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How Do Homeowners, Teachers, and Students Respond to a Four-Day School Week?

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How Do Homeowners, Teachers, and Students Respond to a Four-Day School Week?

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Abstract

Faced with decreasing funds and increasing costs, a growing number of school districts across the United States are switching to four-day school weeks (4DSWs). Although previously used only by rural districts, the policy has begun to gain traction in metropolitan districts. We examine homeowner, teacher, and student outcomes in one of the first metropolitan school districts to adopt the 4DSW. We find 2 to 4 percent home price declines relative to surrounding school districts, a 5 percent decrease in teacher retention for experienced teachers, and a 0.2 to 0.3 standard deviation decrease in student test scores. These results suggest the decision to adopt a 4DSW in a metropolitan setting should not be taken lightly.

Key Words: Education, House prices, Property taxes, Teacher pay, Teacher retention

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1 Introduction

Increases in school spending improve students' educational and economic outcomes. The positive effects are driven by student-to-teacher ratio reductions, additional instruction time, and salary increases that help attract and retain quality teachers (Jackson, Johnson, & Persico, 2016). However, a lack of funds often limits a school district's ability to positively affect student outcomes. The Great Recession exacerbated funding challenges as 29 states provided less total state funding per student in 2015 than in 2008; moreover, because property tax revenues are tied to property values, funding decreases were more pronounced in less-affluent areas that were more likely to have experienced house price declines (Leachman, Masterson, & Figueroa, 2017). Not only did schools have less money to spend, but they also faced increased competition for a lower supply of quality teachers (Sutcher, Darling-Hammond, & Carver-Thomas, 2016). These factors forced school districts to consider alternative non-financial incentives to recruit and retain quality teachers, including, but not limited to, the four-day school week (4DSW).

We examine the effects of a 4DSW on three of the most affected parties: homeowners / parents, teachers, and students. We identify these effects using a differences-in-differences estimation strategy afforded by School District 27J's decision to switch to a 4DSW. School District 27J (hereafter referred to as 27J) is located in the Denver, Colorado metropolitan statistical area.[1] We argue that the novelty, decision-making process, and speed of the adoption generate a quasi-natural experiment. First, although 27J was neither the first school district in Colorado nor the United States to transition from a traditional 5DSW to a 4DSW, it was one of the largest and earliest urban school districts to do so.[2] Second, the

[1]The Denver-Aurora-Lakewood metropolitan statistical area fully encompasses 27J. The Colorado Department of Education assigns 27J, which it also refers to as Brighton 27J, to Adams County, Colorado, for reporting purposes. The internet appendix provides a map of the counties in Colorado and the school districts within Adams County.

[2]87 other school districts in Colorado were already on a 4DSW schedule when 27J officially announced it would switch to a 4DSW in March of 2018. However, 27J's enrollment (∼17,900 students) was over 350 percent higher than the next largest district on a 4DSW when it switched to a 4DSW. 27J's superintendent said the primary benefit of switching to a 4DSW was to "attract and retain teachers" (Robles, 2018).

4DSW was not a voter-approved initiative. Rather, the 27J school board and superintendent decided to switch to a 4DSW only after voters rejected - for the sixth straight time - a mill levy override (i.e., property tax increase) to fund higher salaries for teachers and staff. Third, the decision to switch to a 4DSW occurred over a relatively short time period. The first public discussion of a 4DSW in 27J occurred in December 2017, and the 27J school board officially adopted the 4DSW in March 2018 for the 2018-2019 school year (SY2019).[3] Taken altogether, this chain of events suggests that neither homeowners nor teachers anticipated the change in policy until late 2017 at the earliest.

Previous studies have almost exclusively examined 4DSW effects in rural environments where the 4DSW is more common. The metropolitan setting we examine allows us to provide several new insights into the effects of the 4DSW. First, our study uses a thick residential real estate market that allows us to identify homeowner valuations of the 4DSW. Using transaction-level housing data from Adams County, we find the 4DSW causes 2 to 4 percent price declines relative to surrounding school districts. Second, teacher labor markets are also thicker in metropolitan areas, providing teachers with a greater number of schools in close proximity where they can work. Using administrative teacher-level data from the Colorado Department of Education, we find experienced teachers are 5 percentage points less likely to return - 5.5 percent less likely in relative terms - after the 4DSW. Third, we find student outcome effects that are comparable to those in the previous literature. Using a cohort analysis, we find the 4DSW decreases student performance 0.2 to 0.3 standard deviations on math and language arts standardized exams. In sum, we find 27J's decision to switch to a 4DSW adversely affected house prices, teacher retention, and student learning outcomes in the school district.

This is the first study to identify house price effects caused by a 4DSW policy. The extant literature generally agrees that school factors are a primary determinant of housing

[3]We use the terminal year of a school year to refer to the school year. For example, SY2001 refers to the 2000-2001 school year, and SY2019 refers to the 2018-2019 school year.

demand (Black, 1999; Oates, 1969).[4] We examine the policy's effect on house prices because housing transactions provide immediate market-based value, are a matter of public record, and have important implications for the financing of school districts vis-a-vis property taxes. We find that the adoption of a 4DSW decreases house prices by 2 to 3 percent relative to neighboring school districts in a hedonic model; the relative price decrease is greater (3 to 4 percent) when using repeat-sales near the boundary of the most comparable school district. Although these price declines can result from a number of factors related to the 4DSW, we find childcare costs alone can generate price declines of these magnitudes.

In most cases, the net monetary effect of a policy change cannot be directly estimated since the counterfactual is unavailable. However, we perform a back-of-the-envelope calculation that compares the present value of the homeowners' savings from the rejected mill levy override to the subsequent decrease in house prices caused by the transition to a 4DSW. We estimate that the effect of switching to a 4DSW on house prices was 50 percent greater than the present value of the mill levy override. This calculation, which does not even consider the additional costs of childcare services for homeowners with school-age children, clearly suggests that the homeowners in 27J would have been better off financially (at least in the short term) if they had approved the mill levy override. However, it is unclear if the mill levy override would have been able to attract and retain quality teachers.

We also investigate the effect of the 4DSW on teacher retention. 27J's stated motivation for transitioning to a 4DSW in SY2019 in lieu of increasing salaries was to recruit and retain better teachers - and for good reason. Quality teachers are critical for student achievement and school improvement (Horng, Klasik, & Loeb, 2010) as teachers are the most important school-level factor in student learning (Aaronson, Barrow, & Sander, 2007; Chetty, Friedman, & Rockoff, 2014; Hanushek, 2011; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004), while teacher turnover is financially costly (Barnes, Crowe, & Schaefer, 2007), disruptive to school

[4] Nguyen-Hoang and Yinger (2011) and Black and Machin (2011) provide a thorough review of the literature through 2011. More recent studies include Gibbons, Machin, and Silva (2013), Imberman and Lovenheim (2016), Thompson (2016), and Liu and Smith (2022).

climate, and closely associated with subsequent drops in student achievement (Ronfeldt, Loeb, & Wyckoff, 2013). Although salary and working conditions are the most salient factors in a teacher's decision to return to the same school, research has focused on the role of salary (Nguyen, Pham, Crouch, & Springer, 2020) and its effects on turnover and student outcomes. For example, Hendricks (2014) provides causal evidence that increasing teacher pay reduces teacher turnover, which improves student achievement.[5] Although the research finds that increasing salaries and pecuniary incentives may improve hiring outcomes in difficult-to-staff schools, the monetary incentives are rarely financially sustainable (Cowan & Goldhaber, 2018) and high-poverty schools struggle to fill vacated teaching positions (Kraft, Papay, Wedenoja, & Jones, 2020; Papay & Kraft, 2016).

Despite the importance of teacher pay in recruitment and retention, the National Center for Education Statistics (NCES) estimates the average teacher salary in the United States was 1.3 percent less in SY2018 than SY2000 after adjusting for inflation (U.S. Department of Education, 2019).[6] In Colorado, where this study takes place, the NCES estimates the average teacher salary was 6.3 percent less in SY2018 than SY2000 (U.S. Department of Education, 2019). The declining salaries in Colorado can be tied to provisions in its constitution that vest much of the taxing power with voters.[7] As a result, school districts in Colorado and across the United States are increasingly considering non-financial incentives to recruit and retain teachers (Heubeck, 2022). Therefore, the results of this study can inform education policymakers in an increasingly challenging fiscal environment.

[5]See also Clotfelter, Glennie, Ladd, and Vigdor (2008); Dolton and van der Klaauw (1999); Falch (2011); Feng and Sass (2018); Hanushek, Kain, and Rivkin (2004); Murnane and Olsen (1989); Springer, Swain, and Rodriguez (2016); Swain, Rodriguez, and Springer (2019).

[6]Over the past decade, teachers across the United States were increasingly vocal with their dissatisfaction with their salary. In 2018 alone, just under 400,000 teachers went on strike in Arizona, Colorado, Kentucky, North Carolina, Oklahoma, and West Virginia (Van Damn, 2019).

[7]The Taxpayer Bill of Rights (TABOR), passed in 1992, prohibits any tax increase without a vote of the people. The Gallagher Amendment, passed in 1982, requires a constant ratio between the property tax revenue from residential property and non-residential property in Colorado. As a result of the Gallagher Amendment, the assessment rate for residential property declined by more than two-thirds as Colorado's population grew, and residential real estate values increased. The net effect has been a steep decline in revenues collected from local property taxes, which provided the majority of school funding before the passing of the Gallagher Amendment. Additional information is available on Colorado's Department of Treasury webpage.

2 Four-Day School Week

2.1 Financial Considerations

Historically, the 4DSW has been a practical cost-cutting device, predominantly in rural areas with high per-pupil transportation costs and limited school budgets. See Thompson (2021b) for a comprehensive discussion of the financial pressures faced by rural school districts and their decisions to switch to a 4DSW. The 4DSW postdates the Great Depression of the 1930s with increased adoption occurring during the 1970s as oil prices, associated building operations, and student transportation costs increased. Rural school districts with geographically dispersed student populations that relied more heavily on bus transportation across long distances were early adopters. More recently, an increasing number of districts has switched to a 4DSW, the majority of which adopted the policy for budgetary reasons. Several states now have roughly an equal or greater number of districts running on a 4DSW as a traditional 5DSW (Heyward, 2018).

However, school districts on a 4DSW still represent a relatively small fraction (less than 4 percent) of the roughly 18,300 public school districts in the United States and - because rural districts typically have lower student enrollments - serve an even smaller percentage of the nation's students (Thompson, 2021b). Still, the number of districts on a 4DSW continues to rise and proximity to a district using a 4DSW strongly predicts nearby adoption (Anglum & Park, 2021). Financial challenges resulting from decreased post-Recession school funding at the state level (Leachman et al., 2017), increased competition for a lower supply of quality teachers (Sutcher et al., 2016), statewide teacher walkouts and strikes for better pay (Sainato, 2022), and teachers leaving the profession in the wake of the COVID-19 pandemic (Steiner & Woo, 2021) may force larger, suburban and urban school districts to offer alternative non-financial incentives - such as a 4DSW - to recruit and retain quality teachers. The consequences of enacting policies such as the 4DSW are largely unknown.

Although financial concerns are the most commonly cited motivation for switching to

a 4DSW, sparse evidence exists documenting direct cost savings as a result of the policy change. A study by the Economic Commission of the States found that rural school districts that switched to a 4DSW typically saved between 0.4 percent to 2.5 percent of their annual budget (Griffith, 2011). These figures are similar to spending changes seen in more recent studies at state (Morton, 2021) and national levels (Thompson, 2021a). Research finds that rural school districts that switch to a 4DSW save on utilities, school buses, and long-term building wear and tear (Donis-Keller & Silvernail, 2009). The magnitude of savings has been marginal because educator salaries, which account for, on average, 60 percent of the school budget, are unaffected by the policy change (Griffith, 2011).[8] To wit, 27J expected to save more than one million dollars or just over 1 percent of its annual operating budget by switching to a 4DSW. However, a large portion of the savings would be offset by new initiatives aimed at keeping students connected to the classroom on their days off including laptops and a new comprehensive digital curriculum (Edelman, 2019; Robles, 2018).

2.2 Student Outcomes

The most important and most studied aspect of the 4DSW is its effect on student achievement. Early descriptive studies find little to no negative effect of the policy on student achievement (Daly & Richburg, 1984; Grau & Shaughnessy, 1987; Sagness & Salzman, 1993). More recently, researchers have used a differences-in-differences approach to determine the 4DSW's causal effects on student achievement. Anderson and Walker (2015) examine the policy's effect on student achievement in rural Colorado from 2001-2010, finding that the 4DSW significantly increased school-level test scores for 4th-grade math and 5th-grade reading but only in the first two years following the policy change. Using student-level data for 3rd to 8th graders in Oklahoma from 2005-2016, Morton (2021) cannot reject a null effect of the 4DSW policy on student achievement. In contrast, Thompson (2021b) finds that the 4DSW negatively impacted test scores for 3rd to 8th graders in Oregon from 2007-2019.

[8] See Thompson (2021a) for an in-depth explanation of 4DSW impacts on district budgets and implementation of other cost-cutting strategies just prior to or in tandem with 4DSW adoption.

Thompson (2021b) attributes the drop in student achievement scores in 4DSW schools in Oregon to fewer instructional hours. Importantly, the contrasting results may have been driven by differences in the implementation of the 4DSW as Colorado 4DSW schools, unlike Oregon 4DSW schools, maintained the same number of instructional hours when they adopted the policy.[9] Morton, Thompson, and Kuhfeld (2022)'s recent study of the 4DSW in Colorado, Iowa, Kansas, Montana, North Dakota, and Wyoming also finds negative 4DSW effects on NWEA MAP Growth math and reading scores for 3rd to 8th graders. Interestingly, the authors find that the negative effects of the 4DSW are more pronounced in suburban districts.

Further, the variation in districts' 4DSW implementation is substantial (Thompson, 2021a), and it is unknown how the findings in the burgeoning literature on 4DSWs - more than ninety-nine percent of all districts using a 4DSW in SY2019 were in rural or town geographic designations (Thompson, 2021a) - might generalize to larger, more urban school districts. For instance, recent research by the RAND Corporation provides compelling evidence that the policy is well-received by students, parents, teachers, and school leaders in rural areas (Kilburn et al., 2021). Parent participants in the study, though, noted that the policy might be received unfavorably in urban areas due to contextual factors - e.g., childcare in an urban setting, parents' likely professions, and non-rural labor markets. Furthermore, it remains unknown how homeowners and teachers will respond to a 4DSW when district choice within the metro is possible.

2.3 Additional Outcomes

Several studies have also examined the 4DSW's effect on a wide variety of non-scholastic outcomes. Fischer and Argyle (2018) provide causal evidence of increases in juvenile crime, especially larceny, in rural Colorado as a result of the policy change. Morton (2022) finds

[9]See Anderson and Walker (2015) for a discussion of the conditions offered by a 4DSW that may affect student achievement (e.g., increased professional development, common planning time, decreased student and teacher absences) and Kraft and Novicoff (2022) for a discussion of the roles of instructional time and start time on 4DSW student achievement outcomes.

lower per-student incidents of bullying and fighting in rural schools but no effect on student attendance rates in rural Oklahoma.

Not surprisingly, the policy change also affects employment rates since additional childcare services are required. In particular, Ward (2019) finds decreased employment of mothers in two-parent homes in rural school districts that employ a 4DSW schedule. This latter finding sheds light on one of the biggest concerns associated with the 4DSW: parents having to find a childcare provider for an additional day each week during the school year. This is a concern since it disproportionately affects less affluent families with school-age children that have traditionally relied on the school system not only for five days of childcare services but also for free or reduced-price lunches. This is especially a concern in 27J because approximately 40 percent of the student population qualified for a free or reduced-price lunch leading into the policy's implementation.

2.4 Timing and Structure of the 4DSW in 27J

The history of the 4DSW in 27J is inextricably linked to revenue and expenditures that lagged behind nearly all other districts in Adams County and its inability to raise additional funds through ballot initiatives. For much of the past decade, 27J received less property tax revenue per student than the other school districts in Adams County (Figure 1a). This revenue difference resulted in lower per-student instructional expenses (Figure 1b) and a larger student-to-teacher ratio (Figure 1c) compared to other districts in Adams County.

In November of 2017, voters rejected a $12 million ballot initiative to increase property taxes for the purposes of increasing teacher pay and other materials. It was the sixth straight time voters rejected the district's mill levy override request between 2000 and 2017.[10] In December 2017, the district's superintendent publicly discussed the possibility of a 4DSW for the first time. The idea quickly gained traction, and a series of three public forums were held in early 2018 to discuss the proposal. Less than two months later, 27J formally

[10]Voters previously rejected a mill override in SY2004, SY2006, SY2009, SY2011, and SY2012.

announced its adoption of a 4DSW for the upcoming school year.

Colorado instructional requirements mandate a minimum number of hours, not days, spent in the classroom (Pompelia, 2019). This allows resource-constrained districts like 27J to cut a day from the school week and still comply with the minimum requirements by extending the length of the other four school days.[11] Yet, over the course of an academic year, 27J continued to meet Colorado's 990 instructional hours requirement at the elementary level and 1,080 instructional hours requirement at the secondary level (Pompelia, 2019). To help parents address childcare concerns, the district has offered all-day childcare services on Mondays from 6:30am to 6:00pm. The childcare services cost $30 per day and financial assistance was made available for those that qualified.

3 Data

3.1 Housing

This study uses publicly available housing transaction data from the Adams County Assessor's Office.[12] Given the timing of the 4DSW implementation, housing market volatility during the Great Recession, and COVID-19, we restrict the sample to single-family detached housing transactions between January 1, 2012 and December 31, 2019.[13] We geocode and then assign each property to the appropriate school district in Adams County. Property addresses that were not geocoded are dropped. We also drop records with missing data, abnormal features, outlier transaction prices, and non-arms-length transactions. A complete

[11] Under the new four-day schedule, 27J's elementary school days were extended by 40 minutes (07:50 to 15:30) and its middle and high school days were extended to just over eight hours (08:30 to 16:32) (27J, 2018). Tuesday through Friday were to be school days and Mondays became part of the three-day weekend, meaning five federal holidays would no longer impact instructional time. 27J's schedule is different than the national 4DSW Monday through Thursday schedule employed by approximately 84 percent of districts using the 4DSW in 2019 (Thompson, 2021a)

[12] A small portion (less than 10 percent) of the 27J school district lies just outside Adams County. Thus, a small fraction of the transactions in the cities of Thornton and Commerce City that are associated with 27J are not included in our analysis.

[13] See the Case-Shiller house price index for Denver in Figure A3 of the internet appendix.

list and description of the filters are provided in the appendix. A random sample of 2,000 transactions from the filtered sample is displayed along with the six school districts of interest in Figure 2.[14]

Table 1 displays descriptive statistics for the six school districts in Panel A and a subsample of the two largest school districts (27J and Adams 12) in Panel B. Column 1 displays the variable of interest, Columns 2 to 5 display the minimum, mean, maximum, and standard deviation for each variable, and Column 6 displays the difference between 27J and the other school districts in Adams County. The descriptive statistics in Panel A highlight the fact that houses in 27J were newer, bigger, and more expensive than houses in the rest of the county. Although we can mitigate the effect of these differences using a hedonic model, we also run several specifications that include only houses in 27J and Adams 12. The descriptive statistics in Panel B of Table 1 demonstrate that 27J and Adams 12 were more comparable in terms of transaction price. The quarterly transaction data in Figure 3 further motivates the subsample analysis since the transaction volume for 27J and Adams 12 was much higher than the other four school districts.

3.2 Teachers

We investigate the impact of the 4DSW on the market for teachers in Adams County, CO. The Colorado Department of Education provided restricted-use teacher-level data on 5,833 teachers and 18,130 teacher-year observations for SY2015-SY2020. For each teacher in each year, the data includes teaching experience, school, subject area, full-time equivalence (FTE), master's degree obtainment, and salary. It is important to note that although teaching experience is measured in years, some districts may not give full credit for previous teaching experience for the purposes of the salary schedule.[15]

[14]There are twelve school districts whose attendance boundaries include parcels in Adams County. We only consider the six school districts with a sufficient number of transactions for calculating a quarterly log house price index. Including the six additional rural school districts does not impact our findings.

[15]For example, the Adams 12 Master Agreement states that the district gives no more than 10 years of teaching experience for most newly hired educators.

We restricted our sample to full-time, $FTE \geq 1$, teachers in in-person schools, that are explicitly labeled as elementary, middle, or high schools. We excluded part-time teachers, $FTE < 1$, as the availability of a full-time position elsewhere is more likely than the 4DSW policy to affect their decision to leave their current part-time position. We also excluded online-only schools, preschools, and schools classified by Colorado Department of Education as *Outlying Town* or *Remote*. These final two locale classifications correspond to school districts Bennett 29J and Strasburg 31J, respectively, whose teachers comprised less than 3 percent of teachers. We also removed any full-time teachers who made more than $100,000 or less than $30,000.[16]

Table 2 provides summary statistics for teacher variables. Panel A provides summary statistics for all teachers in our sample. Mean salary was $58,590. Teachers with a master's degree or higher accounted for 0.56 of teacher-year observations, and mean experience was 10.58 years. Panel B provides summary statistics for teachers in 27J. Relative to other teachers in the sample, on average, teachers in 27J earned less, were less likely to have a master's degree, and had fewer years of experience.

3.3 Students

We investigate the effect of the 4DSW on student outcomes in 27J using publicly available Colorado Measures of Academic Success (CMAS) data. We downloaded the CMAS data for SY2016 to SY2019 from the Colorado Department of Education SCHOOLView website. The CMAS assessments are conducted in the latter half of the school year, so they were canceled in SY2020 due to COVID-19. The CMAS test score data is collected at the grade-school level and includes English language arts (ELA) and math subject test scores. Students in grades 3 through 8 take the ELA and math assessments each year.

It is possible that changes in student outcomes after the 4DSW is in place could be driven by changes in the student body and not effects resulting from the 4DSW policy

[16] We believe these to be data-entry errors when comparing the stated salary for the same teacher in different years with otherwise comparable observable attributes.

itself. Figure 1d provides some insight into changes to the student body by plotting each school district's student stability rate from SY2014 to SY2019. The Colorado Department of Education defines the student stability rate as "the percent of students who remained at a district without interruption throughout the school year."[17] Figure 1d indicates that 27J had a relatively high student stability rate, especially around the time of the 4DSW policy change. That said, the student stability rate measures *within* school year movement. It does not capture student movement between school years, which might affect our student outcome results.

To address this concern, we control for changes in student composition within and across the districts and their effect on aggregate student outcomes using several socio-demographic variables. Table 3 reports averages of the school-level socio-demographic variables in Adams County. The data was downloaded from the Colorado Department of Education SCHOOLView website. Columns 2 and 3 of Table 3 report averages for the school districts excluding 27J, whereas columns 4 and 5 report averages for 27J only. Column 6 reports the absolute t-statistic for the differences-in-differences coefficient that compares 27J to the remaining school districts before SY2019 and during SY2019. The t-statistics indicate no systematic change in any socio-demographic characteristics relative to the other school districts in Adams County after the 4DSW is in place. Although aggregate in nature, the relative stability of the differences between 27J and its surrounding districts indicated in Table 3 suggest any estimated effects of the 4DSW on student outcomes are not likely driven by changes in the composition of students in 27J but rather by the effects of the 4DSW policy on existing students.

[17] Additional information about the calculation is provided on the Colorado Department of Education website.

4 Housing Market

4.1 Hedonic Methodology

Housing transactions can provide a market-based valuation of school quality or, in our case, the implementation of a new policy. More importantly, because the market for single-family homes in 27J and Adams County is thick, we can estimate the effect of this policy with reasonable precision. We estimate price effects using a hedonic pricing model. Our most basic specification is given by a differences-in-difference estimator

$$p_{ndt} = x_{nt}\beta + 4\text{DSW}_{nt}\tau + \alpha_d + \delta_t + u_{nt} \tag{1}$$

In Equation 1, p_{ndt} is the log transaction price for house n in district d sold at time t, x_{nt} is a vector of housing characteristic controls, β is a vector of implicit prices for the controls, $4\text{DSW}_{nt} = 1$ if property n is in school district 27J and the 4DSW policy is in effect in 27J at time t and $4\text{DSW}_{nt} = 0$ otherwise, τ is the effect of the 4DSW on house prices, α_d is a district-specific price effect, δ_t is the county-wide price level at time t, and u_{nt} is a term that captures all other price effects and assumed uncorrelated with every other variable in the model.

The variable 4DSW_{nt} is implicitly defined by a cutoff date t^* that determines when the 4DSW is in effect. Because homeowners are forward-looking economic agents and 27J provided information that allowed current and prospective homeowners to update their beliefs about the probability of a 4DSW, we investigate several dates of interest. These dates correspond to the superintendent's initial proposal (December 11, 2017), public feedback forums (January 29, February 7, and February 12, 2018), formal announcement (March 19, 2018), and implementation of the new policy at the start of the following school (August 14, 2018).

The validity of the differences-in-differences estimator relies on a parallel-trends assumption for house prices in 27J and the remaining school districts. This parallel-trends assump-

tion is an assumption about counterfactual house prices in 27J in the absence of the 4DSW policy and is, necessarily, unobserved. However, it is possible to investigate the plausibility of the parallel-trends assumption by comparing price trends for 27J to other school districts in Adams County before the 4DSW. Figure 4 displays separate house price indexes for school districts in Adams County estimated using a hedonic model for 2012 Q1 to 2019 Q4.[18] It is clear from Figure 4 that price dynamics are not homogeneous across the school districts as Adams 12 and 27J exhibit slower rates of growth compared to the other school districts in Adams County.

Figure 4 also indicates that the price dynamics in Adams 12 are very similar to the price dynamics in 27J before the 4DSW. In addition to this graphical evidence, we test for equality between the Adams 12 and 27J house price indexes in Figure 4 using a Wald test. Although we do reject the null hypothesis that all differences between the house price indexes in the two school districts are equal (p-value 0.006), we do not find evidence of a trend as we do not reject the null hypothesis that the average difference from 2012-2014 is equal to the average difference from 2015-2017 (p-value 0.74). The internet appendix presents these results graphically in Figure A4. Based on these test results and the implied plausibility of the parallel trends assumption based on similarity before the 4DSW is put in place, our preferred sample uses Adams 12 as the control group.

4.2 Hedonic Results

Table 4 displays results for $\widehat{\tau}$ the hedonic model in Equation 1. Model 1 uses the district's first public announcement (December 11, 2017) that it was considering a 4DSW as its cutoff date. Model 2 uses the date of the last public feedback forum (February 12, 2018) as its cutoff date. Model 3 uses the official announcement date (March 19, 2018) that 27J would adopt a 4DSW as its cutoff date. Model 4 uses the first day of SY2019 (August 14, 2018) when the policy was implemented as its cutoff date.

[18] For presentation purposes, we only plot the house price index in Figure 4 for 2015 Q1 to 2019 Q4.

The results in Panel A include transactions from all six school districts in Figure 3. The coefficient estimates in Columns 1 to 4 suggest that switching to a 4DSW decreased house prices in 27J between 5.9 percent and 6.1 percent in 27J relative to the five other school districts. The estimates for the first announcement date and the public forum are statistically significant at the 10% level, and the estimates for the official announcement and start of school dates are statistically significant at the 5% level. The results are fairly similar across the first three columns suggesting the choice of cutoff dates does not matter. However, the magnitude of the discount does increase considerably when using the policy's implementation date in Column 4.

As indicated in Figures 3 and 4, Adams 12 appears to be comparable to 27J both in terms of pre-existing price trends and transaction volume. For this reason, the parallel-trends assumptions about house prices in the absence of the 4DSW is most likely to hold when limiting the sample to transactions from Adams 12 and 27J. Coefficient estimates for this subset are reported in Panel B of Table 4. For this subset, the coefficient estimates in Column 3 indicate a more muted response to the 4DSW policy; however, all coefficient estimates are significant at the 1% level. Relative to houses that sold in Adams 12, houses in 27J sold for between 1.8 percent and 2.4 percent less depending on the reference date. In dollar terms, the effect of the 4DSW approximately \$6,525 to \$12,688.[19]

Although Adams 12 and 27J appear comparable in terms of aggregate house prices, these school districts cover a large area, and there may exist heterogeneity in the response to the 4DSW. To mitigate this, we further limit the sample to the subset of properties in either Adams 12 or 27J located within 1 mile of the school district boundary between Adams 12 and 27J. Results from this subset are reported in Panel C of Table 4. The estimated size and significance of the 4DSW on house prices are comparable to the estimates in Panel B.

In addition, despite the the rich set of hedonic controls, it is possible that the set of properties that sell before and after the 4DSW differ along dimensions that are not observed

[19]For simplicity, we use the average transaction price in 27J in 2018 of \$362,536.

in the data set. To eliminate the effect of time-invariant property-specific factors, we further limit the sample to the subset of properties in either Adams 12 or 27J located within 1 mile of their shared school district boundary with two or more transactions. Limiting the sample to this subset of repeat sales allows us to include property-specific fixed effects that control for time-invariant property-specific effects. Results from this subset are reported in Panel D of Table 4. Panel D suggests a slightly larger effect of the 4DSW on house prices compared with Panels B and C. To wit, the effect of the 4DSW on house prices after the school year starts is 4.2% and significant at the 1% level. It is important to point out that limiting the sample reduces the number of observations and including property-specific fixed effects further decreases the degrees of freedom, but all coefficient estimates in Panel D remain statistically significant at the 5% level.

4.3 Childcare and House Prices

The previous section finds that prices decreased in 27J after the district implemented the 4DSW but does not identify which feature of the 4DSW is driving property prices. In this section, we perform a numerical exercise and demonstrate that childcare costs alone can generate the range of price decreases seen in Panels B and C of Table 4. The model uses statutory childcare costs and reasonable demand for childcare services.

Homeowners have per-period utility given by $\log(c_t) + \xi$ where c_t is consumption and ξ is the per-period flow of services from housing. Homeowners purchase the property at $t = 0$ and sell the property at $t = T$. We map prices into per-period housing costs using m as the per-period user-cost of ownership expressed as a fraction of the sale price, p. Given income y_t, consumption is given by $c_t = y_t - mp$. The present discounted utility from living in the home is given by

$$V_0 = \sum_{t=0}^{T} \beta^t [\log(y_t - mp_0) + \xi] \tag{2}$$

When the district adopts a 4DSW, homeowners must pay a per-period childcare cost of a for $t = 0, ..., A$. The parameter A represents the additional number of periods that a homeowner must purchase childcare services. We use reasonable parameter values, statutory childcare costs, and information about Adams County, CO to parameterize the model. We set $\beta = 0.96$, $y_t = 70,199$, $m = 0.06$, $p_0 = 300,688$. Income, y_t, and price, p_0, correspond to their respective 2018 median values in Adams County, CO taken from the American Fact Finder. The annual cost of home ownership is consistent with previous estimates in the literature (Quigley & Raphael, 2004); for robustness, we consider a range of m in our exercise below. For discussion purposes, we set $a = 900$ and $A = 8$. This choice of a corresponds to the approximate annual cost of childcare if the household were to purchase 30 days of childcare at the statutory $30-per-day per-child rate charged by 27J. The length of childcare A assumes a single child requires an additional one day of childcare per week, up to and including grade 8; alternatively, $t = 0$ corresponds to kindergarten.

In equilibrium, the new price of the home, p_{4DSW}, capitalizes this additional cost of childcare. The implicit price, $p^*_{4DSW}(a, A)$, equates the utility of homeownership before and after the 4DSW and is a function of the childcare parameters[20]

$$\sum_{t=0}^{A} \beta^t \log(y_t - mp^*_{4DSW}(a, A) - a) + \sum_{t=A+1}^{T} \beta^t \log(y_t - mp^*_{4DSW}(a, A)) = \sum_{t=0}^{T} \beta^t \log(y_t - mp_0) \tag{3}$$

When this equality is satisfied, homeowners with children are indifferent between a five-day school week and 4DSW policy. Based on the parameters above, $p^*_{4DSW}(a = 900, A = 8) = 294,232$ which implies a price decline of $6,456 or an approximate price decline of 2.1 percent. This price decrease represents the willingness-to-pay for a five-day school week relative to a four-day school week, ceteris parebis.

[20] We suppress the dependence of the price on the remaining parameters in the model as the childcare parameters a and A are of primary interest for this exercise.

Households that have more than one child or require more than 8 years of childcare will have both larger values of a and A. Conversely, households that provide some childcare services themselves or require fewer than 8 years of childcare will have smaller values of a and A. Figure 5 displays the price declines resulting from the 4DSW for various values of m, a, and A. Although the sensitivity of the magnitude of price declines is greater for smaller values of m, the price decreases fall within the range of price declines reported in Panels B and C of Table 4.

This exercise ignores other features that may be capitalized into house prices and therefore reflected in the regression estimates. Specifically, Fischer and Argyle (2018) find that adolescent property crime rates increased when a 4DSW was put in place, yet we assume the flow of services, ξ, remained constant over time. Further, although Ward (2019) finds labor market effects, we include neither an extensive nor intensive household labor supply but assume an inelastic supply of labor. Although these channels are expected to affect property prices, the conclusion from this exercise is that childcare costs alone can account for the range of price declines seen in the data. Nonetheless, we leave quantifying the magnitude of each of these factors for future research.

4.4 Discussion

The justification for switching to a 4DSW should be that it creates not only benefits for homeowners with school-age children but also public benefits for all homeowners within the school district. In other words, if the goal of the policy is to attract and retain teachers in order to improve (or at least) maintain student achievement levels, then all homeowners in the school district should benefit from the policy change (see Hilber and Mayer (2009) for a similar argument). Normally, the net monetary effect of a policy cannot be directly estimated since a counterfactual is unavailable. However, we perform a back-of-the-envelope calculation that compares the present value of the homeowners' savings from the rejected mill levy override to the decrease in house prices resulting from the transition to a 4DSW.

The first alternative that 27J considered was a mill levy override that would have been used to fund higher salaries for teachers in the district. The proposed $12 million mill levy override would have raised property taxes by $73 for every $100,000 of home value (Robles, 2018). In 27J in 2018, the average transaction price was $362,536. The average increase in local property taxes, in real terms, would have been approximately $264.65 per year. Using a discount rate of 3 percent, the present value of the mill levy override in perpetuity is $9,086.36.

We use the repeat-sales estimates in Panel D of Table 4 to calculate absolute house price declines. Using the most conservative coefficient estimate in Panel D, -2.7 percent, and the average transaction price in 27J in 2018, we calculate that the switch to a 4DSW lowered prices by $9,788.47 or $702.11 more than the present value of the mill levy override. However, using the estimated price effect that aligns with the 4DSW implementation, -4.2 percent, we calculate that the switch to a 4DSW lowered prices by $15,226.51 or $6,140.15 more than the present value of the mill levy override. Moreover, Figure 4 suggests a long-term effect, as the price decline remains until the end of the study period. Based on these calculations and assuming the house price effect persists beyond the study period, one could argue that homeowners in 27J would be better off if they had approved the mill levy override.

5 Teacher Retention

5.1 Teacher Retention Methodology

The purpose of the 4DSW was to retain existing teachers and recruit new teachers to the district without increasing wages. Ultimately, the willingness of individual teachers to trade off wages for a 4DSW determines the success or failure of the policy, and it is reasonable to believe that there is significant heterogeneity in these preferences. Nonetheless, we can evaluate the success or failure of the 4DSW in the aggregate.

The teacher recruitment process is best described as a multilateral matching process

between schools and the entire teacher pool. Although modeling and estimating a matching model is possible, the relatively small sample size of our data set precludes estimating any matching models with reasonable precision. We note teacher recruitment is an important part of the 4DSW, but we leave this for future research. However, the teacher retention process is a bilateral decision between only a single school and a single teacher and lends itself to a simple linear-probability model.

For teacher i, teaching subject j, in school s, in year t we estimate a differences-in-differences estimator

$$Return_{idt} = x_{it}\beta + \tau 4\text{DSW}_{dt} + \alpha_s + \mu_{subject(i)} + \delta_t + u_{idst} \tag{4}$$

In Equation 4, $Return_{idt} = 1$ if teacher i teaches in district d in $t+1$ and $Return_{idt} = 0$ otherwise, x_{it} is a vector of teacher-specific variables including annual salary for teacher i at time t, an indicator variable if teacher i has a master's degree in year t, and the number of years of teaching experience for teacher i at time t, $4\text{DSW}_{dt} = 1$ if the teacher is teaching in 27J when the 4DSW is active, $4\text{DSW}_{dt} = 0$ otherwise, and $\alpha_s, \mu_{subject(i)}$ and δ_t are school, subject, and school-year fixed effects, respectively.

District-specific salary schedules could significantly affect the decision to leave one district for another. Teacher salary schedules are seniority-based, weakly increasing in both years of teaching experience and education levels; however, teachers with ten or more years of teaching experience who switch schools would only be credited with ten years of teaching experience for salary purposes. For these reasons, we estimate Equation 4 for the full panel and also for subsets of the data based on teaching experience.

In addition, teacher retention is closely associated with factors including school performance on standardized tests, school level (e.g., elementary, high school), prevalence of disciplinary issues, and school leadership (Nguyen et al., 2020). However, assuming both the district- and school-specific variables and their effects on retention do not change too much

over time, the school-specific fixed effects will control for these effects.

5.2 Teacher Retention Results

Table 5 displays the coefficient estimates for the variables in x and the 4DSW; the subject fixed effects, $\hat{\mu}_{subject(i)}$, are reported in Table A2 in the internet appendix. The first column uses all observations. The control variables have the expected sign: lower-paid teachers, teachers with a master's degree, and teachers with more experience are more likely to leave. The coefficient estimates indicate that switching to a 4DSW decreases the probability that teachers in 27J will return by 3 percentage points. In 27J before the 4DSW, the probability of returning is 0.868 implying the estimated effect of the 4DSW is a decrease in the probability of returning by 3.5 percent.

Panel data allow us to include teacher fixed effects that can control for teacher-specific match quality with their current position. The second column in Table 5 displays results when teacher fixed effects are included. Including these fixed effects indicates that switching to a 4DSW decreases the probability that teachers will return by 4.7 percentage points.

The last three columns in Table 5 investigate if the effects of the 4DSW vary for teachers with different levels of experience. Teachers with less experience will have difficulty moving as they may have difficulty demonstrating their effectiveness, and teachers with more than 10 years of experience may face salary penalties when switching schools. Therefore, we expect the 4DSW to have its largest impact on teachers with a moderate amount of experience. Indeed, the results in Column 4 of Table 5 indicates that teachers in 27J with 5-15 years of experience are 5 percentage points less likely to return.

6 Student Outcomes

6.1 Student Outcomes Methodology

Although not explicitly stated, the ultimate goal of attracting and retaining quality teachers is to improve student outcomes. Accordingly, we examine the effect of 4DSW on student outcomes in 27J relative to surrounding school districts using grade-school-level test score data for the 4 academic years from SY2016 through SY2019. Our baseline analysis estimates student outcomes for ELA and math using the following regression model

$$TestScore_{sgt} = \tau 4\text{DSW}_{st} + \gamma_s + \delta_{gt} + u_{igst} \tag{5}$$

In Equation 5, $TestScore_{sgt}$ is the average ELA or math test score for students in school s in grade g in year t, $4\text{DSW}_{st} = 1$ for schools in 27J when the 4DSW is active, $4\text{DSW}_{st} = 0$ otherwise,, and γ_s and δ_{gt} are school and grade-year fixed effects, respectively. Equation 5 uses the full sample of 1,228 school-grade-year test scores. Consistent with the literature on test scores, we standardize the variable $TestScore_{igt}$ at the grade-year level to have zero-mean and unit standard deviation.[21] We also test for heterogeneous effects of the 4DSW across time (SY2018 and SY2019) and school types (elementary and middle schools). To identify if the effects result from teacher turnover, we include the share of returning teachers to school s in year t, $Return_{st}$, as an additional control.

Importantly, the aggregate data implies that we cannot track individual student performance over time. As students leave elementary schools and combine into one or more middle schools, any time-invariant student-level effects generate correlation in test scores across schools over time. To mitigate the effects of changing student composition across schools and years, we create cohorts at the imputed-birth-year-school level approximating a time-invariant set of students. For example, Brantner Elementary School in located in 27J and includes students in grades 3, 4, and 5. The 2008-Brantner Elementary School cohort

[21] We standardize based on student outcomes from the entire state of Colorado.

corresponds to the set of students with an imputed birth year of 2008 attending Brantner Elementary School in 3rd grade in SY2017, 4th grade in SY2018, and 5th grade in SY2019. This cohort leaves Brantner Elementary after 5th grade where the students mix with other students in middle school. Therefore, in our cohort sample, the 2008-Brantner Elementary School cohort has 3 observations. Our cohort-level analysis estimates student outcomes for ELA and math using the following regression model

$$TestScore_{isgt} = \tau 4\text{DSW}_{st} + \alpha_i + \gamma_s + \delta_{gt} + u_{igst} \tag{6}$$

In Equation 6, $TestScore_{isgt}$ is the ELA or math test score for cohort i in school s in grade g in year t, and α_i, γ_s, and δ_{gt} are cohort, school, and grade-year fixed effects, respectively.

6.2 Student Outcomes Results

Table 6 displays the coefficient estimates for the 4DSW for both ELA and math. The coefficient estimates in Column 1 use observations and indicate that the 4DSW had no effect on ELA but decreased math test scores by 0.186 standard deviations. Given the results in Table 5, it is possible that the decrease in teacher retention resulting from the 4DSW could have led to a decrease in student test scores. To test for this, we include the share of teachers returning to school as a control variable in the second column of Table 6. The estimated effect of the 4DSW is comparable to the estimate in Column 1, indicating that the effect of the 4DSW on teacher retention is not driving the decrease in test scores. It is important to note that the share of returning teachers did not have a statistically significant effect on either ELA or math student outcomes.

The third column in Table 6 uses the full sample and includes cohort-specific fixed effects. The results indicate the policy had negative effects on student outcomes decreasing ELA and math by 0.247 and 0.215 standard deviations, respectively. Although all cohorts can improve

the precision of the estimates, we limit the sample to those cohorts that meet this criteria as these are the only cohorts that directly identify the effect of the 4DSW. For example, the 2008-Brantner Elementary School cohort we describe above is included in the cohort-level analysis as this cohort is at Brantner Elementary School in SY2019; however, the 2007-Brantner Elementary School cohort attends Brantner Elementary School in SY2016, SY2017, and SY2018 and, while attending Brantner Elementary School, is never affected by the 4DSW. Results from the subsample of these cohorts is reported in the fourth column of Table 6. Results from this subsample are comparable to results in the third column and suggest the set of cohorts affected by the 4DSW and those cohorts not affected by the 4DSW are comparable are otherwise comparable.

The fifth and sixth column of Table 6 tests for heterogeneous effects for elementary and middle school students. The coefficient estimates indicate a statistically significant decrease in middle school student ELA and math scores of 0.365 and 0.239 standard deviations, respectively, with no statistically significant effect on elementary school students. We leave explaining this disparity for future research. The sixth column of Table 6 limits the sample to Adams 12 and 27J. The effect of the 4DSW is statistically significant and comparable to the estimates in the third column of Table 6.

7 Conclusion

Over the past decade, decreases in state and local funding in the aftermath of the Great Recession have coincided with an almost tripling of the number of school districts on a 4DSW in the United States. 27J's adoption of the 4DSW may mark a tipping point of this movement into larger, more urban districts. Despite the rapid growth of the 4DSW, no study has examined the policy's effect on market-based measures in a metropolitan region. We show that the 4DSW has a large financial impact on local housing markets. Specifically, we find that house prices near the border of a comparable school district decreased 4 percent in

27J relative to houses on the other side of the border after the 4DSW was implemented. A back-of-the-envelope calculation indicates that this price effect was over 50 percent greater than the present value of the rejected mill levy override.

The stated motivation for 27J's switch to a 4DSW was to attract and retain teachers. However, we find – at least in the short term - that it had the opposite effect on teacher retention. Specifically, we find that experienced teachers were 5 percentage points less likely to return to 27J after the school district switched to a 4DSW. This finding does not necessarily mean that teachers do not value a 4DSW. Instead, it suggests that the teachers that left 27J were unwilling to trade off the higher salaries offered by outside opportunities for the benefits offered by a 4DSW. Finally, we also find that student performance decreased by 0.2 to 0.3 standard deviations on math and language arts standardized exams after 27J implemented the 4DSW. Taken together, the results of this study have important implications for homeowners voting on school funding ballot initiatives and school districts considering the 4DSW.

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Tables and Figures

Table 1: Housing Descriptive Statistics

Variable	Min	Mean	Max	Std Dev	27J Difference
(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All Districts (N=31,321)					
Sale Price	62,000	300,688	800,000	100,148	20,907***
Age	2	28.71	116	20.75	-20.25***
Square feet	450	1,728.07	4,919	607.59	369.80***
Bedrooms	2	3.33	5	0.72	0.11***
Bathrooms	1	2.39	4.5	0.74	0.25***
Panel B: 27J and Adams 12 (N=23,146)					
Sale Price	63,500	320,011	800,000	98,157	-8,954***
Age	2	22.28	116	17.20	-12.97***
Square feet	512	1,873.94	4,919	589.26	186.66***
Bedrooms	2	3.40	5	0.71	0.01
Bathrooms	1	2.57	4.50	0.66	-0.01

*** indicates significance at the 0.01 percent level.

Note: Table 1 presents descriptive statistics for the filtered transaction dataset from January 2012 through May 2019. Panel A presents descriptive statistics for six school districts. Panel B presents descriptive statistics for the 27J and Adams 12 school districts only. The final column in both panels represents the difference between 27J and the remaining school districts in Adams County.

Table 2: Teacher Descriptive Statistics

Variable	Min	Mean	Median	Max	Std Dev
(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All Districts					
Salary ($000s)	30.02	58.59	57.54	99.95	14.59
27J	0.00	0.18	0.00	1.00	0.38
FTE	0.30	0.98	1.00	1.70	0.09
Masters	0.00	0.56	1.00	1.00	0.50
Experience	0.00	10.58	10.00	49.00	8.09
Panel B: 27J					
Salary ($000s)	30.08	53.63	55.17	98.97	12.28
FTE	0.30	0.99	1.00	1.30	0.07
Masters	0.00	0.38	0.00	1.00	0.49
Experience	0.00	9.83	9.00	40.00	7.39

Note: Table 2 presents descriptive statistics for the 18,130 teacher-year observations for the 2015-2016 through 2019-2020 school years. *Salary* is the total salary for a given teacher in a given school year. *27J* is an indicator for teachers teaching in the 27J school district in a given school year. *FTE* is the total FTE for a given teacher in a given school year. *Masters* is an indicator for teachers with a master's degree for a given teacher in a given school year. *Experience* is the total experience for a given teacher in a given school year.

Table 3: Student Descriptive Statistics

	Excluding 27J		27J		
Variable	SY2016-18	SY2019	SY2016-18	SY2019	$\|t\|$
(1)	(2)	(3)	(4)	(5)	(6)
ELA	-0.42	-0.46	-0.32	-0.43	0.47
Math	-0.40	-0.46	-0.14	-0.43	1.13
Percent FRL	64.09	62.68	43.40	40.88	0.44
Percent Asian	3.34	3.46	3.45	3.40	0.72
Percent Black	1.90	1.87	1.76	1.93	0.25
Percent Hispanic	58.04	58.92	46.80	48.60	0.75
Percent White	33.33	32.05	44.11	42.27	1.23

Note: Table 3 presents averages for the districts in Adams County using grade-school-year observations. Column 2 is the average for schools in Adams County in SY2016, SY2017, and SY2018 excluding schools in 27J. Column 3 is the average for schools in Adams County in SY2019 excluding schools in 27J. Column 4 is the average for schools in 27J in SY2016, SY2017, and SY2018. Column 5 is the average for schools in 27J in SY2019. Column 6 is the absolute t-statistic for the differences-in-differences coefficient comparing 27J and the remaining school districts before SY2019 and during SY2019. ELA is the CMAS English language arts score. Math is the CMAS Math score. FRL is the percentage of free-and-reduced-lunch eligible students. Asian, Black, Hispanic, and White are the percentage of Asian, Black, Hispanic, and White students, respectively.

Table 4: Four-Day School Week Announcement Dates

	Model 1	Model 2	Model 3	Model 4
Panel A: All Transactions				
4DSW	-0.059^{*}	-0.060^{*}	-0.060^{**}	-0.061^{**}
	(0.032)	(0.031)	(0.030)	(0.028)
N	31,321	31,321	31,321	31,321
R^2	0.823	0.823	0.823	0.823
Hedonic Controls	✓	✓	✓	✓
Quarterly FE	✓	✓	✓	✓
Panel B: 27J and Adams 12				
4DSW	-0.018^{***}	-0.020^{***}	-0.021^{***}	-0.024^{***}
	(0.003)	(0.003)	(0.003)	(0.003)
N	23,146	23,146	23,146	23,146
R^2	0.810	0.810	0.810	0.810
Hedonic Controls	✓	✓	✓	✓
Quarterly FE	✓	✓	✓	✓
Panel C: 27J and Adams 12 Boundary				
4DSW	-0.021^{***}	-0.023^{***}	-0.023^{***}	-0.028^{***}
	(0.000)	(0.001)	(0.001)	(0.002)
N	8,085	8,085	8,085	8,085
R^2	0.843	0.843	0.843	0.843
Hedonic Controls	✓	✓	✓	✓
Quarterly FE	✓	✓	✓	✓
Panel D: 27J and Adams 12 Boundary Repeat Sales				
4DSW	-0.027^{**}	-0.028^{**}	-0.030^{**}	-0.042^{***}
	(0.009)	(0.009)	(0.009)	(0.009)
N	3,332	3,332	3,332	3,332
R^2	0.962	0.962	0.962	0.962
Property Fixed Effect	✓	✓	✓	✓
Quarterly FE	✓	✓	✓	✓

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Note: Table 4 displays coefficient estimates for various announcement date cutoffs. *Model 1* uses the superintendent's first public announcement that 27J is considering a four-day school week as its cutoff date. *Model 2* uses the last public feedback forum as its cutoff date. *Model 3* uses the official announcement that 27J will adopt a four-day school week as its cutoff date. *Model 4* uses the first day of the 2018-2019 school year (i.e. when the policy was first implemented) as its cutoff date. Panel A includes all transactions in Adams County. Panel B includes only transactions in either the 27J or Adams 12 school districts. Panel C includes only transactions in either the 27J or Adams 12 school districts that are within 1 mile of the border between the two school districts. Panel C includes only transactions in either the 27J or Adams 12 school districts that are within 1 mile of the border between the two school districts where the property has two or more transactions. Standard errors are two-way clustered at the quarter and district levels.

Table 5: Teacher Retention

	Model 1	Model 2	Model 3	Model 4	Model 5
4DSW	-0.030^{**}	-0.047^{**}	-0.004	-0.050^{**}	0.004
	(0.014)	(0.019)	(0.028)	(0.022)	(0.030)
log(Salary)	0.143^{***}	0.025	0.091^{**}	0.108^{***}	0.101^{***}
	(0.019)	(0.031)	(0.044)	(0.030)	(0.035)
Masters	-0.033^{**}	-0.100^{***}	-0.108^{***}	-0.070^{**}	-0.063
	(0.016)	(0.035)	(0.039)	(0.032)	(0.064)
Experience	-0.003^{***}	-0.001	-0.000	0.003	-0.016^{***}
	(0.001)	(0.005)	(0.009)	(0.003)	(0.003)
Masters × Experience	0.002^{*}	0.011^{***}	0.024	0.005^{*}	0.004
	(0.001)	(0.004)	(0.015)	(0.003)	(0.003)
Avg. Return 27J	0.868	0.868	0.833	0.883	0.886
Experience	All	All	<5	5 to 15	>15
N	12,181	12,181	2,807	5,748	3,626
R^2	0.035	0.629	0.058	0.048	0.099
Subject FE	16	16	16	16	16
Year FE	4	4	4	4	4
School FE	74	74	73	73	74
Teacher FE		3,554			

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Note: Table 5 displays regression results for Equation 4. Models 1 and 3 include all teachers. Model 3 includes only teachers with less than 5 years of experience, Model 4 includes only teachers with more than 5 but fewer than 15 years of experience, and Model 5 includes only teachers with more than 15 years of experience. Model 2 includes teacher-specific fixed effects. *log(Salary)* is log salary for the teacher. *Masters* is an indicator for teachers with a master's degree for a given teacher in a given school year. *Experience* is the total experience for a given teacher in a given school year. $4DSW$ is an indicator for the active 4DSW policy. All standard errors are two-way clustered at the teacher and district levels.

Table 6: Student Test Scores

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: English Language Arts						
4DSW	−0.090	−0.088	−0.247**	−0.246**		−0.250**
	(0.082)	(0.082)	(0.116)	(0.115)		(0.121)
Return		−0.103	0.331	0.100	0.121	0.410
		(0.211)	(0.251)	(0.331)	(0.332)	(0.475)
4DSW, Elementary					−0.203	
					(0.146)	
4DSW, Middle School					−0.365**	
					(0.157)	
N	1,223	1,223	1,223	587	587	316
R^2	0.729	0.729	0.886	0.864	0.864	0.905
Grade-Year FE	24	24	24	17	17	17
School FE	97	97	97	93	93	57
Cohort FE			591	218	218	122
Panel B: Math						
4DSW	−0.186***	−0.182***	−0.215*	−0.224*		−0.328**
	(0.048)	(0.048)	(0.121)	(0.122)		(0.131)
Return		−0.225	0.404*	0.565*	0.567*	0.584
		(0.184)	(0.243)	(0.304)	(0.306)	(0.368)
4DSW, Elementary					−0.218	
					(0.164)	
4DSW, Middle School					−0.239**	
					(0.096)	
N	1,223	1,223	1,223	587	587	316
R^2	0.722	0.722	0.887	0.861	0.861	0.906
Grade-Year FE	24	24	24	17	17	17
School FE	97	97	97	93	93	57
Cohort FE			591	218	218	122

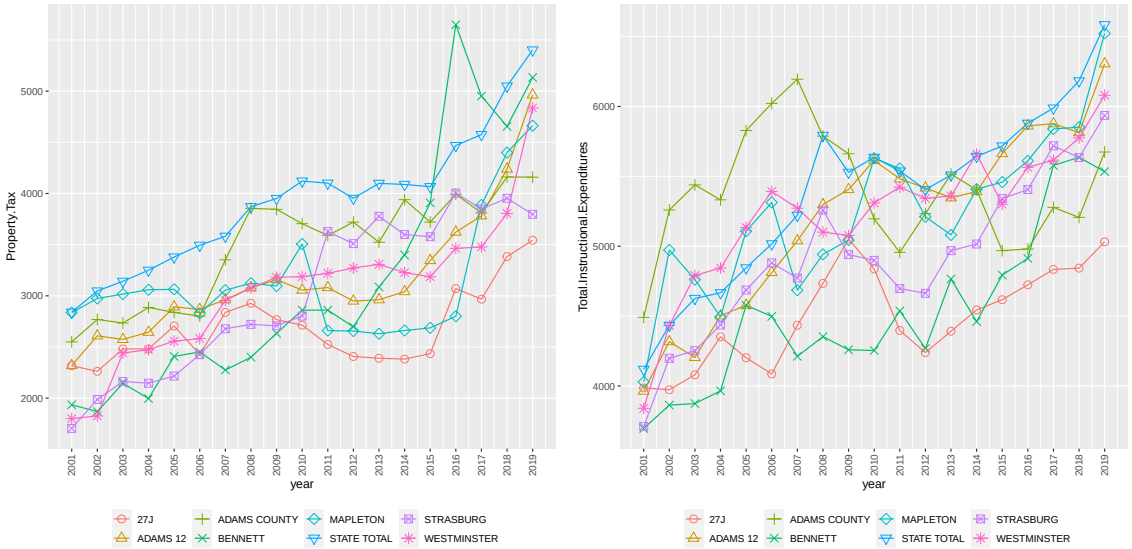
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Note: Table 6 displays regression results for Equations 5 and 6. All models use grade-year observations for grades 3-8 for schools in Adams County. Models 1-3 use all grade-year observations. Models 4-6 use only the observations where the cohort has both a grade-year observation before SY2019 and an observation during SY2019. Model 6 uses only schools in either Adams 12 Five Star or 27J school districts. $4DSW$ is an indicator for the active 4DSW policy, *Return* is the share of returning teachers at the school level, $4DSW$, *Elementary* is an indicator for the active 4DSW policy in a 27J elementary school, and $4DSW$, *Middle School* is an indicator for the active 4DSW policy in a 27J middle school. All standard errors are two-way clustered at the cohort and school levels.

Figure 1: Adams County School District Comparisons

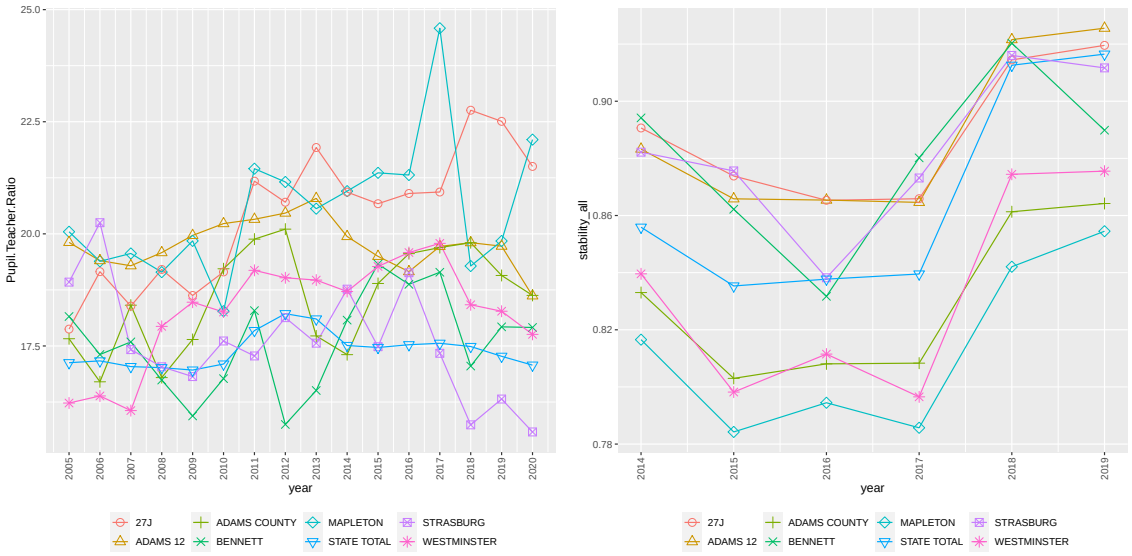
(a) Tax Revenue

(b) Expenditures



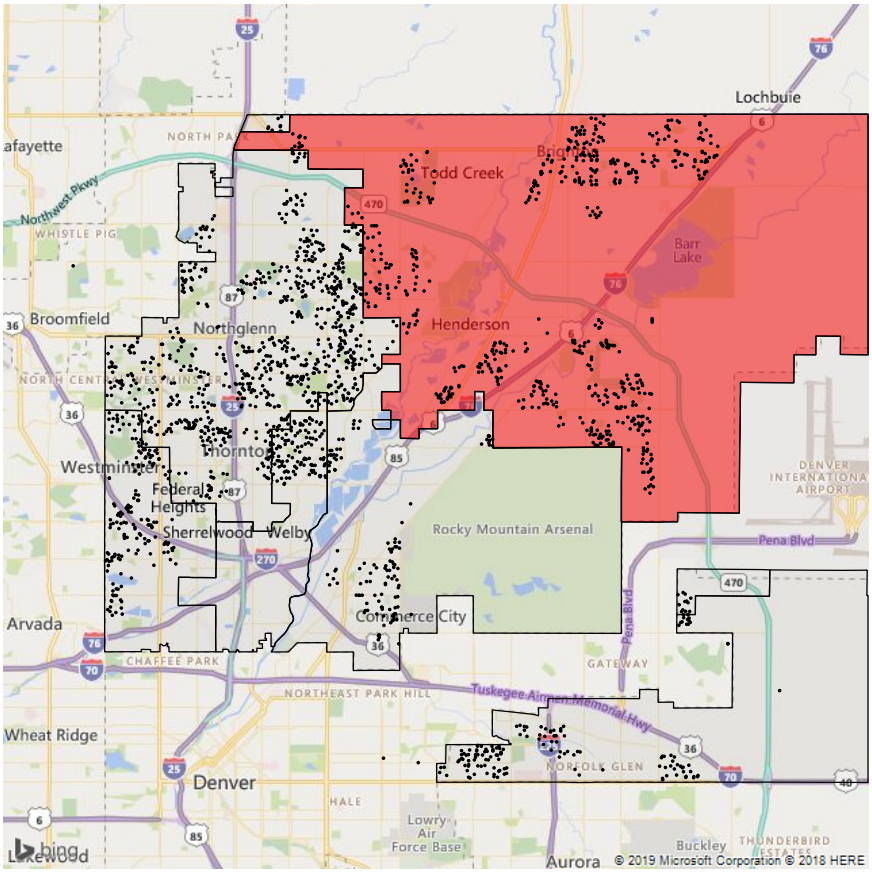
(c) Teacher-to-Student Ratio

(d) Student Stability



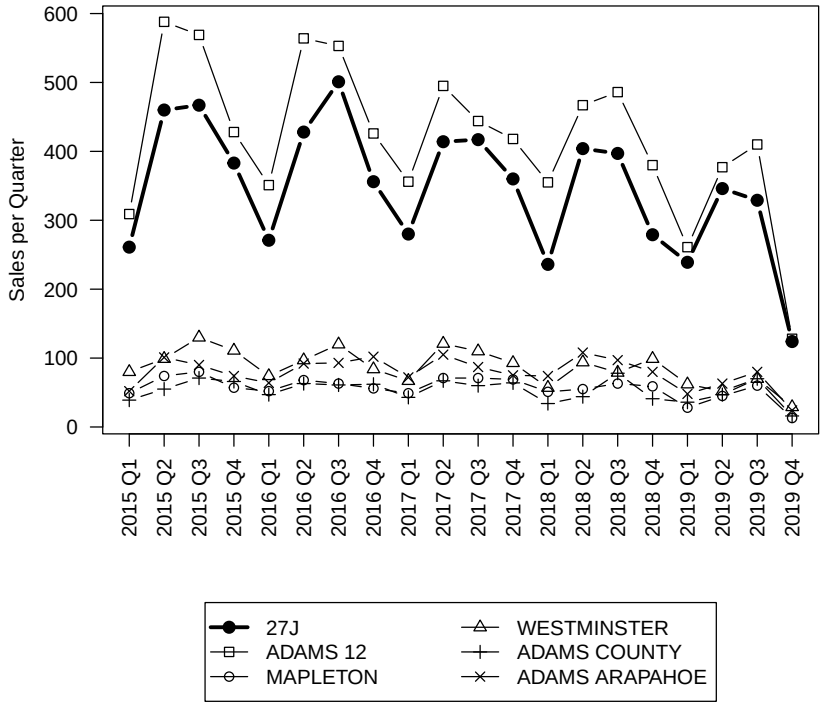
Note: Figure 1a displays property tax per FTE by school district for SY2001 through SY2019. Figure 1b displays total instructional expenditures per FTE by school district for SY2001 through SY2019. Figure 1c displays teacher-to-student ratios by school district for SY2001 through SY2019. Figure 1d displays student stability rates by school district for SY2014 through SY2019.

Figure 2: School Districts and Single-Family Homes in Adams County



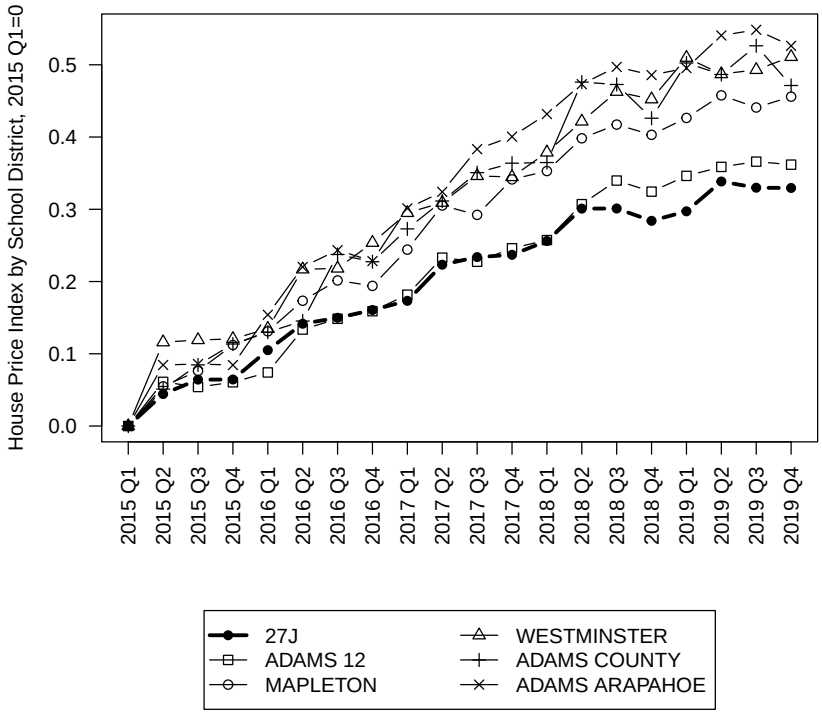
Note: Figure 2 displays the location of a random sample of 2,000 parcels and school district boundaries for six metropolitan school districts (Adams 12, Adams County 14, Bennett 29J, Brighton 27J [shaded in red], Mapleton 1, and Westminster 50) in Adams County, Colorado. Figure 2 only displays school districts with a sufficient number of transactions for calculating a quarterly log house price index. See Figure A2 in the internet appendix for a comprehensive review of the school districts whose attendance boundaries include parcels in Adams County.

Figure 3: Transactions by Quarter for School Districts in Adams County



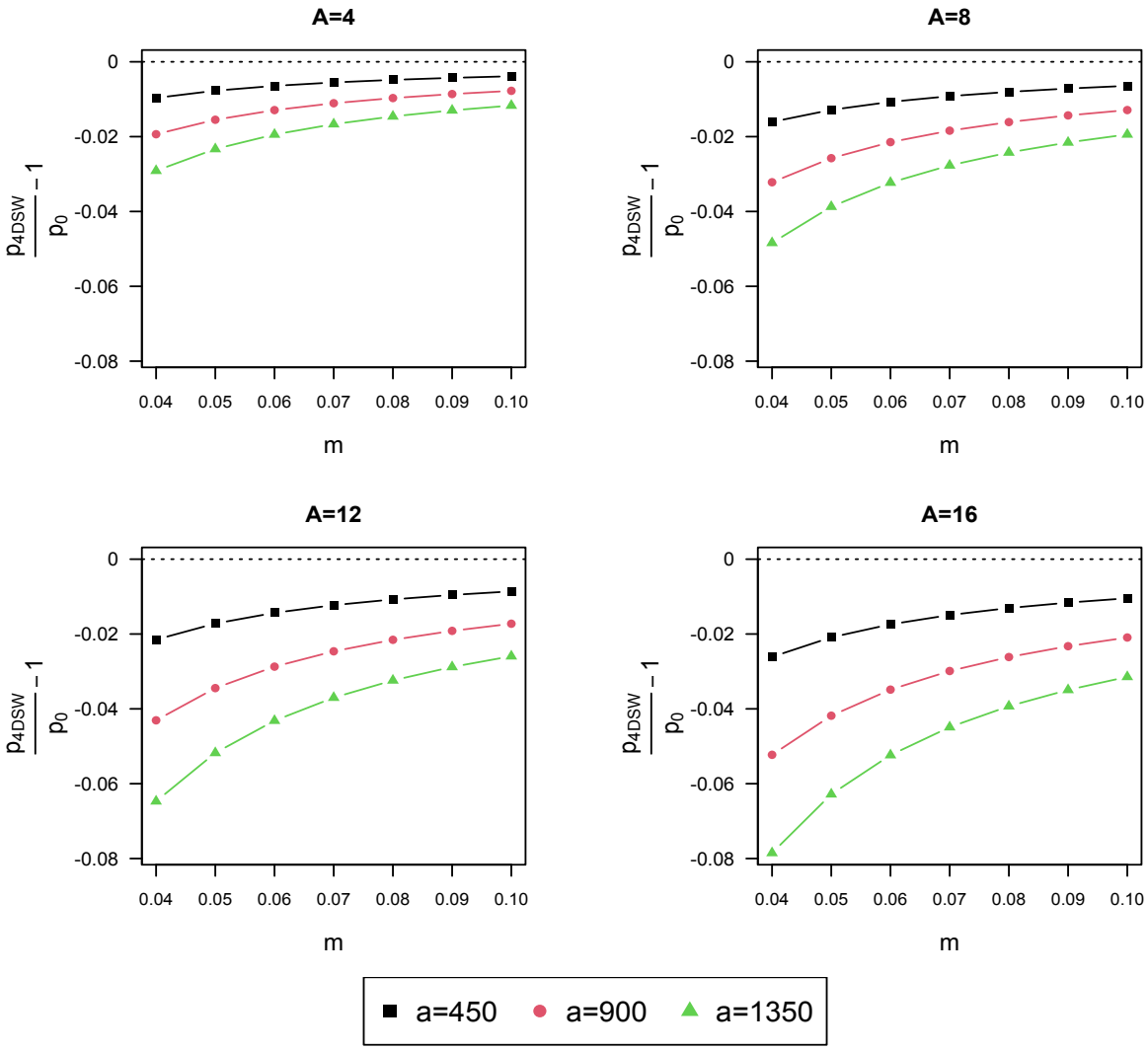
Note: Figure 3 plots the number of single-family housing transactions by quarter for each of the six school districts in Adams County, Colorado from 2012 Q1 to 2019 Q1. The set of school districts displayed in Figure 3 is limited to the number of school districts with a sufficient number of transactions for calculating a quarterly log house price index.

Figure 4: Quarterly House Price Index for School Districts in Adams County



Note: Figure 4 displays the quarterly log house price index for each of the six school districts in Adams County, Colorado from 2015 Q1 to 2018 Q4. The index is calculated using a hedonic price index. The set of school districts displayed in Figure 4 is limited to the number of school districts with a sufficient number of transactions for calculating a quarterly log house price index.

Figure 5: Childcare and Price Effects



Note: Figure 5 displays the price discount associated with the 4DSW that makes homeowners indifferent between the 4DSW and the five-day school week. Homeowners have median income, and the price of the home under the five-day school week is the median price in 2018. The parameter a is the per-child per-year cost of childcare, and the parameter A is the number of years the childcare is purchased. The user cost is the cost of owning the home as a fraction of the price.

Contents

A Internet Appendix

A.1 Filters

The transaction data used in this study is publicly available on the Adams County Tax Assessor website. The table below provides a description of each filter used to clean the transaction data along with the number of observations remaining after the filter was employed. The code used to create the tables and figures will be posted after the paper has been accepted for publication.

Criteria	N
All transactions from 2012-2019	96,930
Single family houses only	84,000
Drop records with missing data	53,029
Price ge 1k and le 800k	50,934
Owner-occupied purchases only	48,036
Lot size le 5 acres	46,795
Age greater than or equal to 2	38,505
Warranty deeds only	33,541
Levenstein sim criteria	32,993
Bedrooms: 1 to 5	32,670
Bathrooms: 1 to 5	32,580
Hvactype: cool air, electric baseboard, furnace, forced air	32,034
Exterior: brick veneer, masonry veneer, siding, stucco	31,514
Stories: 1, 2	31,495
Remodeled: 0, 1	31,495
Absolute, standardized residuals less than 6	31,321

A.2 Hedonic Coefficients

Table A1: Hedonic Coefficient Estimates

	Model 1	Model 3
log(sqft)	0.488***	0.502***
	(0.031)	(0.041)
bed-3	−0.056***	−0.061***
	(0.011)	(0.014)
bed-4	−0.061***	−0.061***
	(0.009)	(0.004)
bed-5	−0.041***	−0.042***
	(0.014)	(0.004)
bath-1.5	0.101***	0.085***
	(0.018)	(0.024)
bath-2	0.131***	0.105***
	(0.017)	(0.024)
bath-2.5	0.235***	0.189***
	(0.023)	(0.015)
bath-3	0.250***	0.200***
	(0.022)	(0.025)
bath-3.5	0.319***	0.265***
	(0.029)	(0.007)
bath-4	0.333***	0.275***
	(0.031)	(0.006)
bath-4.5	0.429***	0.375***
	(0.049)	(0.031)
hvac-electric baseboard	−0.096***	−0.112***
	(0.014)	(0.015)
hvac-furnace	−0.115***	−0.080**
	(0.027)	(0.033)
hvac-forced air	−0.034***	−0.026
	(0.011)	(0.017)
exterior-masonry veneer	−0.372***	−0.392***
	(0.031)	(0.007)
exterior-siding	−0.358***	−0.350***
	(0.024)	(0.007)
exterior-stucco	−0.295***	−0.295***
	(0.035)	(0.027)
stories-2	−0.075***	−0.094***
	(0.023)	(0.035)
remodeled	0.031***	0.021***
	(0.010)	(0.006)

Note: Table A1 displays the coefficients estimates for the control variables used in the hedonic models. *Model 1* includes all transactions in Adams County. *Model 3* includes only transactions in either the 27J or Adams 12 school districts.

A.3 Teacher Retention Controls

Table A2: Teacher Retention and the 4DSW, Controls

	Model 1	Model 2	Model 3	Model 4	Model 5
coreagricultute	−0.220		−0.158		
	(0.166)		(0.160)		
coreart	0.068**		0.165**	−0.035	0.147**
	(0.033)		(0.070)	(0.036)	(0.061)
corebusiness	0.076**		0.162**	−0.013	0.151***
	(0.031)		(0.070)	(0.033)	(0.055)
corecoas	0.041		0.079	−0.035	0.114*
	(0.039)		(0.060)	(0.046)	(0.065)
coreCOREC	0.161***		−0.115**	0.084**	0.367***
	(0.048)		(0.053)	(0.037)	(0.058)
coreelementary	0.059*		0.109*	−0.023	0.149***
	(0.032)		(0.059)	(0.034)	(0.052)
coreenglish	0.043		0.066	−0.050	0.156***
	(0.035)		(0.061)	(0.040)	(0.051)
coreFACS	−0.017		0.066	−0.051	0.069
	(0.032)		(0.092)	(0.065)	(0.059)
corehealth	0.061**		−0.771***	0.053	−0.100*
	(0.028)		(0.044)	(0.035)	(0.051)
coreIT	0.135***		0.227***	0.097***	0.240***
	(0.035)		(0.051)	(0.035)	(0.063)
coremath	0.041		0.060	−0.052	0.175***
	(0.034)		(0.061)	(0.033)	(0.051)
coremusic	0.071*		0.077	−0.005	0.183***
	(0.039)		(0.075)	(0.042)	(0.055)
corePE	0.062**		0.101	−0.027	0.151***
	(0.030)		(0.071)	(0.040)	(0.050)
corepre school	0.191***		0.166***		
	(0.031)		(0.061)		
corescience	0.069**		0.106*	0.004	0.131**
	(0.034)		(0.060)	(0.033)	(0.053)
coresocial	0.081**		0.161***	−0.009	0.148***
	(0.034)		(0.057)	(0.031)	(0.053)
coresped	0.077**		0.126**	−0.011	0.194***
	(0.030)		(0.055)	(0.033)	(0.055)
coretech	0.045		−0.015	−0.051	0.130**
	(0.037)		(0.196)	(0.059)	(0.052)
N	12181	12181	2807	5748	3626
R^2	0.035	0.629	0.058	0.048	0.099
Year FE	4	4	4	4	4
School FE	74	74	73	73	74
Identifier FE		3554			

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Note: Table A2 displays regression results for Equation 4. Models 1 and 3 include all teachers. Model 3 includes only teachers with less than 5 years of experience, Model 4 includes only teachers with more than 5 but fewer than 15 years of experience, and Model 5 includes only teachers with more than 15 years of experience. Model 2 includes teacher fixed effects. All standard errors are two-way clustered at the teacher and district levels.

A.4 Student Outcome Heterogeneity

Table A3: Student Test Scores FRL

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: English Language Arts						
4DSW	−0.090	−0.088	−0.247**	−0.246**		−0.250**
	(0.082)	(0.082)	(0.116)	(0.115)		(0.121)
Return		−0.103	0.331	0.100	0.121	0.410
		(0.211)	(0.251)	(0.331)	(0.332)	(0.475)
4DSW, Elementary					−0.203	
					(0.146)	
4DSW, Middle School					−0.365**	
					(0.157)	
Num. obs.	1,223	1,223	1,223	587	587	316
R^2	0.729	0.729	0.886	0.864	0.864	0.905
Grade-Year FE	24	24	24	17	17	17
School FE	97	97	97	93	93	57
Cohort FE			591	218	218	122
Panel B: Math						
4DSW	−0.186***	−0.182***	−0.215*	−0.224*		−0.328**
	(0.048)	(0.048)	(0.121)	(0.122)		(0.131)
Return		−0.225	0.404*	0.565*	0.567*	0.584
		(0.184)	(0.243)	(0.304)	(0.306)	(0.368)
4DSW, Elementary					−0.218	
					(0.164)	
4DSW, Middle School					−0.239**	
					(0.096)	
N	1,223	1,223	1,223	587	587	316
R^2	0.722	0.722	0.887	0.861	0.861	0.906
Grade-Year FE	24	24	24	17	17	17
School FE	97	97	97	93	93	57
Cohort FE			591	218	218	122

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Note: Table A4 displays regression results for Equations 5 and 6 using only students who are eligible for free-and-reduced-lunch. All models use grade-year observations for grades 3-8 for schools in Adams County. Models 1-3 use all grade-year observations. Models 4-6 use only the observations where the cohort has both a grade-year observation before SY2019 and an observation during SY2019. Model 6 uses only schools in either Adams 12 Five Star or 27J school districts. $4DSW$ is an indicator for the active 4DSW policy, *Return* is the share of returning teachers at the school level, $4DSW$, *Elementary* is an indicator for the active 4DSW policy in an elementary school, and $4DSW$, *Middle School* is an indicator for the active 4DSW policy in a middle school. All standard errors are two-way clustered at the cohort and school levels.

Table A4: Student Test Scores Non-FRL

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: English Language Arts						
4DSW	−0.093	−0.096	−0.155	−0.159		−0.149
	(0.109)	(0.109)	(0.113)	(0.114)		(0.113)
Return		0.209	0.431	0.411	0.438	−0.407
		(0.279)	(0.290)	(0.359)	(0.360)	(0.332)
4DSW, Elementary					−0.097	
					(0.142)	
4DSW, Middle School					−0.325**	
					(0.147)	
N	1,228	1,228	1,228	596	596	313
R^2	0.712	0.713	0.891	0.872	0.872	0.913
Grade-Year FE	24	24	24	17	17	17
School FE	97	97	97	93	92	56
Cohort FE			590	219	219	121
Panel B: Math						
4DSW	−0.214**	−0.215**	−0.302**	−0.321**		−0.401***
	(0.090)	(0.091)	(0.128)	(0.130)		(0.135)
Return		0.056	0.415	0.834**	0.843**	0.149
		(0.235)	(0.276)	(0.345)	(0.349)	(0.402)
4DSW, Elementary					−0.299*	
					(0.174)	
4DSW, Middle School					−0.378***	
					(0.107)	
N	1,228	1,228	1,228	596	596	313
R^2	0.749	0.749	0.887	0.867	0.867	0.903
Grade-Year FE	24	24	24	17	17	17
School FE	97	97	97	92	92	56
Cohort FE			590	219	219	121

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Note: Table A4 displays regression results for Equations 5 and 6 using only students who are not eligible for free-and-reduced-lunch. All models use grade-year observations for grades 3-8 for schools in Adams County. Models 1-3 use all grade-year observations. Models 4-6 use only the observations where the cohort has both a grade-year observation before SY2019 and an observation during SY2019. Model 6 uses only schools in either Adams 12 Five Star or 27J school districts. $4DSW$ is an indicator for the active 4DSW policy, *Return* is the share of returning teachers at the school level, $4DSW$, *Elementary* is an indicator for the active 4DSW policy in an elementary school, and $4DSW$, *Middle School* is an indicator for the active 4DSW policy in a middle school. All standard errors are two-way clustered at the cohort and school levels.

A.5 Miscellaneous

Adams County is shaded blue on a map of Colorado in Figure A1, thereby highlighting its proximity to the city of Denver. Adams County includes a portion of twelve different school districts. Figure A2 displays the school district boundaries for each of the twelve districts. Only seven of the twelve school districts are directly assigned to Adams County. The remaining five school districts are assigned to either Arapahoe County or Weld County.

Adams County

- Adams 12
- Adams County 14
- Bennett 29J
- Brighton 27J
- Mapleton 1
- Strasburg 31J
- Westminster 50

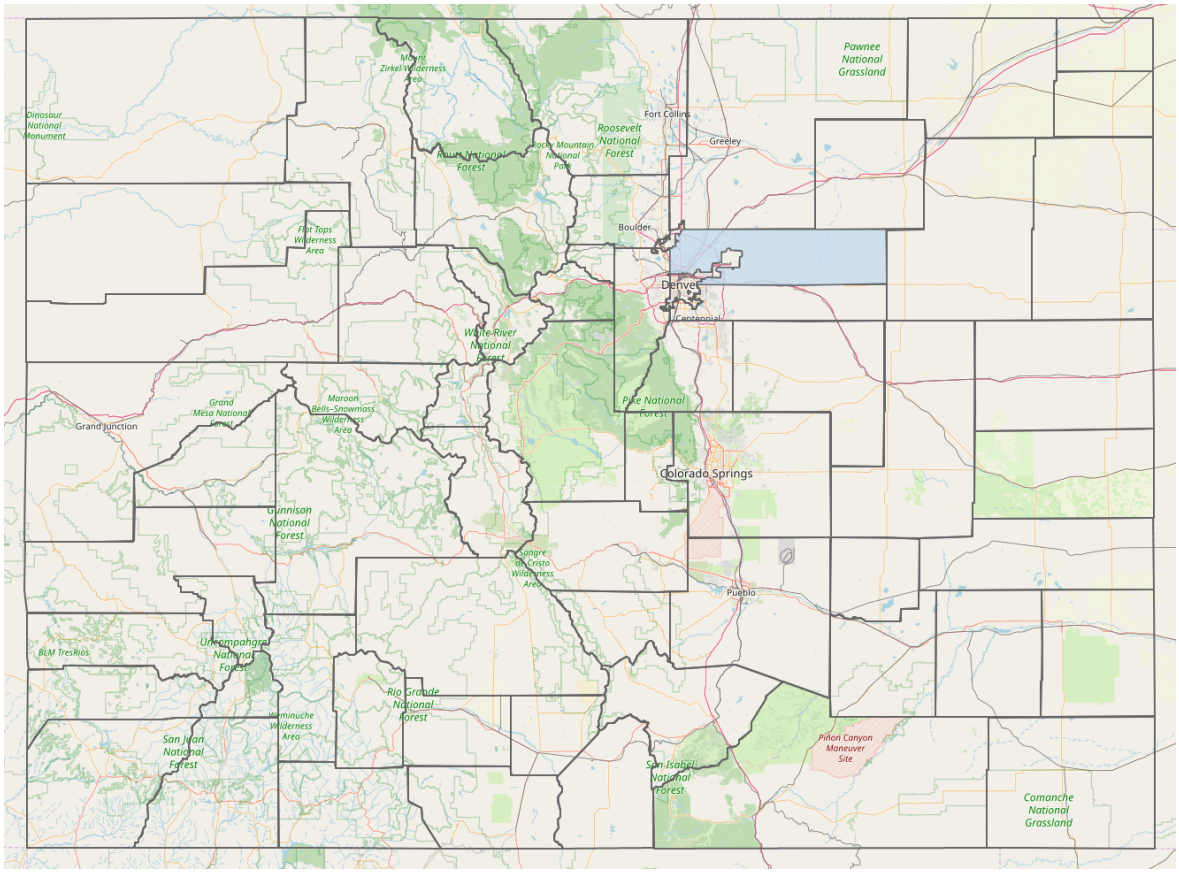
Arapahoe County

- Adams Arapahoe 28J
- Byers 32J
- Deer Trail 26J

Weld County

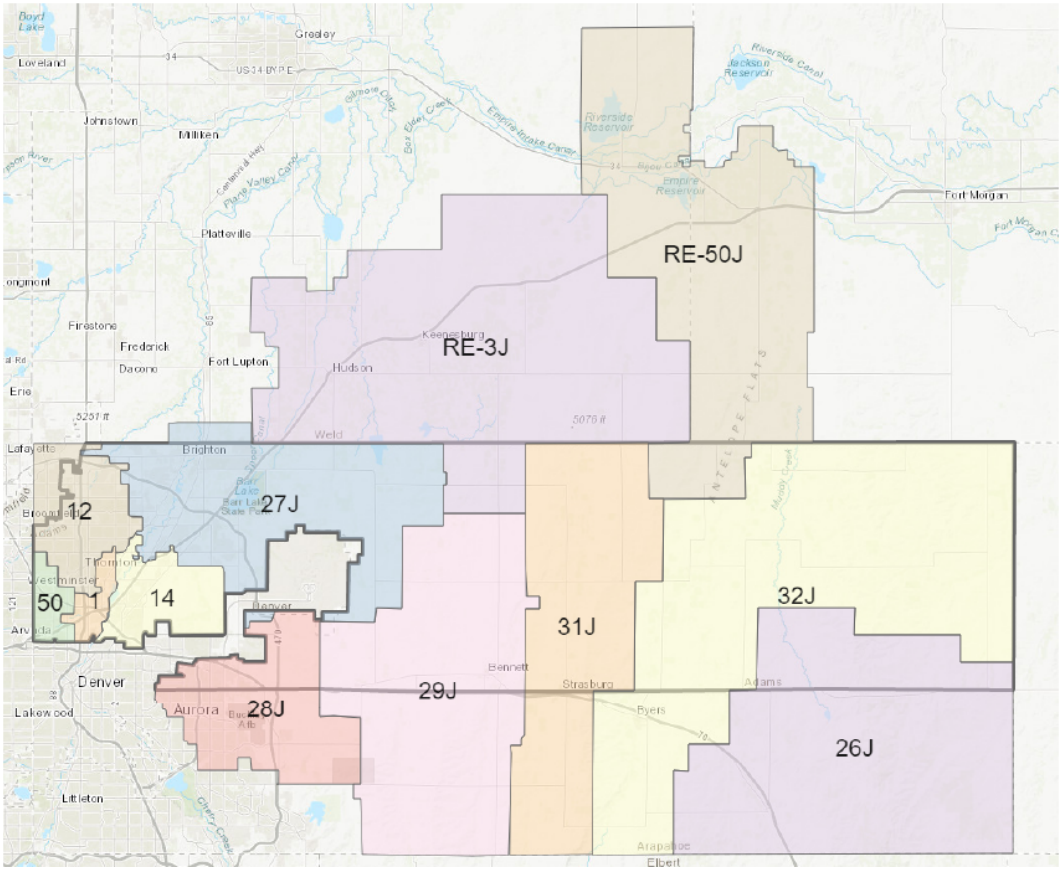
- Weld RE-3J
- Wiggins RE-50J

Figure A1: Adams County



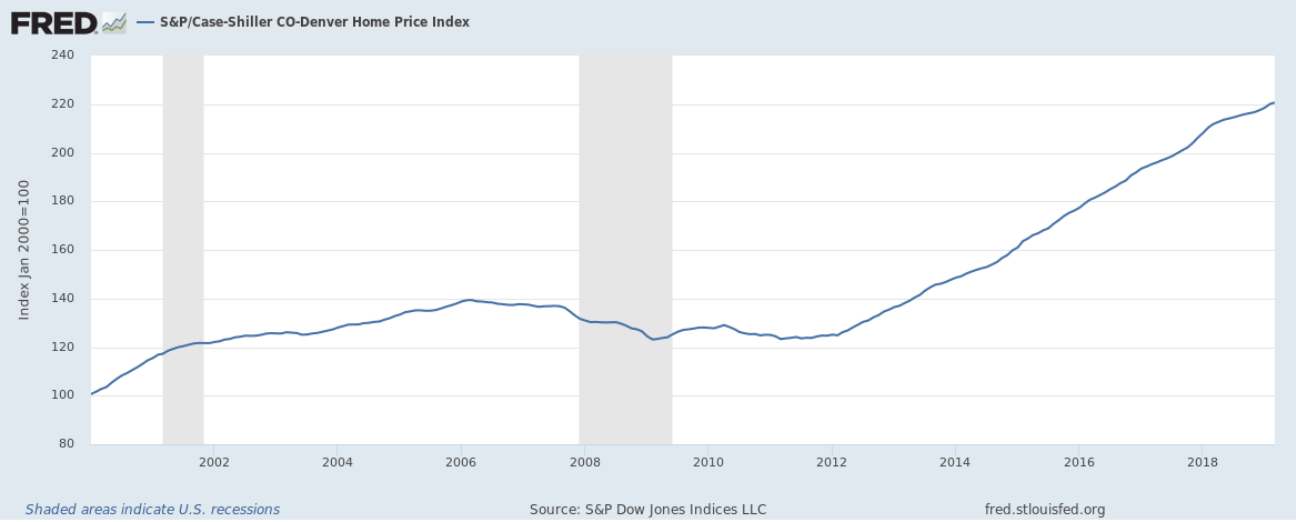
Note: Figure A1 displays Adams County in relation to the state of Colorado.

Figure A2: School districts in Adams County



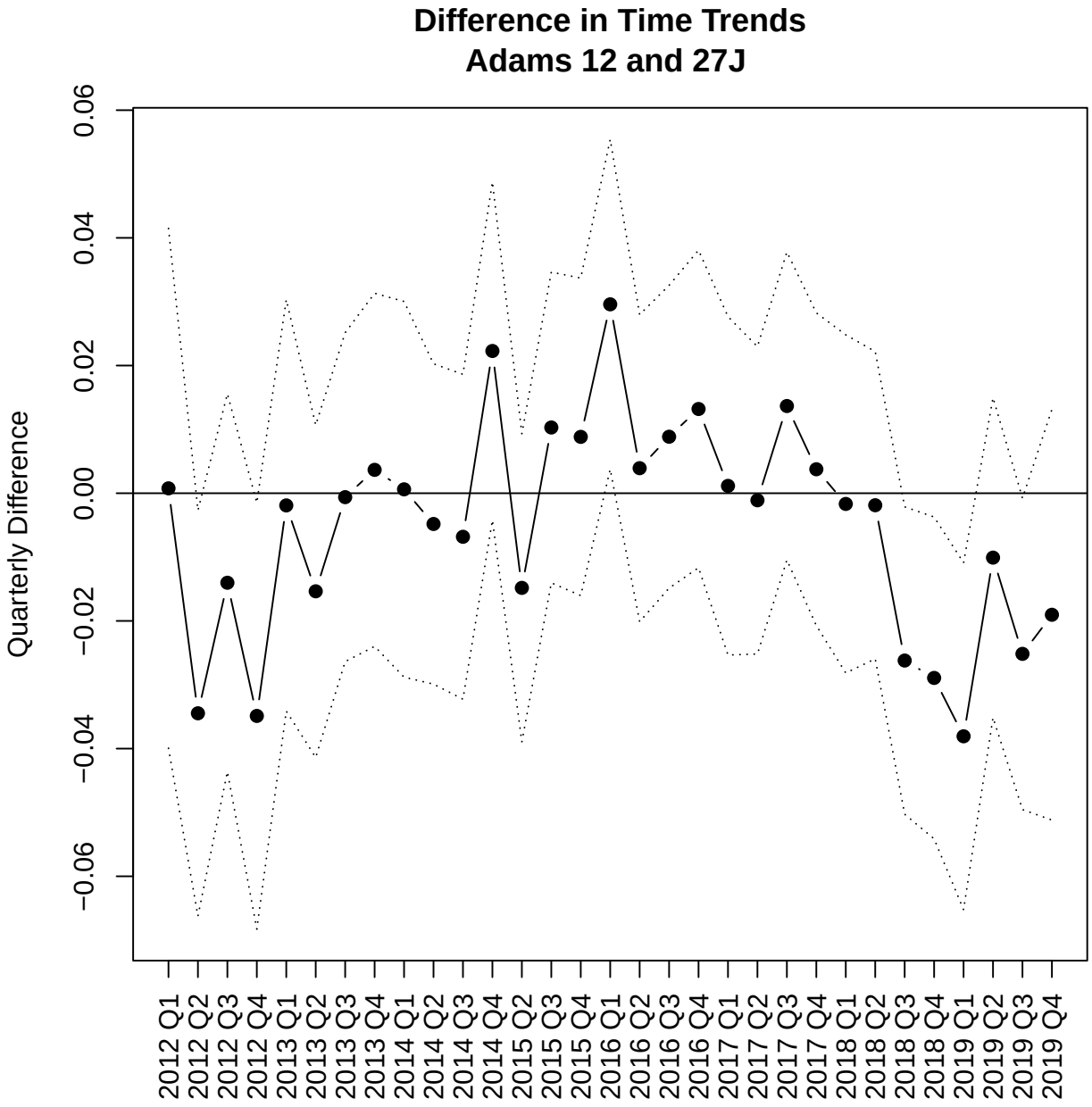
Note: Figure A2 displays school district boundaries for school districts in Adams County. They include (from left to right) Westminster 50, Adams 12, Mapleton 1, Adams County 14, Brighton 27J, Adams Arapahoe 28J, Bennett 29J, Weld RE-3J, Strasburg 31J, Wiggins RE-50J, Byers 32J, and Deer Trail 26J.

Figure A3: Case-Shiller House Price Index



Note: Figure A3 displays the Case-Shiller house price index for Denver between January 2000 and June 2019. It is available at https://fred.stlouisfed.org/series/DNXRSA

Figure A4: Quarterly House Price Index Differences for Adams 12 and 27J



Note: Figure A4 displays the differences in the quarterly house price index between Adams 12 and 27J and Adams 12 based on a hedonic house price index.