gifted Program Participation			
	White	Non-White	White	Non-White		Gifted	Non-Gifted	Gifted	Non-Gifted
Four-day	-0.030*	0.030*	-0.040*	0.041*	Four-day	0.050	-0.012	-0.089*	-0.015
	(0.017)	(0.016)	(0.021)	(0.024)		(0.044)	(0.018)	(0.046)	(0.023)
Observations	48,059	32,631	48,054	32,658	Observations	2,332	78,495	2,345	78,504
R-squared	0.426	0.464	0.398	0.436	R-squared	0.264	0.435	0.240	0.414
	ESL Program Participation					Special Education Status			
	ESL	Non-ESL	ESL	Non-ESL		Special Ed	Non-Special Ed	Special Ed	Non-Special Ed
Four-day	0.055*	-0.017	0.096**	-0.024	Four-day	-0.019	-0.011	-0.007	-0.018
	(0.031)	(0.017)	(0.038)	(0.020)		(0.025)	(0.018)	(0.029)	(0.024)
Observations	6,105	74,585	6,092	74,620	Observations	11,653	69,037	11,619	69,093
R-squared	0.246	0.452	0.190	0.419	R-squared	0.406	0.425	0.371	0.402

Notes: Each cell of the table presents results for the $fourday_{dt}$ variable from a separate regression containing the specified dependent variable, controls for student demographics and program participation, school district characteristics, and kindergarten assessment scores. The "Above Median Scorers" group includes students who scored in the top 50 percentile of the score distribution (50-100 percentile). The "Below Median Scorers" group includes students who scored in the bottom 50 percentile of the score distribution (0-49 percentile). Robust standard errors, clustered at the school district-level are given in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix
Table A1: Interacted model of heterogeneous effects of 4-day school outcomes on 3rd grade math and reading scores

	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(15)	(16)
	Math	Reading	Math	Reading	Math	Reading	Math	Reading	Math	Reading
	Approaches to Learning		Early Math		Letter Names		Letter Sounds		Student Sex	
Fourday	-0.022	-0.018	-0.013	-0.014	-0.015	-0.015	-0.010	-0.015	-0.029**	-0.025
	(0.013)	(0.015)	(0.014)	(0.016)	(0.013)	(0.016)	(0.012)	(0.016)	(0.014)	(0.017)
Interaction	-0.004	-0.009	-0.022**	-0.020*	-0.017	-0.016	-0.027**	-0.016	0.012*	0.005
	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.011)	(0.011)	(0.014)	(0.006)	(0.010)
Interaction variable	Above median scorer		Above median scorer		Above median scorer		Above median scorer		Female Student	
Observations	94,470	94,497	94,470	94,497	94,470	94,497	94,470	94,497	94,470	94,497
R-squared	0.454	0.430	0.454	0.430	0.454	0.430	0.454	0.430	0.454	0.430
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
	Math	Reading	Math	Reading	Math	Reading	Math	Reading	Math	Reading
	Economically Disadvantaged		Student Race		Gifted Program		ESL Program		Special Education	
Fourday	-0.045**	-0.044**	0.010	0.023	-0.024*	-0.023	-0.026*	-0.027*	-0.024*	-0.025
	(0.019)	(0.020)	(0.013)	(0.017)	(0.013)	(0.015)	(0.013)	(0.014)	(0.014)	(0.016)
Interaction	0.033**	0.033**	-0.043***	-0.059***	0.058*	-0.007	0.064**	0.120***	0.004	0.011
	(0.016)	(0.017)	(0.013)	(0.015)	(0.032)	(0.046)	(0.027)	(0.030)	(0.013)	(0.016)
Interaction variable	Economically Disadvantaged		White Student		Gifted Student		ESL Student		Special Ed Student	
Observations	94,470	94,497	94,470	94,497	94,470	94,497	94,470	94,497	94,470	94,497
R-squared	0.454	0.430	0.454	0.430	0.454	0.430	0.454	0.430	0.454	0.430

Notes: Each cell of the table presents results for the $fourday_{dt}$ and Interaction term from a separate regression containing the specified dependent variable (listed along the rows of the table), controls for student demographics and program participation, school district characteristics, and kindergarten assessment scores. The Interaction is an interaction term between the listed interaction variable and the $fourday_{dt}$ variable. Robust standard errors, clustered at the school district-level are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2: Mean and SDs for study variables by above and below median scoring groups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Approaches to Learning		Early Math		Letter Names		Letter Sounds	
	Above Median	Below Median	Above Median	Below Median	Above Median	Below Median	Above Median	Below Median
Std. 3rd Grade Math Score	0.20	0.00	0.27	-0.02	0.25	-0.05	0.25	-0.03
	(0.31)	(0.33)	(0.31)	(0.30)	(0.30)	(0.31)	(0.31)	(0.31)
Std. 3rd Grade Read Score	0.21	0.00	0.26	-0.02	0.26	-0.06	0.26	-0.04
	(0.33)	(0.34)	(0.33)	(0.32)	(0.32)	(0.31)	(0.32)	(0.32)
Approaches to Learning Score (out of 5)	4.32	3.07	3.90	3.57	3.90	3.52	3.90	3.54
	(0.40)	(0.55)	(0.74)	(0.79)	(0.74)	(0.78)	(0.74)	(0.79)
Early Math Score (out of 16)	8.89	7.52	11.11	5.93	9.64	6.79	9.68	6.88
	(3.14)	(3.03)	(1.89)	(1.80)	(2.98)	(2.66)	(2.97)	(2.70)
Early Letter Names (out of 100)	22.43	14.43	26.88	11.91	32.30	4.50	30.00	7.93
	(17.21)	(14.98)	(16.96)	(13.03)	(12.04)	(4.68)	(14.74)	(9.93)
Early Letter Sounds (out of 100)	8.95	4.82	11.43	3.37	12.48	1.29	13.98	0.43
	(10.86)	(8.12)	(11.58)	(6.21)	(10.99)	(3.03)	(10.28)	(0.70)
Four-day	0.05	0.05	0.05	0.04	0.04	0.05	0.05	0.04
	(0.21)	(0.21)	(0.21)	(0.20)	(0.21)	(0.21)	(0.22)	(0.20)
Female	0.58	0.40	0.48	0.50	0.52	0.47	0.52	0.47
	(0.49)	(0.49)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
White	0.63	0.60	0.70	0.55	0.72	0.51	0.72	0.52
	(0.48)	(0.49)	(0.46)	(0.50)	(0.45)	(0.50)	(0.45)	(0.50)
Economically Disadvantaged	0.55	0.69	0.49	0.71	0.46	0.77	0.46	0.76
	(0.50)	(0.46)	(0.50)	(0.45)	(0.50)	(0.42)	(0.50)	(0.43)
Special Education	0.08	0.21	0.10	0.18	0.09	0.20	0.09	0.19
	(0.27)	(0.41)	(0.29)	(0.39)	(0.28)	(0.40)	(0.29)	(0.39)
ESL Program Participant	0.06	0.08	0.03	0.10	0.02	0.13	0.02	0.12
	(0.23)	(0.28)	(0.16)	(0.31)	(0.12)	(0.33)	(0.14)	(0.32)
Gifted/Talented Reading	0.02	0.01	0.03	0.00	0.03	0.00	0.03	0.00
	(0.15)	(0.09)	(0.18)	(0.05)	(0.17)	(0.04)	(0.18)	(0.05)
Gifted/Talented Math	0.02	0.01	0.04	0.00	0.03	0.00	0.03	0.00
	(0.15)	(0.09)	(0.18)	(0.05)	(0.17)	(0.04)	(0.18)	(0.05)
Enrollment	456	452	456	453	457	451	455	453
	(148)	(146)	(152)	(143)	(150)	(144)	(153)	(142)
Fraction White	0.61	0.60	0.63	0.58	0.64	0.56	0.64	0.57
	(0.21)	(0.21)	(0.20)	(0.22)	(0.19)	(0.22)	(0.19)	(0.22)
Fraction Free and Reduced Lunch	0.53	0.57	0.49	0.59	0.48	0.62	0.48	0.61
	(0.24)	(0.23)	(0.24)	(0.22)	(0.24)	(0.21)	(0.24)	(0.21)
Rural	0.14	0.15	0.15	0.14	0.15	0.15	0.15	0.14
	(0.35)	(0.35)	(0.36)	(0.35)	(0.35)	(0.35)	(0.36)	(0.35)
Observations	48540	45930	41842	52628	47715	46755	45420	49050

Notes: Table includes means and standard deviations (in parentheses) for scores on 3rd grade math and reading assessments and the five kindergarten readiness assessments, 3rd grade students demographics, 3rd grade program participation, and school district characteristics. The total analytic sample includes 90,897 five-day students and 4,324 four-day students.