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Does Shortening the School Week Impact Student Performance? Evidence from the Four-Day School Week

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Abstract

Public schools face difficult decisions on how to pare budgets. In the current financial environment, school districts employ a variety of policies to close budget gaps and stave off teacher layoffs and furloughs. An increasing number of schools are implementing four-day school weeks hoping to reduce overhead and transportation costs. The four-day-week policy requires substantial schedule changes as schools must increase the length of their school day to meet state-mandated minimum instructional hour requirements. Although some schools have indicated that this policy eases financial pressures, it is unknown whether the restructured schedule has an impact on student outcomes. In this study, we use school-level longitudinal data from the state of Colorado to investigate the relationship between the four-day school week and academic performance among elementary school students. We exploit the temporal and spatial variation in the four-day school week using a difference-in-differences empirical strategy. Our results suggest that student academic achievement has not been hurt by the change in schedule. Instead, the evidence indicates that the adoption a four-day school week shares a positive and often statistically significant relationship with performance in both reading and mathematics; the math results in particular are generally robust to a range of specification checks. These findings have policy relevance to the current U.S. education system, where many school districts must cut costs. The four-day school week is a strategy currently under debate.

"There's no way a switch like that wouldn't negatively affect teaching and learning."

-Tim Callahan, spokesman for the Professional Association of Georgia Educators (*Wall Street Journal*)

"We took our budget savings and plowed it right back into instructional content."

-Riley Ramsey, Webster County, Kentucky school district director of personnel and technology (*TIME Magazine*)

1. Introduction

A surprising number of schools have changed from the traditional Monday through Friday school week to a four-day-week schedule. This policy has been in place for many years in rural school districts in western states such as Colorado and Wyoming and it appears to be spreading, with school districts from Oregon to Missouri to Florida currently considering it.[1] Although there are alternative ways to implement the policy, typically the four school days are lengthened in order to meet state-mandated minimum instructional hour requirements.[2]

The motivation for the schedule change is most often stated as financial, with savings related to transportation and overhead costs. For example, Kentucky's Webster County school district reported substantial savings on transportation, utility, and insurance costs after adopting a Tuesday through Friday schedule (Kingsbury 2008). The shortened week has helped the Peach County, Georgia school district decrease spending on custodial and cafeteria workers in addition to transportation expenditures and utilities (Herring 2010).[3]

This policy change yields a number of implications that should be evaluated to understand the cost/benefit impact of the four-day week. For example, how much does a four-

[1] Newspaper articles from the Tampa Bay Times (December 18, 2011), the NewsPress NOW in St. Joseph, Missouri (December 25, 2011), and the Seattle Times (December 27, 2011) describe the current public discussion of a proposed schedule change.

[2] Generally, no classes are held on Friday; however, a small minority of schools operating on the four-day week take Monday as their day off.

[3] For additional evidence on financial savings, see Blankenship (1984) and Grau and Shaghnessy (1987).

day week actually affect school expenditures? If school buildings and gymnasiums are opened on Fridays to accommodate extra activities (e.g. athletic events), cost savings could be modest.[4] How do teachers react to a four-day schedule, is there less turnover, increased teacher satisfaction? Spillover effects on communities could also be present; teens out of school on Friday might engage more in crime or other risky behaviors.

Finally, and perhaps more critical than the aforementioned issues is the question of the effect on student achievement. How do students fare under the altered schedule? Anecdotally, results and opinions are mixed. Some educators and parent groups complain the shorter week harms students academically (Herring 2010), while others have reported higher grade-point averages and test scores after switching to the shortened week (Toppo 2002; Turner 2010). Some accounts indicate that savings on transportation and utilities costs have been redirected to instructional uses (Kingsbury 2008). Interestingly, the empirical research on the four-day week generally supports the notion that student achievement is not adversely affected by the alternative schedule.[5] This research is entirely descriptive in nature, however, and often consists of case studies focusing on only one or a few school districts. There has been no research on the relationship between the four-day school week and academic performance that incorporates more rigorous controls for potentially confounding factors.

This study estimates the impact of the four-day school week on student achievement using 4th grade reading and 5th grade mathematics test scores from the Colorado Student Assessment Program (CSAP). Over a third of school districts in Colorado have adopted the

[4] If buildings are closed and placed on a weekend cycle, then savings equivalent to a three-day weekend are possible. However, it is often the case that buildings are kept open for extra activities and for staff use (Dam 2006).

[5] Daly and Richburg (1984), Sagness and Salzman (1993), Feaster (2002), Lefly and Penn (2009), and Hewitt and Deny (2011) found little evidence that the four-day week had an impact on test performance. On the other hand, McCoy (1983), Grau and Shaughnessy (1987), and Yarborough and Gilman (2006) found some evidence of higher test scores.

four-day schedule. Our primary empirical strategy is a difference-in-differences estimation that exploits the temporal and spatial variation in the adoption of four-day-week schedules. Our results suggest that student academic achievement has not been compromised by the change in schedule. Instead, the evidence indicates that the adoption of a four-day school week shares a positive and often statistically significant relationship with performance in both reading and mathematics; the math results in particular are generally robust to a range of specification checks.

These findings have clear policy relevance to the current situation in the U.S. education system, where many school districts must find ways to cut costs but, of course, do not want to hamper student achievement. An important caveat is that our results speak only to impacts for smaller and more rural districts; a wider adoption of the policy across more densely populated areas would be required to allow a broader understanding of the effects.

The remainder of this paper is organized as follows: Section 2 provides background information, including a description of the adoption of the four-day week in Colorado, a review of the relevant academic literature, and a brief discussion on the possible advantages and disadvantages of the policy; Section 3 describes the data; Section 4 lays out the empirical strategy; Section 5 discusses the results; Section 6 concludes.

2. Background

2.1 Background of the Four-Day Week

It is reported that school districts in South Dakota in the 1930s were the first to use a four-day-week schedule (Donis-Keller and Silvernail 2009). It was not until the energy crisis of the early 1970s, however, that the shortened school week gained popularity (Ryan 2009). As transportation and utilities costs dramatically increased, schools in Maine, Massachusetts, New Jersey, New Mexico and Washington experimented with the four-day week (Gaines 2008; Donis-Keller and Silvernail 2009).[6] Schools in Colorado began adopting four-day weeks following the legislature's decision in 1985 to alter the minimum school year requirement from 180 days to 1080 hours for secondary schools and 990 hours for elementary schools (Dam 2006).[7] This change allowed schools to meet the minimum instructional hour requirements by increasing the length of their school day and shortening their days per week.

As of 2008, as many as 17 states have school districts operating on a four-day-week schedule (Gaines 2008).[8] The four-day week is currently most prevalent in Colorado, New Mexico, and Wyoming (Dam 2006; Darden 2008). In Colorado, over 60 of the 178 school districts utilize a four-day week.[9] This constitutes over 30% of the school districts in Colorado but only about 3% of the state's student population is covered by the alternative schedule, reflecting the fact that most four-day-week schools are in rural and sparsely populated districts (Lefly and Penn 2009).

A 2010 survey conducted in Colorado by the Department of Education solicited information from school administrators who had applied to either switch their school's schedule to a four-day week or to renew their current four-day-week status. The results are tabulated in

[6] Cimarron School District in New Mexico has the longest history of the four-day-week schedule; they switched to the shortened week in 1973-1974 and have used it consistently since (Feaster 2002).

[7] Although most of the schedule changes occurred after this amendment, some schools were allowed to pilot the four-day week prior to 1985 (Dam 2006).

[8] See Gaines (2008) for a list of these states. In addition, Hawaii recently implemented 17 mandatory "Furlough Fridays" for state public schools and the Peach County district in 2010 was the first in the state of Georgia to switch to the four-day week (Herring 2010).

[9] All four-day schools in Colorado regularly hold school on Tuesday, Wednesday, and Thursday. The majority of these schools conduct no class on Friday, but some choose Monday as their day off (Dam 2006). The change to a four-day week usually occurs at the district level; however, there are a few Colorado districts that have individual schools, but not the entire district, on the shortened week (Lefly and Penn 2009).

Table A1; more than two thirds of the respondents stated that financial savings were a motivation for the altered schedule, with another third citing community support.

2.2 Advantages and Disadvantages of the Four-Day Week

There are a host of possibilities that could allow for a changed weekly schedule to affect student achievement. First, consider how teachers might respond to the changed schedule. It has been conjectured that longer class periods give teachers flexibility to organize particular lessons more effectively and incorporate more varied teaching methodologies (Rice et al. 2002). Yarbrough and Gilman (2006) reported that teachers claimed the four-day week cut out wasted time and forced them to focus their instruction more successfully. Durr (2003) found that teachers actually reported covering more content under the shortened school week. In some districts, the day off is devoted to teacher planning and enhances faculty collaboration (Yarbrough and Gilman 2006). An additional teacher effect could be reduced turnover and absenteeism; teacher turnover has been shown to have an impact on student achievement gains (Ronfeldt et al. 2011). While it is unclear whether the four-day week has reduced turnover, many school districts have reported fewer teacher absences after switching to the alternative schedule (Chamberlain and Plucker 2003). Lastly, a different effect could be that teachers are happy with the four-day weeks, and this leads to higher productivity while on the job. This would be in accordance with the literature from psychology on the relationship between the four-day workweek and employee satisfaction (Baltes et al. 1999).[10]

Although the four-day school week might lead to teacher effects that improve student achievement, potential drawbacks exist. Critics note that teachers could initially face difficulties

[10] It has also been shown that the compressed workweek can lead to decreased employee absenteeism (Pierce et al. 1989).

adapting their lesson plans to the change of schedule (Chamberlain and Plucker 2003). A survey from an Idaho school district indicated that 24% of teachers reported greater stress and fatigue due to the longer school days under the shortened week (Sagness and Salzman 1993).

From the standpoint of the students, a four-day week might lead to better attendance and anecdotal evidence suggests this is the case (Toppo 2002; Kingsbury 2008; Turner 2010). Not surprisingly, higher student attendance has been associated with better performance on standardized tests (Ehrenberg et al. 1991). It has also been reported that students are less distracted, exhibit improved morale, and behave better on the shortened weekly schedule (Koki 1992; Shoemaker 2002; Dam 2006; Donis-Keller and Silvernail 2009). All of these factors have the potential to improve academic performance.[11] In addition, students with long commutes might fare better on a schedule with fewer trips (Ryan 2009).

On the other hand, the four-day school week has potential disadvantages from a student perspective. For example, some worry that it is more difficult for students to retain subject matter when given an extra day off (Gaines 2008). Perhaps the biggest concern is that the longer school day requires extended focus and attention, and this could be especially relevant for younger students (Dam 2006; Gaines 2008; Ryan 2009).[12]

Aside from the possible advantages and disadvantages listed above, there are several reasons why the alternative schedule might actually increase the total amount of instructional time students receive. First, the shortened school week gives parents the opportunity to schedule medical and other necessary appointments on their school's day off instead of on a regular

[11] Sixty-three percent of 4th through 7th graders from the Shelley School District in Idaho reported that they felt they "learned more in school" after their district switched to the four-day school week (Sagness and Salzman 1993).

[12] Some schools have helped elementary students adjust to the longer school days by providing breakfast and serving lunch later in the day (Hazard 1986).

school day (Grau and Shaughnessy 1987). This has the potential to reduce student absenteeism and is particularly important for those who live in rural communities where long travel distances for appointments are common (Richberg and Sjogren 1983; Dam 2006).[13] Second, travel for sporting events results in missed school time for student athletes. The four-day school week alleviates absenteeism in this regard as many schools schedule athletics and other extra-curricular activities on their day off (Dam 2006).[14] This is less relevant for our study, however, because we focus on the academic performance of elementary school students. Lastly, the four-day schedule permits flexibility in the event of weather-related school cancellations; schools can reschedule missed days without increasing the length of the school year (Donis-Keller and Silvernail 2009). This is important for our research because the CSAP tests are administered during the spring. As a result, if school is cancelled due to winter weather, then students will generally make up lost time before taking the standardized tests rather than after.[15]

Although the data used in this study do not allow us to identify the mechanisms through which the changed schedule may affect academic performance, it is useful to delineate the possibilities in the hopes that future research can confirm or reject these hypotheses.

2.3 Relevant Literature on School Schedule Changes

While none of the schedule changes that have been rigorously empirically scrutinized match precisely with the schedule change created by the four-day school week, there are at least three relevant areas of inquiry. First, some research deals with block-scheduling, the reallocation

[13] The same argument applies to teacher absenteeism. Decreases in teacher absenteeism have been reported as a source of financial savings in terms of substitute teacher costs (Grau and Shaughnessy 1987).

[14] This is especially relevant for rural areas because students at these schools are more likely to participate in school-sponsored sports activities than students who attend urban schools (Lippman et al. 1996).

[15] One school district estimated that students were in school approximately one week more per year after switching to the four-day school week (Richburg and Sjogren 1983).

of fixed amounts of classroom time into longer blocks for some subjects. Implemented at the high school level, the block schedule is designed to allow for more variety in instructional formats, encourage more active teaching strategies, decrease disruptions during the school day, and ultimately better prepare students for college work (Rice et al. 2002; Hughes Jr. 2004). This educational policy change is appealing because overall class hours are not increased, so that no new resources are required. However, the evidence is mixed regarding the ability of block scheduling to enhance student performance (Rice et al. 2002; Hughes Jr. 2004).

Second, other research has examined the impacts of year-round schooling.[16] Similar to students on the four-day school week, students at year-round schools are typically expected to receive the same amount of instructional time as students on traditional schedules. This alternative school calendar simply consists of a set number of instructional hours spread over the entire year. While past reviews of the research on year-round schooling are inconclusive (Merino 1983; Cooper et al. 2003), recent work by Graves (2010, 2011) indicates the year-round calendar may have detrimental effects on academic performance.[17]

Lastly, a number of studies have investigated the effects of an overall increase in instructional time (see, e.g., Brown and Saks 1986, 1987; Link and Mulligan 1986; Coates 2003; Marcotte 2007; Marcotte and Hemelt 2008; Bellei 2009).[18] Generally, this research suggests that

[16] Related to research on year-round schooling, others have examined the effects of mandatory summer schooling on subsequent achievement. For example, Matsudaira (2008) uses a regression discontinuity design based on cutoff scores on year-end exams to show small improvements in academic performance for those attending summer classes.

[17] Graves (2010, 2011) specifically focuses on multi-track year-round school calendars. These calendars have the potential to mitigate school overcrowding by serving more students within the same facility than is possible under traditional or single-track year-round calendars.

[18] Along these lines, research has also considered the effects of full-day as opposed to half-day kindergarten (DeCicca 2007; Cannon et al. 2011).

a positive relationship exists between instructional time and academic achievement, and that instructional time is subject to diminishing returns.

3. Data

3.1 Data on Test Scores

We use test score data from the Colorado Student Assessment Program (CSAP) to measure student performance.[19] The CSAP tests are administered each spring and every public school student within specified grades is required to take the exams.[20] The tests are graded based on one of four possible achievement levels: unsatisfactory, partially proficient, proficient, and advanced. Our measures of interest are the percentage of students scoring proficient or advanced in reading and the percentage of students scoring proficient or advanced in mathematics.[21] These measures represent some of the achievement benchmarks used to evaluate school performance under No Child Left Behind (NCLB).

In particular, we focus on 4th grade reading and 5th grade mathematics scores. These data are reported consistently over time and represent the longest time-series of available test scores for Colorado public schools. Currently, students in grades 3 through 10 are required to complete the reading and math assessments; but this was not always the case. In 1997, the reading exam was only taken by students in the 4th grade. For math, the exams were first administered in elementary schools in 2001 to 5th grade students. In addition, because there are many more

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[19] These data are publicly available from the Colorado Department of Education.

[20] Schools are required to administer the tests during the period beginning on the second Monday in March and ending on the third Monday in April. Additional details on the test schedules are available at http://www.cde.state.co.us/cdeassess/co_law.html#Bullet3.

[21] Although not our primary focus, we also consider results for all four possible test outcomes (see Table 6).

elementary schools than middle or high schools, these data are perhaps the most appropriate for examining the causal effects of the four-day week on student achievement. Our final data set consists of a school-level panel for the periods 2000-2010 and 2001-2010 for reading and mathematics, respectively.[22]

Table 1 provides descriptive statistics for the test scores. A comparison of sample averages for schools on four-day-week schedules to those for schools on traditional schedules indicates that schools on the four-day week have lower percentages of 5th graders scoring proficient or advanced in mathematics. The mean percentage of 4th graders scoring proficient or advanced in reading is also slightly lower for schools on the four-day schedule, but this difference is not statistically significant.

Table 2 illustrates test score results for the schools that changed their schedules to the four-day week during our sample period. For the 5th grade math and 4th grade reading samples we observe 14 and 17 schedule changers, respectively. We report means for the percentage of students scoring proficient or advanced for the two years prior to the schedule change, the year in which the schedule change took place, and the two years after the schedule change. Figures 1 and 2 plot the means from Table 2. In addition, these figures also plot means for the schools in our control group (i.e. schools on traditional schedules). We randomly assigned a year of a schedule change to these schools.[23] For both math and reading, test scores appear stable for the control group for the pre- and post-schedule change periods. However, for schools that switched to a four-day week, there is a discrete increase in the percentage of students scoring proficient or

[22] We do not present reading results for the period 1997-2010 because some of the covariates were not available for the late 1990s. However, it should be noted that results from models with school and year fixed effects for the period 1997-2010 are similar to those presented below.

[23] In each figure, a vertical line distinguishes the years before the schedule change from the year of the schedule change and the years after the schedule change.

advanced in math during the year in which the schedule change took place. For reading scores, there also appears to be a discontinuous increase in performance for the four-day-week schools, but this occurs one year after switching schedules.

3.2 Covariates

Table 1 also shows descriptive statistics for the remaining variables used in this paper. The independent variable of interest is the *Four-Day Week* indicator. The Colorado Department of Education provided the majority of information on school schedules and the timing of schedule changes. For the few cases where schedule information was incomplete, we contacted school districts individually to fill in the missing data.

At the county level, we control for the percent living in poverty and population density.[24] Given that four-day-week schedules are implemented primarily for financial reasons in rural areas, these variables are of particular importance.

We also control for several variables measured at the school district level. Instructional expenditures per student are included as a standard input to the education production function.[25] Other district-level controls include the percentage of teachers who are male, the percentage who are white, and the percentage who are Hispanic.[26] These demographic characteristics vary across districts and are likely to be correlated with unobservables that influence academic outcomes.[27]

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[24] More specifically, the poverty measure represents the percentage of people aged 0 to 17 in families living in poverty. This variable was imputed for 2010. The poverty and population density data are from the U.S. Census Bureau.

[25] The literature on the relationship between expenditures and student performance is extensive. For examples, see Hanushek (1986), Dolan and Schmidt (1987), Lopus (1990), and Papke (2005).

[26] All district-level data are from the Colorado Department of Education.

[27] Some research suggests that teacher demographic characteristics such as gender and race directly influence student achievement (Dee 2005; Hoffman and Oreopolous 2009).

Lastly, we control for the following school-level variables: total enrollment, pupil-to-teacher ratio, percentage of students who receive free lunch, percentage of students who are white, and percentage of students who are Hispanic.[28] While the county- and district-level variables control for important time-varying characteristics, the school-level variables perhaps better capture environmental factors that impact test scores and are associated with four-day-week status.

Because the four-day-week schedule is implemented in rural areas and sparsely populated school districts, we base our estimation sample on restrictions to the *Population density* and *Total students* variables. Our control group includes only schools with *Population density* and *Total students* values that are less than the maximum values for these variables for the four-day-week schools. Specifically, we restrict our focus to schools with enrollments not exceeding 1,100 students and that are in counties with less than 300 persons per square mile.[29] We evaluate the sensitivity of our results to alternative sample selection criteria in the robustness checks below.

Table 1 indicates that, despite the sample selection criterion, differences across schools persist. For example, schools on the four-day-week schedule are generally smaller and in poorer areas. The four-day-week schools also have slightly lower student-teacher ratios and somewhat lower percentages of Hispanic students than the traditional schedule schools. Again, because of these differences, we examine the robustness of our results to alternative control group specifications.

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[28] The school-level data are from the National Center for Education Statistics' *Common Core of Data.*

[29] Frontier Academy is the largest four-day-week school with 1,108 students in 2010. Ellicott Elementary is the four-day-week school in the most densely populated county with over 290 persons per square mile in 2010. We also drop observations from schools that have fewer than 5 years of available test score data.

4. Empirical Strategy

A standard difference-in-differences (DD) approach is used to estimate the effect of the four-day school week on student performance. This method allows us to exploit the panel nature of our data by estimating a model that includes school fixed effects and year effects. The baseline estimating equation is:

$$(1) \qquad \%\ Proficient/Advanced_{st} = \beta_0 + \beta_1 Four\text{-}Day\ Week_{st} + \boldsymbol{X_{sdct}\beta_2} + v_s + \omega_t + \varepsilon_{st},$$

where *% Proficient/Advanced* is the percentage of students in a specific grade at school *s* and year *t* who score proficient or advanced in a particular test subject (math or reading).[30] The variable *Four-Day Week* indicates whether a four-day-week schedule was in place in school *s* and year *t*. The coefficient of interest, β_1, represents the marginal effect of switching to a four-day week. Standard errors are adjusted for correlation at the district level (Bertrand et al. 2004).[31]

The vector ***X*** is comprised of the time-varying school (*s*), district (*d*), and county (*c*) characteristics described above. The school fixed effects and year effects are represented by v_s and ω_t, respectively. The school fixed effects control for differences across schools that are time-invariant, while the year effects control for differences across time that are common to all schools.

[30] Marcotte (2007), Marcotte and Hemelt (2008), and Papke (2005) use a similar dependent variable to evaluate student performance at the school level.

[31] Inference is similar when standard errors are adjusted for correlation at the school level.

A potential source of selection bias comes from the possibility that certain types of parents might opt to enroll their child in a four-day-week school. For example, a shortened school week could increase the expense of childcare arrangements, so that this schedule could appeal more to parents who are relatively less burdened by childcare costs.[32] If children from these families perform systematically better (or worse) in school than others, then estimates of the effect of the four-day week on test scores will be biased. The chances of parents moving their children to schools on the four-day week, however, are limited due to the rural location of most four-day-week schools.[33] School selection is also limited by restrictions on within-district transfers. School fixed effects would account for this type of bias for schools that used the four-day-week schedule throughout the sample period.

A second selection bias could result from the fact that school districts choose their schedule. If only schools with financial issues change to a four-day-week schedule, then an observed relationship between the four-day week and test scores might simply reflect the financial situation of the school. School fixed effects would purge our estimates of this type of bias.

School fixed effects cannot account for unobserved time-varying factors that simultaneously influence student performance and the school's choice of schedule. In addition, it is possible a school could switch to a four-day week in response to a downward trend in test scores. To address these issues, we include district-specific time trends in a sensitivity analysis below.

[32] Higher income households, families with a stay-at-home parent, or farm and ranch households may find the four-day-week schedule appealing.

[33] Within our data, we found little evidence that student enrollments increased after schools switched schedules.

5. Results

5.1 Primary Results

Table 3 presents our baseline OLS estimates of the relationship between the four-day school week and the percentage of students scoring proficient or advanced on 5th grade math tests. Each column illustrates results from a separate regression and all models include school-level fixed effects.

These results are striking; even when controlling for county-, district- and school-level differences in socio-economic characteristics, the four-day school week is associated with an increase of over 7 percentage points in the percentage of students scoring proficient or advanced on the math achievement tests, and this result is estimated with precision. This represents roughly a 12 percent increase from the mean test scores for schools on traditional schedules (7.43/63.2 = 0.12).

Table 4 contains the results of similar models estimated using the percentage of students scoring proficient or advanced on 4th grade reading tests. The estimated impact of the four-day week is generally smaller and less precisely estimated, but even when all covariates are included, we still find a positive point estimate of over three percentage points.[34]

In Table 5, we present regression results designed to provide some insight into the dynamic pattern of test scores prior to and following the change to a four-day school week. Specifically, we replace the *Four-Day Week* variable with two lead indicators, an indicator for the year of the schedule change, and three lag indicators. The omitted category is 3+ years before a schedule change occurred. Column (1) shows results for the math scores. The estimated coefficients prior to the policy change are positive, though not statistically significant,

[34] It is fairly common to find stronger effects on math scores than on reading scores; see, for example, Dee and Jacob (2011).

whereas the point estimates post-change are much larger and estimated with precision. These results, to an extent, quell concerns that academic adjustments were made in anticipation of schedule changes. Further analysis of the sensitivity of our baseline results to pre-existing trends is included in the robustness checks below. The results in column (2) provide some evidence that performance in reading goes up after schools switch to a four-day week; although, only the estimates for the final two lags are individually statistically significant at conventional levels. The indicator for the year of the schedule change and the three lag indicators are weakly jointly significant.

Because our results indicate that the percentage of students achieving proficient or advanced scores increases when schedules are changed, it is interesting to consider which group of students accounts for the improvement. As mentioned above, the Colorado Department of Education tabulates student scores according to four possible achievement levels: unsatisfactory, partially proficient, proficient, and advanced. Table 6 shows results of regressions where each achievement level is considered as a separate outcome and is regressed against the policy indicator and the full set of covariates. These results tell an interesting story. For math, we find that the biggest share of the improvement comes from the students formerly classified as partially proficient, this group falls by an estimated 4.6 percentage points following the schedule change. As a result, we see a large and statistically significant increase in the percentage of students scoring at the proficient level. For reading, the only statistically significant results occur in the lowest and the highest categories. The results show that the percentage of students rated unsatisfactory fell by nearly 2.5 percentage points after the schedule change whereas the percentage of students in the advanced category rose by over two percentage points. Of course, this does not necessarily imply that formerly unsatisfactory students are now scoring at the advanced level. It may simply be that the four-day week resulted in a relatively uniform shift upward in test scores across all achievement levels.

5.2 Robustness Checks

We first perform a robustness check based on Luallen (2006). Specifically, we create a placebo *Four-Day Week* indicator using a random number generator based on the uniform distribution. Because 14 schools switched to a four-day week during our sample period for math scores, we assign 14 placebo policies for each trial run. For the reading sample, we assign 17 placebo policies.[35] We run 25 trials for each test score outcome.

Table 7 illustrates the average coefficient estimates for the placebo *Four-Day Week* on the percentage of 5th graders scoring proficient or advanced in mathematics and the percentage of 4th graders scoring proficient or advanced in reading. In both regressions, the average estimate is very small in magnitude. Furthermore, in 25 trials, only one estimate was positive and statistically significant at the 5 percent level for math performance and only two estimates were positive and statistically significant at the 5 percent level for reading performance.[36] These results provide evidence that random assignment of the four-day-week schedule cannot generate our results.

As discussed above, the schools on the four-day-week schedule are different than schools on traditional schedules along several margins. In reality, the four-day week is not a randomly assigned policy. While the inclusion of school fixed effects controls for time-invariant

[35] A year for a schedule change was randomly selected between 2000 and 2010 for the reading test regressions and 2001 and 2010 for the math test regressions.

[36] For math performance, one estimate was negative and statistically significant at the 5 percent level. For reading performance, two estimates were negative and statistically significant at the 5 percent level.

heterogeneity across schools, it is useful to consider a propensity score matching technique used in conjunction with our difference-in-differences estimator.[37] This method essentially amounts to re-estimating equation (1) on a matched sample, a subset of the original sample.[38]

The goal for matching is to find a group among the comparison population (i.e. the schools that remained on the traditional schedule) that looks as similar as possible to the schools that changed schedules.[39] Thus, we predict whether a school switches to a four-day week during our sample period based on observable characteristics from 2001. Table A3 presents the probit results. Consistent with anecdotal evidence, schools with higher transportation expenditures are more likely to switch to a four-day week.

Table 8 illustrates results from the estimation of equation (1) on propensity score matched samples.[40] For math, the estimates are smaller than those shown in Table 3; however, they are still relatively large in magnitude and two of the three estimates are statistically significant at the 5 percent level even though the sample has shrunk by a factor of four. While the estimate for the case where $k = 5$ is positive and substantial in size, it is not statistically significant at conventional levels (p-value = 0.101). For reading, the magnitudes of the estimates are on par with those from Table 4 and two of the three estimates are weakly statistically significant.

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[37] For a practical discussion on propensity score matching, see Becker and Ichino (2002).

[38] For research employing similar methods, see Heckman et al. (1997), Sabia (2006), Gilligan and Hoddinott (2007), and Debaere et al. (2010).

[39] Table A2 presents descriptive statistics for the propensity score matching analysis.

[40] Specifically, we use the *k*-nearest neighbor matching algorithm, an approach where each four-day-week school is matched to multiple schools from the comparison group.[40] We consider values of $k = 25$, $k = 10$, and $k = 5$; the choice of *k* involves a trade-off between reduced variance and increased bias. That is, variance is reduced when a higher value of *k* is chosen because more information is used to construct the counterfactual for each treated unit; but, increased bias results from poorer matches on average (Caliendo and Kopeinig 2005).

For completeness, we perform the following additional robustness checks. The sensitivity analyses for the math results are reported in Table 9. In column (1), the baseline estimate of the fully specified model (see column (5) of Table 3) is reported for comparison. Column (2) of Table 9 reports results from a model where the school fixed effects are replaced with district fixed effects. Not surprisingly, the coefficient estimate on the *Four-Day Week* indicator is larger in magnitude and highly statistically significant.[41]

Column (3) illustrates results where school district-specific linear time trends are added to the right-hand-side of equation (1). The district-specific trends are intended to control for the influence of difficult-to-measure factors at the district level that evolve smoothly over time. Although the coefficient size remains relatively large, it is measured with less precision and is no longer statistically significant at conventional levels.[42] Of course, because this model uses up degrees of freedom, less precision is to be expected.

The results in column (4) come from a regression weighted by the school-level student population.[43] Here, the coefficient estimate remains relatively large in magnitude and is statistically significant at the 5 percent level.

For the results in column (5), we restrict the sample to only schools that were on traditional schedules at the beginning of our sample period. Identification in our difference-in-differences framework comes from the schools that we observe switching schedules.

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[41] As expected, the model with district fixed effects explains less variation in the percentage of students scoring proficient or advanced. This implies that school-level time-invariant unobserved characteristics explain much of the variation in test scores across schools.

[42] Results based on district-specific trends are presented as opposed to results based on school-specific trends because the policy change almost always occurs at the district level. As a result, it is conceivable that unobserved time-varying characteristics that drive the decision to switch to the four-day week are more likely to be district-level factors. However, it is important to note that results are similar when controlling for school-specific linear time trends (coefficient estimate on *Four-Day Week* = 5.95; standard error = 4.33).

[43] Weighted least squares helps to deal with heteroskedasticity that may arise because smaller schools are more likely to see greater swings in their percentage of students scoring proficient of advanced.

Consequently, our results should change little from baseline when excluding schools that enter our sample already on the four-day week. The estimate in column (5) confirms that this is the case.

Finally, we restrict our sample based on the U.S. Census's definition of "rural." While this selection criterion increases our sample size by over 80 percent, the results change little from baseline.[44]

The results from the sensitivity analyses for the reading scores are provided in Table 10. While the reading results are more sensitive than the math results to model specification and sample selection, all coefficient estimates remain positive in sign. With the exception of the column (3) result, the magnitudes of the coefficient estimates remain large. When district-specific trends are added, the estimate becomes much smaller and is not measured precisely.

6. Conclusion

In a time of tough budget situations for most public school systems, a variety of cost-saving measures have been adopted. To relieve financial pressures, a growing number of smaller and more rural school districts are switching from the traditional Monday through Friday school week to a four-day-week schedule. One concern, however, is that student academic performance may be compromised by such a switch. The results presented in this paper illustrate that academic outcomes are not sacrificed under the four-day week; in fact, we provide some evidence that math and reading achievement scores in elementary schools actually improve following the schedule change. The math results in particular are robust to a number of alternative specifications and checks.

[44] According to the Census, a "rural" county has a population density of less than 1,000 persons per square mile (Ricketts et al. 1998). Though not reported for the sake of brevity, it is important to note that results based on specifications with no sample restrictions are similar to the baseline estimates.

Specifically, using data from the Colorado Department of Education, we find that scores on math achievement tests increase by roughly 12 percent after the switch to a four-day-week schedule. The estimated impact of the four-day week on reading achievement is always positive in sign but is generally smaller in magnitude and estimated with less precision. Policy-makers and school administrators will want to take these potential gains in academic performance into consideration when weighing the costs and benefits associated with the four-day school week.

Although we discussed a variety of channels through which the four-day week may impact student performance, our school-level data leaves us silent as to which mechanisms are most important. It will be valuable for future work to determine whether factors such as teaching methods, teacher satisfaction, or student attendance account for improving student achievement.

There are a number of other possible implications of this schedule change that merit examination. In particular, this study looked only at 4^{th} and 5^{th} grade math and reading scores. One might conjecture that this policy change could have an even greater influence on older students. For high school students, four-day school weeks may make it easier to handle part-time jobs. An interesting line of inquiry would be the impact of this alternative schedule on drop-out rates.

Lastly, a key issue for consideration is whether our results generalize to larger and less rural districts. There has been some discussion that the four-day school week would not work as well in more urban areas due to issues concerning the increased demand for child care, special needs students, and delinquency (Fager 1997).

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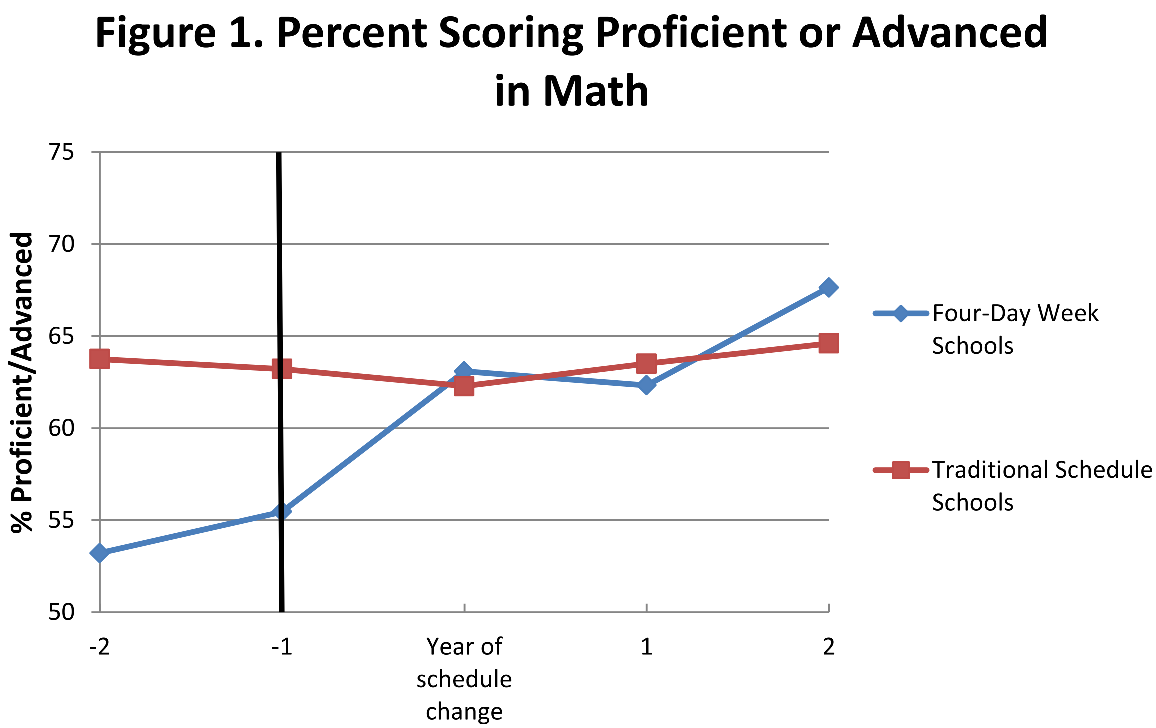
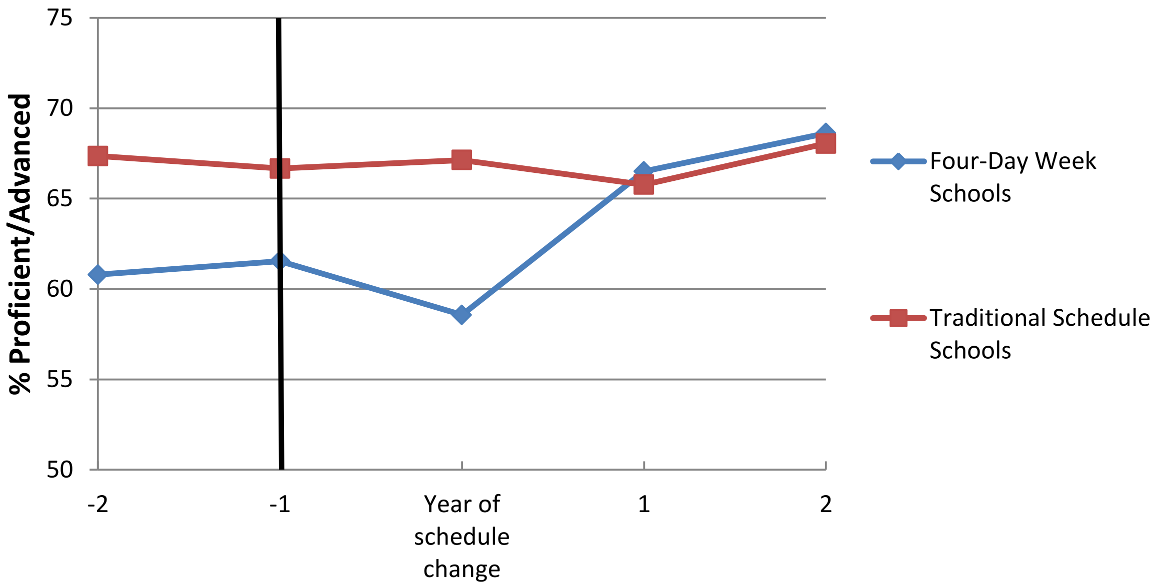


On the horizontal axis, "year of schedule change" represents the year in which schools changed to a four-day week. It was randomly assigned to schools that remained on traditional schedules during the period under study.

Figure 2. Percent Scoring Proficient or Advanced in Reading



On the horizontal axis, "year of schedule change" represents the year in which schools changed to a four-day week. It was randomly assigned to schools that remained on traditional schedules during the period under study.

Table 1: Descriptive Statistics

	(1) Four-day week: 5th grade math sample		(2) Traditional schedule: 5th grade math sample		(3) Four-day week: 4th grade reading sample		(4) Traditional schedule: 4th grade reading sample	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Test scores								
Percent scoring proficient or advanced[a]	60.3	16.8	63.2	17.0	66.1	15.6	66.9	15.5
County-level variables								
Percent poverty [a, b]	18.7	9.81	14.4	6.17	18.5	9.71	14.4	6.11
Population density (per sq. mile)[a, b]	51.2	92.1	122	108	50.1	91.6	120	108
School district-level variables								
Instructional expenditures per student[a, b]	4566	630	4135	501	4575	661	4110	511
Percent of male teachers[a, b]	29.7	9.95	26.4	5.20	29.2	9.21	26.4	5.10
Percent of Hispanic teachers[a]	7.55	15.8	6.46	6.54	7.15	15.2	6.35	6.54
Percent of white teachers[b]	91.4	16.1	90.3	10.7	91.9	15.5	90.5	10.7
School-level variables								
Total students[a, b]	228	156	399	150	225	152	399	149
Pupil-teacher ratio[a, b]	14.2	2.91	16.2	10.2	14.1	2.86	16.3	10.7
Percent free lunch	39.9	21.9	37.3	23.9	39.8	21.0	37.2	23.8
Percent of Hispanic students[a, b]	21.2	22.3	24.8	21.1	20.3	21.3	24.8	21.2
Percent of white students[a, b]	75.4	222	67.7	22.0	76.4	21.2	67.9	22.0
N	282		3759		326		4304	

Notes: [a] Means are statistically different at 5% level for 5th grade math sample. [b] Means are statistically different at 5% level for 4th grade reading sample. Unweighted means for the 5th grade math sample are based on data from 2001-2010. Unweighted means for the 4th grade reading sample are based on data from 2000-2010.

Table 2: Descriptive Statistics for Schedule Changers: Mean Percentages of Students Scoring Proficient or Advanced

	(1) 2 years before change to a four-day week		(2) 1 year before change to a four-day week		(3) Year of change to a four-day week		(4) 1 year after change to a four-day week		(5) 2 years after change to a four-day week	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
5th grade math	53.2	17.4	55.5	19.2	63.1	16.2	62.3	16.8	67.6	14.2
4th grade reading	60.8	15.7	61.5	14.5	58.9	17.4	66.5	16.3	68.6	15.0

Notes: Unweighted means for the 5th grade math sample are based on data from 2001-2010; fourteen schools changed their schedule to a four-day week during this period. Unweighted means for the 4th grade reading sample are based on data from 2000-2010; seventeen schools changed their schedule to a four-day week during this period.

Table 3: Four-Day School Week and Student Performance: Baseline 5th Grade Math Results

	(1) *% Proficient/ Advanced in Math*	(2) *%Proficient/ Advanced in Math*	(3) *% Proficient/ Advanced in Math*	(4) *% Proficient/ Advanced in Math*	(5) *% Proficient/ Advanced in Math*
Four-Day Week	13.15***	7.44***	7.43***	7.22***	7.43***
	(1.48)	(1.68)	(1.77)	(1.70)	(1.72)
N	4041	4041	4041	4041	4041
R^2	0.659	0.707	0.707	0.708	0.711
School FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
County variables	No	No	Yes	Yes	Yes
District variables	No	No	No	Yes	Yes
School variables	No	No	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2. Standard errors, corrected for clustering at the school district level, are in parentheses.

Table 4: Four-Day School Week and Student Performance: Baseline 4th Grade Reading Results

	(1) *% Proficient/ Advanced in Reading*	(2) *%Proficient/ Advanced in Reading*	(3) *% Proficient/ Advanced in Reading*	(4) *% Proficient/ Advanced in Reading*	(5) *% Proficient/ Advanced in Reading*
Four-Day Week	5.96**	3.32	3.64	3.68	3.76*
	(2.54)	(2.49)	(2.47)	(2.42)	(2.24)
N	4630	4630	4630	4630	4630
R^2	0.709	0.726	0.726	0.727	0.733
School FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes	Yes
County variables	No	No	Yes	Yes	Yes
District variables	No	No	No	Yes	Yes
School variables	No	No	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2. Standard errors, corrected for clustering at the school district level, are in parentheses.

Table 5: Four-Day School Week and Student Performance: Policy Timing

	(1) *% Proficient/ Advanced in Math*	(2) *% Proficient/ Advanced in Reading*
2 years before four-day week	1.50	2.06
	(2.50)	(5.54)
1 year before four-day week	4.67	2.58
	(3.68)	(4.19)
Year of schedule change	10.37***	0.602
	(2.52)	(3.26)
1 year after four-day week	7.99***	5.24
	(2.54)	(3.62)
2 years after four-day week	11.62***	8.23**
	(3.87)	(4.16)
3+ years after four-day week	5.78*	5.97*
	(2.94)	(3.22)
N	4041	4630
R^2	0.711	0.733
School FE	Yes	Yes
Year FE	Yes	Yes
County variables	Yes	Yes
District variables	Yes	Yes
School variables	Yes	Yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2. The omitted category is "3+ years before four-day week." Standard errors, corrected for clustering at the school district level, are in parentheses.

Table 6: Four-Day School Week and Student Performance: All Test Score Categories

	(1) *% Unsatisfactory in Math*	(2) *% Partially Proficient in Math*	(3) *% Proficient in Math*	(4) *% Advanced in Math*
Math				
Four-Day Week	-2.48*	-4.61***	3.80**	3.63
	(1.49)	(1.12)	(1.87)	(2.38)
N	4041	4041	4041	4041
R^2	0.593	0.549	0.332	0.693
	(1) *% Unsatisfactory In Reading*	(2) *% Partially Proficient in Reading*	(3) *% Proficient in Reading*	(4) *% Advanced in Reading*
Reading				
Four-Day Week	-2.43*	-0.666	1.63	2.14***
	(1.39)	(1.69)	(1.99)	(0.799)
N	4630	4630	4630	4630
R^2	0.638	0.580	0.651	0.554
School FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
County variables	Yes	Yes	Yes	Yes
District variables	Yes	Yes	Yes	Yes
School variables	Yes	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring in one of the following four indicated categories: unsatisfactory, partially proficient, proficient, advanced. The covariates are listed in Table 2. Standard errors, corrected for clustering at the school district level, are in parentheses.

Table 7: Random Four-Day Week Assignment

	(1) *% Proficient/ Advanced in Math*	(2) *% Proficient/ Advanced in Reading*
Average *Four-Day Week* coefficient estimate	-0.908	0.514
Number of trials	25	25
Number of *Four-Day Week* estimates that were positive and significant at 5% level	1	2
School FE	Yes	Yes
Year FE	Yes	Yes
County variables	Yes	Yes
District variables	Yes	Yes
School variables	Yes	Yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a series of OLS regressions. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2.

Table 8: Four-Day School Week and Student Performance: Matched Samples

	(1) *% Proficient/ Advanced in Math*	(2) *% Proficient/ Advanced in Math*	(3) *% Proficient/ Advanced in Math*
Math			
Four-Day Week	5.32**	5.44**	4.32
	(2.35)	(2.48)	(2.57)
k-nearest neighbors	*k* = 25	*k* = 10	*k* = 5
N	1042	822	569
R^2	0.711	0.713	0.687
	(1) *% Proficient/ Advanced in Reading*	(2) *% Proficient/ Advanced in Reading*	(3) *% Proficient/ Advanced in Reading*
Reading			
Four-Day Week	4.02*	3.60*	2.75
	(2.22)	(2.01)	(1.84)
k-nearest neighbors	*k* = 25	*k* = 10	*k* = 5
N	1129	777	607
R^2	0.704	0.720	0.731
School FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
County variables	Yes	Yes	Yes
District variables	Yes	Yes	Yes
School variables	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2. Standard errors, corrected for clustering at the school district level, are in parentheses.

Table 9: Four-Day School Week and Student Performance: Sensitivity of Math Results

	(1) Baseline results for comparison	(2) Replace school fixed effects with district fixed effects	(3) Add district trends	(4) Weight regression by school size	(5) Restrict sample to schools on traditional schedule at baseline (2001)	(6) Restrict sample based on the Census definition of "rural"
Four-Day Week	7.43***	8.19***	5.10	5.58**	7.33***	7.91***
	(1.72)	(1.38)	(3.77)	(2.27)	(1.79)	(1.78)
N	4041	4041	4041	4041	3807	7335
R^2	0.711	0.586	0.742	0.746	0.720	0.787
School FE	Yes	No	Yes	Yes	Yes	Yes
District FE	No	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County variables	Yes	Yes	Yes	Yes	Yes	Yes
District variables	Yes	Yes	Yes	Yes	Yes	Yes
School variables	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2. Standard errors, corrected for clustering at the school district level, are in parentheses.

Table 10: Four-Day School Week and Student Performance: Sensitivity of Reading Results

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline results for comparison	Replace school fixed effects with district fixed effects	Add district trends	Weight regression by school size	Restrict sample to schools on traditional schedule at baseline (2000)	Restrict sample based on the Census definition of "rural"
Four-Day Week	3.76*	6.18**	1.45	5.84***	3.85*	3.72
	(2.24)	(2.74)	(2.90)	(2.14)	(2.22)	(2.27)
N	4630	4630	4630	4630	4377	8169
R^2	0.733	0.640	0.759	0.773	0.746	0.807
School FE	Yes	No	Yes	Yes	Yes	Yes
District FE	No	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County variables	Yes	Yes	Yes	Yes	Yes	Yes
District variables	Yes	Yes	Yes	Yes	Yes	Yes
School variables	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a separate OLS regression. The dependent variable is equal to the percentage of students within a school scoring proficient or advanced; the covariates are listed in Table 2. Standard errors, corrected for clustering at the school district level, are in parentheses.

Table A1: Reasons for Four-Day School Week Application/Renewal in Colorado

	(1) Financial savings of some form	(2) Community support, parent support, or tradition	(3) Improved attendance	(4) Increased academic performance
Number of school administrator reports	51	26	17	6

Notes: These data are based on 76 school administrator responses from a Colorado Department of Education survey that was conducted in 2010. Of the responses, 10 districts were applying to switch their schedule to a four-day school week and 66 districts were applying to renew their current four-day-week status. The total number of responses sum to greater than 76 because respondents were allowed to list multiple reasons. These data were supplied through correspondence with the Colorado Department of Education.

Table A2: Descriptive Statistics for Propensity Score Analysis

	(1) 5th Grade Math Sample		(2) 4th Grade Reading Sample	
	Mean	Std. Dev.	Mean	Std. Dev.
Dependent variable				
Eventual Four-Day Week	0.050	0.217	0.050	0.217
Independent variables				
Percent poverty (County-level)	13.1	5.39	13.1	5.43
Instructional expenditures per student (District-level)	3911	522	3898	481
Transportation expenditures per student (District-level)	190	86.8	191	97.7
Operational expenditures per student (District-level)	616	142	613	128
Total students (School-level)	337	112	339	109
Pupil-teacher ratio (School-level)	16.1	2.79	16.0	2.61
Percent free lunch (School-level)	36.5	22.2	36.9	22.3
N	303		303	

Notes: Means of the independent variables are based on data from 2001.

Table A3: Probit Models for Propensity Score Analysis

	(1) *Eventual Four-Day Week* (Math Sample)	(2) *Eventual Four-Day Week* (Reading Sample)
Total students (100s)	0.179	0.123
	(0.177)	(0.172)
Pupil-teacher ratio	0.033	0.057
	(0.068)	(0.076)
Percent free lunch	0.003	0.007
	(0.010)	(0.010)
Instructional expenditures per student (100s)	0.054*	0.064**
	(0.029)	(0.029)
Transportation expenditures per student (100s)	0.400**	0.343**
	(0.202)	(0.183)
Operational expenditures per student (100s)	0.000	0.040
	(0.099)	(0.102)
Percent poverty	0.100***	0.085**
	(0.036)	(0.034)
N	303	303

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each column represents the results from a separate probit regression. The variables are listed in Table A1. Standard errors are in parentheses.