Too Late to Buy a Home? School Redistricting and the Timing and Extent of Capitalization[*]

Xiaozhou Ding[†]
Dickinson College

Christopher Bollinger[‡]
University of Kentucky

Michael Clark[§]
University of Kentucky

William Hoyt[¶]
University of Kentucky

Abstract

In the past fifty years, a voluminous literature estimating the value of schools through capitalization in home prices has emerged. Prior research has identified capitalization using a variety of approaches including discontinuities caused by boundaries. Here, we use changes in school boundaries and the opening of a new school in Fayette County (Lexington), Kentucky to identify this capitalization. Critical to properly estimating the effect of redistricting is to account for when information on the redistricting is available. We treat the information about the effects of zoning as occurring in three stages: announcement of the intent to open the new high school and redistricting, approval of the specific redistricting plan (map) and implementation (opening of the new high school and actual changes in boundaries). We find significant changes in values for homes redistricted from lower-performing schools and we find that this capitalization occurs well before implementation of the redistricting. As we show, failure to account for capitalization occurring before implementation will attenuate and even change the sign of capitalization.

Keywords: Property Values; Hedonics; School Quality; School District; Difference-in-differences

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[†]Department of Economics, Dickinson College. Email: dingx@dickinson.edu.

[‡]Department of Economics, University of Kentucky. Email: crboll@email.uky.edu.

[§]Department of Economics,University of Kentucky. Email: michael.clark@uky.edu.

[¶]Martin School of Public Policy and Department of Economics, University of Kentucky. Email: whoyt@uky.edu.

1 Introduction

There were 99,728 public elementary and secondary schools operating in the United States during the 2020-2021 school year. Among them, 1,027 schools changed agency or boundaries and 258 were expected to open in the near future.[1] Reflecting changes in schools and school quality, home values in the school district (zone for individual schools) are affected as households purchase (or sell) a home to gain access to better schools for their children. A survey of recent home buyers found that fifty-three percent of households with children under the age of eighteen said that the quality of the school district was important in their housing decisions and fifty percent cited convenience to schools as important.[2] According to a local news report, redistricting Henrico County, Virginia in 2017 drew criticism from some elementary school parents in the county, "[s]ome parents explained that they moved into a house thinking their kid would go to a certain middle school",[3] underscoring the importance in understanding how people make housing choices and how they value a change in attendance boundaries.

Beginning with the seminal papers of Oates (1969) and Kain and Quigley (1970) a voluminous literature on the relationship between measures of school quality or educational expenditures and property values has developed. The traditional approach of identifying the impacts of schools and school quality on property values is through cross-sectional variation in quality among schools. More recently, quasi-experimental approaches have emerged –through boundary-fixed effects (Black, 1999) or changes in school boundaries (Bogart and Cromwell, 2000; Ries and Somerville, 2010; Collins and Kaplan, 2017). We follow the latter approach, taking advantage of recent high school redistricting in Fayette County, Kentucky to employ a difference-in-differences approach to measure how housing prices change when a neighborhood is redistricted and how adding a new school to the system changes housing prices. In contrast to studies that examine the relationship between property value and specific measures of educational quality or services, including student test scores (Black, 1999), school report cards (Figlio and Lucas, 2004), or educational expenditures (Bayer, Blair and Whaley, 2020), our approach essentially compares the differences in the value of the "bundle" of educational services between schools. In addition, as discussed in Section 2, using the difference-in-differences approach along with consideration of "new," rather than pre-existing boundaries provides some distinct advantages. Further, as we have comprehensive data on (mean) ACT scores for the public high schools in Fayette County, we also contribute to the large literature on the capitalization of school quality measures.

In contrast to existing studies focusing on elementary school quality, we examine the impact

[1] U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD), "Public Elementary/ Secondary School Universe Survey."

[2] National Association of Realtors, "2018 Profile of Home Buyers and Sellers."

[3] http://wtvr.com/2017/06/22/henrico-school-board-votes-for-option-e-middle-school-redistricting-plan/

of high school redistricting for several reasons. First, while the redistricting impacted all three levels of schooling, in Fayette County high schools zones were the most affected.[4] Second, by far the most focus in the local media and public forums was on the opening of the new high school and the associated redistricting. Finally, while our focus is on high school redistricting, we control for changes in redistricting at all levels of schooling throughout our analysis.

Numerous studies have used exogenous changes in educational policy, for example, changes in educational funding (Jackson, Johnson and Persico, 2016; Bayer, Blair and Whaley, 2020) or changes in school boundaries (Bogart and Cromwell, 2000; Ries and Somerville, 2010; Collins and Kaplan, 2017). While these policy changes may be implemented at a specific date, there is always a time between announcement and implementation of the policy. Our paper differs from other studies of educational policy as we are not only capturing the actual impact of school quality change associated with such redistricting on house values but also the impact of the expected quality change. While there has been little attention to when capitalization of educational quality might occur, studies of other policy changes have considered "anticipation" effects. Examples include Malani and Reif (2015) that considers anticipated physician labor supply effects from tort reform and Blundell, Francesconi and van der Klaauw (2011) that considers the effects of welfare reform in the UK on female labor supply during both an anticipatory period and following implementation. In the literature on hedonics and environmental quality, the timing of capitalization has been addressed as a "learning" phenomena in, for example, Kiel and McClain (1995), Case et al. (2006), and Somerville and Wetzel (2021).[5] For policies in which the period between announcement (or anticipation) of the policy change and its implementation is relatively short, consideration of these anticipatory effects prior to implementation may not be a concern. However, these studies, like ours, suggest that for when the period between announcement or anticipation of a proposal change and its actual implementation are longer, ignoring anticipation or learning can lead significant biases in the estimated impacts of the policy being evaluated.

In our case, as with most cases of school boundary changes or the opening of new schools, the process of approval and implementation of the boundary and new high school (Frederick Douglass) in Fayette County took several years. The site for the new high school was announced in late 2013 and the redistricting process began in 2014. The proposed redistricting was presented by the Lexington-Fayette Board of Education in April 2015 and approved by the board on June 3, 2015 for revisions of the five existing high school catchment areas or, as the Board refers to

[4]Out of 22,526 sales after 2015, 26% were in rezoned high school areas, 23% were in rezoned elementary school areas, and only 12% were in rezoned middle school areas. Among all sales, only 8% were subject to both elementary and high school rezoning and only 3% were subject to all redistricting of all three levels of schools.

[5]Kiel and McClain (1995) looked at a rumored but later constructed incinerator facility and its impact on house prices; Case et al. (2006) examined the effect of contamination on property values where the location of contamination was affected by urban growth; and a recent paper, Somerville and Wetzel (2021), also investigates information shocks based on proximity to negative externalities from facilities.

them and the term that we shall use, school “zones” and the boundaries for the new high school, Frederick Douglass.[6]

As our results suggest, the timing of capitalization matters and, as we show, failure to account for capitalization prior to educational reform may bias estimates of the effect of the reform on property values. That the process of boundary revisions took several years with the revised boundaries being known over two years before the new school became operational raises an important question: when did capitalization of these changes occur? If it did occur, was it after the announcement of potential unspecified changes (April 2014), after the approval of a specific redistricting plan (June 2015), or not until the approved plan became effective (August 2017)? We address this question using multi-period difference-in-differences and show, in fact, that most significant capitalization occurred prior to the implementation of the new boundaries and opening of Frederick Douglass. In our case, failure to consider these anticipatory effects and, instead, focus only on the opening of the school or implementation of the new boundaries as the “treatment,” will significantly attenuate the estimates of capitalization. Implementing the difference-in-difference approach using boundary changes for several high schools in Fayette County allows us to investigate the impacts of boundary changes on property values in the different zones – essentially allowing for a less parameterized estimate.

While our results show that the redistricting proposed in 2015 had, on average, no significant effect on housing values in Fayette County, this result is not surprising – some houses were redistricted from high-performing high schools to ones that are low-performing high schools as measured by numerous metrics while the reverse is true for other houses. However, when we identify houses that are redistricted from low-performing to high-performing high schools, as measured by mean ACT scores, we find that these houses had statistically significant increase in property value and that this appreciation occurred prior to the actual implementation of the redistricting. Further reexamining changes in property values by pairs of schools, we find that houses redistricted from the lowest-performing school as measured by mean ACT score (Bryan Station) to other existing schools significantly increased in value. However, houses redistricted from a higher performing school (Henry Clay) to the proposed school had statistically significant decreases in value after the implementation of the redistricting. Moreover, for most of the current higher-performing schools, values of redistricted houses decreased with this impact not being uniform at all stages.

As has been done with many studies, we also consider how a possible measure of school quality, in our case, the mean ACT score in the high school affects property values. However, as

[6]The five operating high schools in Fayette County prior to August 2017 are Bryan Station, Paul Dunbar, Henry Clay, Lafayette, and Tates Creek as can be seen in Figure A1. As also seen in Figure A1 the zone for Frederick Douglass is between those of the Bryan Station High School and Henry Clay High School.

with our analysis focusing on the change in school zones, we also focus on whether the "return" on school ACT score is affected by timing. We find that test scores contribute to changes in home values only when we use expected (future) school test scores rather than current schools scores during the approval stage.

In Section 2 we provide a brief review of the literature on the relationship between primary and secondary education and property values. Background on the process for and, importantly, the timing of determining school boundaries is provided in Section 3. Section 4 discusses the data used in empirical analysis and Section 5 provides the basic methodology. Section 6 presents the results of estimation, addresses the possibility of learning in the model, and provides a placebo test. Section 7 concludes.

2 Literature Review

2.1 Education and Property Values

Economists have long been interested in estimating the relationship between housing prices and school quality. Early work done by Oates (1969) and Kain and Quigley (1970) inspired a burgeoning literature examining the impact of school quality on property values. However, a critical problem associated with evaluating the casual link between housing prices and school quality is controlling for neighborhood characteristics. As "good" schools are often correlated with other neighborhood amenities, it is difficult to isolate the effect of school quality from the effects of these amenities through ordinary least squares regressions. If increased housing prices increase property tax revenues, a greater willingness to pay for school quality in a district will lead to increased school spending – making school quality endogenous to the district (Epple and Romano, 2003; Nechyba, 2003).

Numerous studies have attempted to identify the relationship between school quality and property values. Bogart and Cromwell (1997) use an Oaxaca-decomposition to examine houses across school districts where jurisdiction districts are overlapped and isolate the common public service effect from observable component and unobservable component. Weimer and Wolkoff (2001) also follow the same spirit finding significant impact of test scores on housing values. Downes and Zabel (2002) adopt a standard log-linear regression, a first-difference model, and a value-added model to examine the impact of school characteristics on housing prices. They find that individuals are willing to pay more for a house close to a school with higher standardized test scores. Clapp, Nanda and Ross (2008) use a panel of school districts in Connecticut to examine the effect of school district test scores and demographic composition on housing prices after controlling for the influence of unobserved neighborhood attributes with fixed effects. They find a one standard deviation increase in test scores leads to 1.3 percent increase in property values. They also find that a 10 percentage point increase in the percent of African-Americans and Hispanic leads to a 3.5 percent and 3 percent decline in property values, respectively, in contrast to earlier work where they do not find demographic changes affect differences in housing prices (Clapp and Ross, 2004).

2.2 Quasi-Experimental Approaches and the Valuation of School Quality

Boundary Fixed Effects and Regression Discontinuities One approach to avoid some of the issues plaguing the traditional panel approaches to estimating the effects of educational quality on property values is to identify differences in property values along school boundaries, the "boundary fixed effect" model pioneered by Black (1999). She uses elementary school data in Massachusetts and compares houses within similar neighborhoods but across school attendance boundaries, finding a 2.5 percent increase of house prices for a five percent increase in test scores. An alternative boundary is related to voting on education spending. Cellini, Ferreira and Rothstein (2010) utilize discontinuities in voting on education spending to see the impact of school facility investment on housing markets and find $1 increase in spending increase housing prices by $1.5 and the effect from test scores is small.

Bayer, Ferreira and McMillan (2007) expand on the boundary fixed effect approach of Black (1999) by controlling for differences in demographics (parents' college education, percentage black, income) along school catchment boundaries that might arise from sorting. Employing boundary fixed effects and neighborhood demographic controls with San Francisco MSA property value data, they find that the impact of school quality on property values is reduced by almost fifty percent relative to estimates with the boundary fixed effects alone. Kane, Riegg and Staiger (2006) use boundary fixed effect and regression discontinuity methods with data from Mecklenburg County, North Carolina between 1994 and 2001 to study the impact of various school characteristics on housing prices. They test whether observed housing and neighborhood characteristics shift discontinuously at the school boundaries and find pronounced correlation between differences in school test scores and differences in housing and neighborhood characteristics, which shows the importance to control for these differences. An alternative approach to addressing these concerns with boundary fixed effects is to control for demographic differences that may arise from sorting and employ panel data (repeated cross-sections) along boundaries (Dhar and Ross, 2012; Dachis, Duranton and Turner, 2012).

Educational Reforms, Difference-in-Differences, and Property Values In contrast to studies that employ boundary fixed effects or regression discontinuities, which might be thought of as comparing equilibrium property values across school zones, are studies that employ exogenous changes in educational quality to identify differences in property values between those areas subject to the reforms (treated) and those areas that are not (comparison).

For example, Bogart and Cromwell (2000) use a difference-in-differences framework to examine the impact of redistricting schools on house values in Shaker Heights, Ohio where school closings resulted in dramatic shifts in boundaries. They find the impact of losing a neighborhood school on home values reduces house values by 9.9 percent ($5,738 at the mean house value). However, as all schools in Shaker Heights are considered to be of high quality, they are not able to exploit variations in the quality of schools. Ries and Somerville (2010) use repeated sales in Vancouver and exploit a redistricting process that redraws catchment areas to study the impact of school quality on housing values. They find the only significant effects of this redistricting occur for top-quartile residences. Machin and Salvanes (2016) use Norwegian data to examine whether access to school choice affect housing prices exploiting a policy removing catchment areas. They find housing valuation sensitivity is reduced as a result, suggesting that parents value better performing schools. Bonilla-Mejía, Lopez and McMillen (2020) take the reform of school lottery in Chicago to study the capitalization effect and find significant impact of higher admission probability associated with close proximity on housing prices. Collins and Kaplan (2017) utilize exogenous boundary changes in Shelby County, Tennessee to estimate the effects of school quality and district attributes on housing prices. They use repeated sales data and control for original school district fixed effects in a difference-in-differences framework. Their result shows that within the original school zone, areas zoned to higher-quality schools did not experience increases in prices, relative to areas redistricted to lower quality schools. A one standard deviation increase in test scores increases housing prices by 3.2 percent and the municipal district effect is 5.5 percent.

Our approach most closely follows that of Bogart and Cromwell (2000), Ries and Somerville (2010) and Collins and Kaplan (2017) by taking advantage of a natural experiment – changes in school boundaries– with difference-in-differences estimation. In this way we avoid concerns about cross-sectional sorting along existing school boundaries (Kane, Riegg and Staiger, 2006; Bayer, Ferreira and McMillan, 2007).[7] A distinction between our approach and those of Bogart and Cromwell (2000), Ries and Somerville (2010) and Collins and Kaplan (2017) is the treatment of the period between the announcement and implementation of changes in school boundaries. In the case of Bogart and Cromwell (2000) the period following the announcement of a proposed

[7] While, as discussed in the literature cited above, there are obvious econometric advantages to using quasi-experimental approaches, including difference-in-differences, there are challenges to interpreting the findings from these approaches as welfare measures (Klaiber and Smith, 2013; Kuminoff and Pope, 2014; Banzhaf, 2021). In another paper, we provide a fuller treatment of these issues and how they might be addressed (Ding et al., 2022).

redistricting plan is the start of the treatment period; for Ries and Somerville (2010) the treatment period begins with the approval of the redistricting plan; and in Collins and Kaplan (2017) the treatment period begins with the implementation of redistricting.[8] Thus, each of these three studies follows different definitions of when the treatment, redistricting, begins. While in Bogart and Cromwell (2000) and Ries and Somerville (2010) the period between announcement and implementation of the redistricting was relatively short; in contrast, because redistricting in Fayette County also involved construction of a high school, the period between announcement and implementation of redistricting was almost four years in our study. Then with this length of time, unlike these other studies, we are able to not only capturing the actual impact of school quality change associated with such redistricting on house values but also the impact of the anticipated quality change. To do this, we split the entire redistricting process into multiple periods to see how people update their beliefs about where the redistricting will take place and its impact on house prices, thereby also contributing to a related literature on information and learning in hedonic evaluations (Cheshire and Sheppard, 2004; Ma, 2019).

3 Redistricting in Fayette County

In the Fayette County schools, there has been an average increase in enrollment of 600 to 750 students a year for the past ten years. Figure 1 shows the upward trend of increasing enrollment in most of the public high schools prior to 2016. To accommodate this growth, a redistricting process began in late 2013 in anticipation of a new high school opening in 2017. The year-long work of drawing new school boundaries began in spring 2014 with a committee of parents, teachers, Fayette County Public School administrators, two school board members, a district Equity Council representative, a city planning official, a home builder and other community stakeholders. The committee met three times to review some initial demographic information and community growth trends. In April 14, 2015, the committee presented a plan to the Fayette County Board of Education with a summary of its draft proposals. The school board then met with the redistricting committee on April 21st for a joint work session. At their June 3, 2015 meeting, the Fayette County Board of Education approved the redistricting plan. Table 1 summarizes the timeline of the rezoning process.

Figure 2 shows the map of the original school catchment areas or, henceforth, the school

[8] In the case of redistricting in Shaker Heights, OH, the redistricting evaluated in Bogart and Cromwell (2000) was made public in January 1987 and approved in March 1987 and implemented in September 1987. All sales in 1987 were considered to be in the treatment period. In the case of Vancouver, BC redistricting studied in Ries and Somerville (2010) the initial proposal was public in September 2000, approved with minor changes in January 2001, and effective in September 2001. All sales in 2001 were considered to be in the treatment period. The Memphis/Shelby County redistricting studied in Collins and Kaplan (2017) is more complicated as it involved state involvement and creation of six new school districts. However, their treatment period is consistent with our implementation period.

"zones" and the proposed zones with the school boundaries change. The dashed line represents the old school district boundaries and red solid line represents changes in school district boundaries from the redistricting. Based on these changes, we are able to determine the school catchment area for each house sold before and after the redistricting process.[9] Under the new plan, Bryan Station still covers a large proportion of Fayette County but its southeast share was redistricted to the proposed school, Frederick Douglass.[10] There are not large geographical changes in the other four high-school zones.

Housing sales data from Fayette County Property Valuation Office (PVA) come with an address for each sale record. We use ArcGIS to match each sale with a high school zone.[11] Our data from 2010 to August 2017 are prior to the implementation of the new school district plan with data from August 2017 to August 2020 following implementation. We identify three "treatments": 1) the Fayette County School Board vote to undertake redistricting and build a new high school on Winchester Road (April 29, 2014) with no mentioned of any specific changes in school zones or what the catchment area for the new school would be; 2) the passage of the proposal (June 3, 2015) that mapped the approved school zones; and 3) the implementation of the approved school zones and opening of the new high school (Frederick Douglass) (August 16, 2017). Then, as the rezoning proceeded, information about the new zones increased and, presumably uncertainty decreased. The information regarding each of these "treatments" was well-reported in local media, including the Lexington daily newspaper, the *Lexington Herald Leader (LHL)*.[12] Though the construction of the new high school was made public in December, 2013, no specific information about catchment area (re)assignment was available until April 29, 2014, a committee was formed and began their work in redrawing school attendance boundaries. If anything, our result of post-announcement effect under April 29, 2014 would underestimate the true effect. Given the extensive press coverage in Lexington, we expect that those in the market for housing would have been aware of the upcoming changes in school districts. As will be seen, our empirical results support this conjecture.

Sales for the pre-treatment and the three treatment periods need to be matched with a high

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[9] Figure A1 presents separate maps for original and the proposed school zones with high school locations labeled on the map.

[10] The name for the proposed high school was not announced until November 10, 2016 and was approved by the Fayette County School Board on November 21, 2016 over a year after the approval and districting for the proposed high school (see Spears, Valarie Honeycutt (November 10, 2016) "Frederick Douglass recommended as name for new Lexington high school," *The Lexington Herald Leader, https://www.kentucky.com/news/local/education/article114008613.html*).

[11] The geographic coordinates for all Fayette County addresses are available from the Lexington Fayette Urban County Government.

[12] As mentioned, the relevant articles are all from the *Lexington Herald Leader (LHL).* All were written by Valarie Honeycutt Spears. The first article on rezoning we found in the *LHL* was "New $76 million Lexington high school proposed for Winchester Road, outside New Circle," (December 14, 2013) followed by "Fayette County Public Schools redistricting committee releases tentative rezoning maps" (January 29, 2015), "Public gets look at final Fayette school attendance zone recommendations" (April 14, 2015), and "Fayette County school district issues final versions of new school attendance zones (get maps)" (June 17, 2015).

school zone. Sales prior to April 29, 2014 are matched to the "old" zone, the zone in operation, and are in the pre-treatment period. Sales after April 29, 2014 are matched to the "new" zones, that is, the zones that will be effective after August 2017. Of course, sales after August 2017 are in the new zones, which at that time are operational. Table B1 shows sales transactions categorized into before announcement, after announcement and before approval, after approval and before opening, and after opening for both the properties' old and new school zones. Of the 10,610 houses sold in the old Bryan Station area during the years of study, 9,021 sales are within both old and new Bryan Station zone while 841 sales occurred in the area to be redistricted to the Paul Dunbar High School and 6,870 sales were in the area to be in the proposed school (Frederick Douglass) zone. The second largest change was in the Henry Clay High School zone where 5,189 of the 8,788 sales were located in the Henry Clay area, 730 of the sales were in the Tates Creek zone and 1,516 transactions were in the zone of the proposed high school. Lafayette High School zone was subject to redistricting to both the Henry Clay and proposed high school zones, but with only a few sales in the latter (19, 52, and 89 sales after announcement, approval, and implementation). Similarly only 11, 23, and 28 sales were in the area that was rezoned from Tates Creek to Henry Clay in these three stages. Therefore, we exclude Lafayette to proposed and Tates Creek to Henry Clay for school-pair analyses.

4 The Data

4.1 Housing Data

Our housing price data comes from the Fayette County Property Valuation Administrator (PVA).[13] These data include the general characteristics of all parcels matched to a sales data set. The sales data set records all transactions from January 2010 to August 2020. For each dwelling, we have its physical characteristics including the number of bathrooms, square footage, and exterior finish along with its transaction history (e.g. sale date, price, and sale type). We restrict our sample to the arm's length transactions of single-family residential houses. Column (1) - (5) of Table 2 shows the summary statistics of all houses in each school zone that were sold before the approval of the redistricting. The Henry Clay and Paul Dunbar zones have the most expensive houses but these houses also tend to be larger, have more bathrooms and are more likely to have brick finishes. In contrast, Bryan Station has the least expensive and smallest houses. It is also worth noting that houses sold in Bryan Station on average are 3.3 miles from the high school, almost double the distance for houses in the Paul Dunbar and Tates Creek zones. In Figure 3, we plot the median price of sales for each school zone between 2010 and 2020. The ordering of median

[13] See https://fayettepva.comfor more on the Fayette County PVA.

house price across the high school areas is generally unchanged and inflation-adjusted housing prices are relative constant with the exception being the Henry Clay zone where there have been significant price increases since 2011.

In columns (6) and (7) of Table 2, we divide sales into rezoned and nonrezoned groups. The t-statistics for the differences between the two groups are reported in column (8). In doing so, we do not see large differences in log sales price, log square footage, and percentage of houses located inside urban area. Not surprisingly, the most significant difference is in the age of the house and distance to school.

4.2 Test Score Data

While our empirical strategy does not rely on school test scores or other measure of school quality to quantify school quality premiums, we follow much of the literature and obtain data on the mean ACT test score for each of the high schools between 2003 and 2020.[14] Following Dills (2004), we use mean ACT scores as a measure of school quality and examine its effect on property values. In Figure 4, we present the annual average ACT composite scores for each school by year. It is clear that Bryan Station has significantly lower scores than the other high schools in all tested subjects. The other four schools have relatively similar scores except for a recent (post 2015) decrease in the scores of Tates Creek. We only have two years, 2018 and 2019, of ACT scores for Frederick Douglas and its scores are slightly above those of Bryan Station. Similar to consistency in differences in housing prices across high school zones shown in Figure 3, Figure 4 shows similar pattern in ACT scores across high schools.

A possible concern with using ACT scores to measure school quality is the possibility of selection bias – the students taking the exam might not be a representative sample of all students in the school. As of 2007-2008 school year all Kentucky juniors are required to take the ACT, dramatically reducing concerns about selection bias. Based on the school report cards we obtained, the percentage of students tested does not vary much across schools nor years with more than ninety-eight percent of high school students in Fayette County taking the ACT during our sample period.

[14] ACT test scores are available from the Kentucky Department of Education, see here.

5 Empirical Strategy

5.1 A Multi-Period Difference-in-Differences Approach

We exploit a natural experiment arising from school boundary changes to examine the capitalization of school quality.[15] A "naive" approach would be using a difference-in-differences (DID) model to estimate the impact of changing school zone boundaries on housing prices. Letting $\ln P_{ijt}$ denote the log of sale price of house i in census tract j at time t, we estimate

$$\begin{aligned} \ln P_{ijt} = & \mathbf{X}_i\beta + \mathbf{Z}_i\delta + \phi Rezoned_i + \tau Post_{it} + \theta Rezoned_i \times Post_{it} \\ & + \text{Elementary}_{it} + \text{Middle}_{it} + \zeta_j + \zeta_t + u_{ijt}. \end{aligned} \quad (1)$$

where P_{ij} is sale price of a house i in school zone j, $\mathbf{X}_i$ is a vector of housing attributes and $\mathbf{Z}_i$ represents locational amenities such as distance to parks, schools, and distance to urban service boundary. $Rezoned_i$ is a dummy variable indicating the treatment status of house i in census tract j that equals one if a house will be in a new school zone after redistricting is implemented – these are the "switchers". In Table B1, the control group are the diagonal representing those non-switching house sales. The binary variable $Post_{it}$ that equals one if a house i sold in time t was after the implementation of redistricting plan and equals zero if sold before. The term θ represents the effect of switching zones on housing prices and should be interpreted as the effect of all aspects of how schools affecting property values. Specifically, we have not included any separate measures of educational quality in (1) but in Section 6.2 we consider how the redistricting affects the impact of current test scores on housing prices. To eliminate confounding factors including the quality of elementary schools and middle schools that were also affected by the rezoning plan, we include time varying elementary and middle school effects. To absorb any aggregate shocks at the neighborhood level, we use census tract fixed effects ζ_j. The term ζ_t accounts for year and quarter fixed effects which capture the aggregate shocks and seasonal factors in the housing market.

The key identifying assumption of difference-in-differences model is common trends. It implies that in the absence of the redistricting, the potential log prices of houses in the treated group would have followed the same trend as log prices in the control group. Under this assumption θ will identify the average treatment effect on the treated. However, Figure 5 shows that properties sold in treatment areas started trending differently before the implementation in 2017, which is also supported by an inspection of event-study graph in Figure A2 where we compare the difference in log sales between rezoned and non-rezoned homes relative to 2013. In regard to our DID estimates, there might be concerns that some people have anticipated redistricting prior to its

[15] Black and Machin (2011) and Machin (2011) provide a summary of major empirical approaches that deal with those issues, including regression discontinuity, instrumental variables, and difference-in-differences methods.

implementation (August 2017) and passage (June 2015) as the Fayette County Public Schools (FCPS) announced its intention to redraw school boundaries on April 29, 2014. If the boundary changes were anticipated, the coefficient on $Rezoned \times Post$, our measure of the impact of redistricting on housing prices, could be biased.

To address this concern, we use a multi-period difference-in-differences model adding two periods before the implementation of the plan.[16] The first is post-announcement period containing sales between the day FCPS announced the redistricting process (April 29, 2014) and the day the plan was officially approved (June 3, 2015). The second is post-approval period including sales between the day FCPS approved the plan and the day new plan was implemented. Specifically, we define a new set of binary variables $Post_k$ indicating the period of a house sold at time k with $k = \{1, 2, 3\}$. $Post_1$ is equal to one if a house was sold after the announcement but before the approval; $Post_2$ is equal to one if a house was sold after the approval but before the plan was in effect; and $Post_3$ is equal to one if a house was sold after August 2017.

$$\begin{aligned} \ln P_{ijt} =& \mathbf{X}_i\beta + \mathbf{Z}_i\delta + \phi Rezoned_i + \sum_{k=1}^{3} \tau_k Post_{ik} + \sum_{k=1}^{3} \theta_k Rezoned_i \times Post_{ik} \\ &+ \text{Elementary}_{it} + \text{Middle}_{it} + \zeta_j + \zeta_t + u_{ijt} \end{aligned} \tag{2}$$

where θ_1 captures the premium of information received by home buyers between the day when FCPS announced that redistricting was to be considered and the approval date of the plan. The term θ_2 captures the "net" impact of approval of the redistricting plan. The term θ_3 captures the "net" impact of the plan after implementation. In the absence of an information effect, that is no anticipation of redistricting changes, we expect θ_1 to equal zero.[17]

In essence, we are looking at the same house before and after each time information of redistricting is updated including the announcement of the intent to redistricting, the approval of redistricting and the implementation of the approved plan though we are not using repeated sales as in Ries and Somerville (2010) but pooled cross-sections. Our identification comes from variation in both anticipated and realized school quality. As the quality of the existing high schools, at least as measured by ACT scores and funding, has not significantly changed during the time of our study, we are able to capture how redistricting affects housing prices through expectations on future school quality through approved, but not yet implemented, boundary changes. With the help of sales data post-implementation, we are also able to examine how people

[16] A more detailed examination of heterogeneous treatment effect in a multiple period setting can be found in Callaway and Sant'Anna (2021). In our case, all the treated houses received treatment at the same time. For this reason, we believe our approach is not subject to their criticism.

[17] Even though we control for both year and quarter fixed effects in our specification, *Post* dummies will not be dropped because all three treatments happened in mid-year. The interpretation of *Post* however will be less intuitive since it captures within year time effect.

value school quality based on actual school quality. Our ability to estimate the impact of expected school quality cannot been addressed in studies focused on using contemporaneous test scores (or moving averages) to determine the extent that school quality is capitalized into housing prices.

Equation (2) implicitly assumes that redistricting has the same effect on housing prices regardless of the high school zone of a house before redistricting and its zone following redistricting. We address the possibility that the effect of redistricting depends on the change in high schools in two ways. First, we estimate a model that distinguishes between houses that are redistricted from lower-performing high schools to higher-performing ones, as measured by mean ACT, and those for which the reverse is true – a triple difference-in-difference. Second, we perform pair-wise comparisons of houses that were redistricted to a specific high school to those that were in the same pre-2017 high school zone and were not redistricted (example: sales of houses that remain in Bryan Station vs. houses redistricted from Bryan Station to Frederick Douglass).

Finally, we relate sale prices to one measure of school quality or performance, mean school ACT score, following an extensive literature on boundary fixed effect model. However, to highlight the possible effects of redistricting and its timing, we examine the relationship between property values and test scores along the school boundaries both prior to and following redistricting.

5.2 Identification and Interpretation

With our methodology and data, two important threats to identification of causal results merit attention: 1) divergent pre-treatment trends for our treated and comparison groups (parallel trends) in difference-in-difference estimation; and 2) concerns about the exogeneity of school district boundaries.

Concerns about pre-treatment trends were discussed earlier. In our analysis, whether and when the parallel trends assumption applies is essentially a question of when the treatment(s), the effects of redistricting, occurs. As was seen in Figure 5, parallel trends are not maintained at the time when the redistricted plan is implemented (August 2017) but if treatment begins with the announcement of the redistricting plan, it does not indicate any significant divergence in trends in sales prices prior to the announcement (April 2014).

Difficulties with boundary estimation, either following the boundary-fixed effect approach (Black, 1999) or regression discontinuity can arise for several reasons: 1) sorting along the border; 2) changes in other policies; and 3) boundaries not being drawn randomly.

As discussed in Section 2, Kane, Staiger and Samms (2003) and Bayer, Ferreira and McMillan (2007) provide nice demonstrations of significant demographic differences at school boundaries arising from sorting. These demographic differences may, in themselves, affect school quality and performance measures, in our case school mean ACT scores. In Table 3 Panel A, we report differences in the percentage white and median income for houses located in census tracts along the old (pre-2015) school borders. As can be seen in this panel, we find large and significant differences in both measures along these borders. In contrast, in Panel B we compare census tracts along the new (post-2015) boundaries in 2016. While there are still some statistically significant differences in these measures along the boundaries, in all but one boundary the difference in median household income has decreased and in a few cases, the difference has reversed sign and exceeds a reduction of over $10,000. Differences in percentage white have also been reduced along border for all but two boundaries. Importantly, the difference in median income and percentage white along the Bryan Station-Frederick Douglass border are a statistically-insignificant ($1,882 and 13.9%) and along the Henry Clay-Frederick Douglass border the differences are $7,780 and 11.6%. To give more perspective for the differences along the Henry Clay-Frederick Douglass border, the differences along the old Henry Clay-Bryan Station border were $9,804 and 11.7%. In addition, as our data are repeated cross-sections, we can account for time-invariant factors employing neighborhood (census tract) fixed effects as in Dhar and Ross (2012) and Dachis, Duranton and Turner (2012) for example. The school-level statistics also show that there is no evidence that the composition of students changed abruptly after the rezoning.[18]

As stated at the Fayette County School District website, the School Zoning committee "…involves parents, teachers, FCPS administrators, two school board members, a district Equity Council representative, a city planning official, a home builder, and other community stakeholders. The committee's meetings are open to the public, and community input is welcome throughout the process."[19] As this suggests, the assignment of school boundaries are not random for this and other reasons including balance student populations across the schools. However, we note that while the high school boundaries are not "straight lines" as in Turner, Haughwout and van der Klaauw (2014) with few exceptions they follow major corridors in the city rather than streets that are primarily residential. Finally, and importantly, sales prices reflect the valuation of the properties by new residents of the house, the majority of whom are likely to be from another part of Lexington or even from outside of it. While current residents of the area may have had some influence and input in determining school boundaries, households purchasing homes following the determination of the new school zones are unlikely to have had any significant input.

[18]Figure A3 presents the trend of the percent of free and reduced lunch in each school and the percent of nonwhite students.

[19]See https://www.fcps.net/zones.

6 Results

We begin with a discussion of the results of estimating equation (2) with the entire sample to determine the average effect of being redistricted. We then discuss the results when extend (2) to distinguish between houses redistricted to higher-performing schools and those redistricted lower performing schools. Next we examine how the impact of the redistricting may differ for different school pairs.

Next we follow Black (1999) using common school boundaries to eliminate unobserved neighborhood effects and find that the redistricting approval disrupts the relationship between current school quality, as measured by current ACT scores, and housing prices. Our results indicate ACT scores had significant effect on housing prices prior to the announcement of redistricting and continued through the post-approval period. However, expected school quality, that is, the test scores for the area school effective in August 2017, affects property values for the period following the approval of redistricting and before its actual implementation.

Finally, we conduct a series of tests examining re-sorting of residents after the approval and whether our treatments and timing are valid. The results show that residents re-sort into redistricted areas after the school redistricting and randomizing the rezoning status and time will eliminate the impact of such policy, implying our findings are causal.

6.1 The Effects of Redistricting on Property Values

6.1.1 Aggregate Redistricting Effects

Table 4 reports the results of difference-in-differences estimation of the effect of redistricting across all boundary changes including the districting for existing schools and opening of Frederick Douglass. As seen in Equation (2) we have redistricting separated into three distinct treatments corresponding to the announcement of the intent to redraw new boundaries *(PostAnnounce)*, the approval of the boundaries *(PostApprove)*, and the implementation of the boundaries and opening of Frederick Douglass *(PostOpen).* Sales that are in the areas that change high school zones after the announcement of the new boundaries are designated as treated. All specifications control for house characteristics, distances to parks, schools, and urban service boundaries, as well as elementary and middle schools effects.

Column (1) of Table 4 includes all three treatment periods and aggregates all redistricted houses into a single treated group. The coefficient on *Rezoned* is not significantly different from zero in all specifications implying that, on average, houses in redistricted areas are not systematically higher in value than houses that are not redistricted. As houses could be rezoned to either a better-performing school or a less-performing school, on average, it is difficult to predict either the sign or magnitude of the coefficients of the interactions between *Rezoned* and the three treatment periods ($Post_{\_}$). Thus, that these three coefficients are small and insignificant is not surprising.

The effect of redistricting on property values is likely to critically depend on the perceived quality of the high school to which a house is rezoned. Then to better understand how redistricting affects property values, we create a binary variable *BetterRezoned* that equals one if a home was rezoned to a higher-ranking school based on the average ACT composite scores between 2010-2013. We interact this variable with each $Post_{\_}$ variable to examine the effects of rezoning based on the direction of rezoning (to a higher-performing school or to a lower-performing one).

The results are shown in Column (2). The coefficient for $BetterRezoned \times PostAnnounce$ implies moving to a better-performing school increases sale price by 1.1 percent after the announcement of a potential redistricting relative to a house rezoned to a lower-performing school. In contrast to the result without accounting for the direction of rezoning, houses rezoned to a better school will experience a 3.1 percent appreciation during the approval period.[20] This impact is large and significant compared to announcement stage and the effect found in column (1). The interaction between *BetterRezoned* and *PostOpen* is still large and similar to the approval period, though with more noise.

In columns (3) - (5) we test to see if omitting or grouping different periods alters our estimate with the three distinct periods reported in column (2). Column (3) excludes the treatment of announcement, including the sales during this period into the pre-treatment. Column (4) further excludes the treatment of approval so that only sales following the redistricting are in the treatment period (*PostOpen*). Column (5) aggregates sales during the post-approval and post-opening as a single treatment period (*PostApproveOpen*).

Our results suggest that failure to account for different stages in the rezoning process will bias the results. The coefficient on $BetterRezoned \times PostApprove$ in column (3), where we included the announcement stage with pre-treatment, is 2.8 percent, almost 10% less than what we have in the full model. As seen in column (4), when the treated group includes only sales after implementation and sales during the announcement and approval periods are included in the pre-treatment period, the treatment estimate becomes even more attenuated, reducing it to 2.3 percent and making it insignificant. Interestingly, grouping post-approval and post-opening treatments yields no statistical difference between the two specifications in column (2) and (5), justifying the approach in Ries and Somerville (2010) where they use approval as the treatment and the gap between announcement and approval was relatively short.

[20] The t statistic of $Rezoned \times PostApprove + BetterRezoned \times PostApprove$ is 2.05, indicating the better rezoning effect is salient.

6.1.2 Disaggregating Redistricting

That we found weak evidence of any capitalization from redistricting when we aggregated sales across redistricting in all of the high school zones is not surprising – while we estimated an average treatment effect from redistricting there is no reason to believe it is a uniform effect. The redistricting proposal involved every high school in Fayette County with some houses being rezoned from what are considered higher-performing schools to lower-performing schools while other properties were rezoned from lower-performing school to higher-performing schools. As discussed later, there is a strong relationship between mean high school ACT score and property value in that zone. While some of the redistricting involved redistricting to high schools with higher mean ACT scores such as part of the Bryan Station zone to Paul Dunbar (2010-2013 mean composite score of 18 for Bryan Station and 22 for Paul Dunbar) other redistricting resulted in houses rezoned to schools with lower mean ACT scores Henry Clay (mean score of 22) to Tates Creek (mean score of 20). To address the likelihood of heterogenous impacts of these boundary changes, we disaggregate them into redistricting pairs and run separate difference-in-differences estimation for each pair of boundary changes. We also put corresponding changes in terms of rankings of school based on ACT score under each case for easier tractability for readers.

Results of this estimation are found in Table 5. Each column is a regression following equation (2) using all sales from a single school (pre-2017) zone. Our focus is on the three interaction terms, the difference-in-differences estimate of housing price changes for houses in redistricted area post-announcement, approval, and new school opening. Inspection of the coefficients across the columns does indeed indicate heterogeneous impacts of redistricting with the most pronounced effects being appreciation for houses redistricted to the proposed school (Frederick Douglass). Columns (1) and (3), respectively, show the effect of being redistricted to the proposed school for houses previously in the zones for Bryan Station and Henry Clay. Appreciation started after the announcement but only had trivial impacts on house values in the two schools, with 0.8 percent in Bryan Station and 0.1 percent in Henry Clay. Following approval, properties from Bryan Station redistricted to Frederick Douglass increased by 2.2 percent while those redistricted from Henry Clay depreciated by a statistically-insignificant 0.8 percent. The most significant impact for the proposed school happened in the $PostOpen$ stage where homes in the old Bryan Station zone had a 4.8 percent increase while in contrast, homes in old Henry Clay saw a dramatic 6.6 percent decrease in prices. Given that the proposed school had limited information available to home buyers, it is reasonable to see insignificant effects prior to the opening. Once it was opened with more information on the school quality, diverging effects emerged for the two original school zones.

Confirming our expectations about school quality of the respective high schools, being redistricted from Bryan Station to Paul Dunbar results in a 1.6, 2.8, and 11.4 percent increase in housing price relative non-switchers in Bryan Station in the three periods. Moving from Lafayette to Henry Clay leads to a 7.7, 5.0, and 3.1 percent increase as well. Only redistricting from Henry Clay to Tates Creek and from Paul Dunbar to Lafayette show negative net impact in the post-approval period, consistent with the differences in test scores between these schools.

In addition to the magnitude of capitalization from this redistricting, the timing of the capitalization merits discussion as well. From Table 5 we see that significant capitalization occurs early – following the announcement of redistricting in three of the six rezoned boundaries. It seems puzzling that people in Lafayette and Paul Dunbar reacted to an uncertain boundary change so early as no information about the redistricting was available at this time. However, further analysis actually shows it is quite possible people had prior information on redistricting. Figure A4 presents a magnified map focusing on Lafayette to Henry Clay redistricting. The old school zones were covered by light and dark blue colors, and the boundaries after redistricting were drawn by solid black lines. It is apparent that the south-east corner of Lafayette was the only part on the shared boundary that is cut into the new Henry Clay zone. No sales were possible in this area as it is a university campus. In addition, the old boundary was overlapped with Tates Creek Road and the new boundary overlapped with Nicholasville Road, another major road in Lexington. To understand the odd estimate for Paul Dunbar, as shown in Table B2, we control for the fact that much of the redistricted area is within 0.35 miles from the Lafayette-Dunbar border. By doing so, we find that this result disappears – there is no significant appreciation in the rezoned areas during the announcement period.

6.1.3 Discussion: Expectation versus Implementation

The importance of how policy expectations, rather than simply implementation, affect housing prices can be seen by comparing the estimation results in Table 5 to the results found in Table 6, Panel A, a set of "naive" regressions in which the only treatment is the implementation of the redistricting (*PostOpen*). If we compare the coefficients on $Rezoned \times PostOpen$ for the respective samples in Table 5 to those found in Table 6 we see a pattern of attenuation – smaller coefficients (in absolute value) and fewer significant results. This result is not surprising as sales in the redistricted (treated) areas following the announcement of the redistricting proposal and prior to its implementation are now part of the comparison group rather than another treatment – for the entire sample, sales during this period comprised 38 percent of the comparison sample. Then, as seen in Table 5, these sales had appreciation (or depreciation) of equal or greater magnitudes to that found after opening any comparison that includes these sales tends to bias the coefficient on $Rezoned \times PostOpen$ towards zero in Table 6. As can be seen in Table 6, Panel B, this attenuation is exacerbated when there is a higher percentage of sales incorrectly placed in pre-treatment phase that should considered in the post-approval treatment.

These results are also consistent with Cheshire and Sheppard (2004), where it is argued that uncertainty plays an important role in determining expected school quality and hence expected housing value. Because both the quality of a school could change and boundaries could be redefined, home buyers face uncertainty. Cheshire and Sheppard (2004) estimates show that for houses located in periphery areas with new construction the value of educational quality is discounted by more than 40 percent relative to houses in other parts of the city. That the houses previously in the Bryan Station and Henry Clay school zones redistricted to the proposed saw little changes in sales prices during the approval period contrasts with the significant changes in sales prices found during the approval period for houses redistricted between existing schools. This finding is consistent with the possibility of more uncertainty about the quality of education in the proposed school. Following opening of the new school (Frederick Douglass) and more information about it, there is significant capitalization.

6.1.4 Redistricting and the Number of House Sales

In a long-run equilibrium with relatively stable boundaries for schools as was the case for Lexington prior to the 2017 redistricting, theory suggests we should have a sorting of households based on their preferences (willingness to pay) for schooling (Tiebout, 1956). Redistricting, then, change one of the most important amenities associated with a neighborhood – its schools. As parents bid for good schools, housing demand is affected by school redistricting. Liu and Smith (2022) find a positive shock to school quality will reduce the time-on-market by 4.6 weeks in Atlanta, Georgia. In Table 5 we saw evidence of how redistricting affects the willingness to pay for houses in the redistricted areas. As these changes in schools and school quality may not be valued for all current residents, we should expect re-sorting of residents to occur within these areas – an increase in housing sales relative to those areas that were not redistricted.

In Table 7 we report on the effect of redistricting on the number of sales, monthly and quarterly per census tract. While there are 82 census tracts in Fayette County, 17 were dropped because they had a mix of houses that were redistricted (treated) and those that were not (comparison). The results show, as we should expect, an increase in housing sales in the redistricted tracts following the approval of redistricting, almost 1 more sale per month and 2.6 more sales per quarter, in a rezoned tract, which are twice the estimates during post-announcement period with the effect attenuating after the school opening. To give some further perspective, the .896 higher monthly sales for tracts in rezoned areas during the period following approval is 17% higher than in those areas not subject to rezoning. Using quarterly sales gives us similar results.

6.1.5 Specification Checks

Last, we implement a placebo test to assess validity of our difference-in-differences approach. In this exercise, we randomly assign treatment status to sales in each old school zone from a uniform distribution. Then we discard the true treatment groups and run regressions on the false treatment and control group for each old school zone. The results are found in Table B3. The coefficients on both $Rezoned \times PostApprove$ and $Rezoned \times PostOpen$ in each regression are not statistically different from zero, suggesting our findings that redistricting affect the housing prices are causal.

6.2 Test Scores, Capitalization, and The Timing of Redistricting

One explanation for the effect of redistricting on property values reported in Table 5 is the change in expected school quality for those houses scheduled to be redistricted. As discussed in Section 2, a frequently used measure of school quality in the literature is school test scores. In the case of Kentucky high schools the standard test used is the ACT, required for all students after 2007. The relationship between housing prices and ACT scores is summarized in Figure 6. The scatter plot of annual median sale price and average ACT score shows a clear, if noisy, positive correlation between the two. To better understand the impacts of redistricting on property values, we next estimate the relationship between test scores (ACT) and property values. Our particular interest is on how the impact of test scores on property values may differ throughout the redistricting process.

We follow Black (1999), among others and use a boundary fixed effect approach to isolate the effects of school quality on property values from other shared amenities along school boundaries. There are seven shared boundaries between high schools in Fayette County. These bordered pairs capture those unobserved characteristics within a neighborhood. As we have a repeated cross-section following Dhar and Ross (2012) and Dachis, Duranton and Turner (2012), we include fixed effects for each school/border to control for sorting and resulting demographic differences along school boundaries (Bayer, Ferreira and McMillan, 2007). As discussed in Section 5.2 concerns about sorting and unobserved differences in populations along the school boundaries are reduced both because we have a repeated cross-section and the fact that the borders we use were announced only in 2015 and implemented in 2017.

We estimate separate repeated cross-sectional regressions using observations within 0.35 mile from the common boundary for sales for three separate periods: 1) before the approval of redistricting; 2) between approval and implementation of the redistricting; and 3) after implementation. For the periods prior to approval of the redistricting plan and following its implementation we use the ACT score for the high school to which the property is zoned. However, for the period between approval of the plan and its implementation (June 2015 - August 2017) the appropriate measure of ACT is not obvious for those properties to be redistricted in 2017 – should it be their current high school or their high school effective in 2017? For this reason, we estimate two regressions for this period with one using current ACT and one using expected ACT, that is, the ACT score of the 2017 high school. We express our estimating equation as a simple cross-sectional hedonic in which, as mentioned, the sample is restricted to sales within 0.35 mile of the seven boundaries and run separately for sales prior to and after the June 2015 approval of redistricting.

In Column (1) of Table 8 we report coefficient estimates when we include all sales within Fayette County and do not control for demographic variables while in column (2) we include percent of black, percent of hispanic, and median household income to account for residential sorting. In general, we find that before the redistricting proposal increases in ACT composite test scores increase housing prices. In contrast to Bayer, Ferreira and McMillan (2007) among others, the coefficient we estimate on test score controlling for boundary fixed effects is not statistically different from when we control for demographics.

Panel B shows the estimates where we use sales after approval but before implementation of the redistricting plan with current school ACT scores. The valuation of school quality appears unchanged as one point increase in ACT scores continues to lift housing prices by 2.5 percent. However, the results found in Panel C,[21] where current high school ACT score is replaced with the ACT score for the 2017 high school for redistricted properties, serves as a striking contrast to the results in Panel B. Coefficients on the ACT scores in Panel C are all significant and of magnitudes almost doubled as those found in Panel A and B. That current high school ACT score during the approval period had little impact on housing prices (Panel B) but the scores of the future high school had a large and significant impact (Panel C) strongly suggests that home purchasers knew of redistricting plans and considered them and their implications on future school quality when purchasing for housing. Finally, we conduct similar analyses but with the new boundaries in panels D through F. We do not find significant impacts of test scores on hypothetical boundaries for sales before the approval. Using current school test scores along the new boundaries actually attenuate the impact by about 30% though not statistically significant. Nonetheless, it is still an economically large impact as we replace the current school with the expected school test scores and the effect of ACT on house values increases to 1.9 percent, almost 50% increase compared to 1.3 percent in Panel D.

[21] Sales in old Bryan Station but in new Frederick Douglass are not included because no test scores data are available.

7 Conclusion

Using the process of school redistricting in Fayette County, Kentucky, we are able to identify the changes in housing values from switching from one school zone to another. Our estimates suggest that on average prices of houses being redistricted will increase by around one percent after the approval of the redistricting plan but the extent of appreciation differs across redistricting pairs. Houses in the lowest-performing school (as measured by ACT scores) that are redistricted to the new school appreciate by 4.8 percent relative to houses there that are not being redistricted, equivalent to a price increase of $8,048 using the mean price of the original zone. As well, following Black (1999) we estimate a boundary fixed effect model to examine the impact of test scores on house prices and find that changes in boundaries disrupt existing valuation of school quality near the boundaries after the approval of redistricting.

In contrast to existing studies examining the effect of educational reform on housing prices, we consider the possibility that the timing of these effects differs among stages in the policy process – the announcement of a policy reform, its approval, and, finally, its implementation. We find that residents update their beliefs and anticipate the policy in their housing decisions – changes in housing prices occur before the policy reform is implemented. Evidence of this can be seen by differences in the impact of school quality on property values for houses to be redistricted when we use the test scores for their current schools and their future schools during the approval period. The placebo check that random assigns rezoning status to each house showing no significant effects supports our main estimate that the redistricting effect is causal.

While we are examining a specific type of policy reform in education, high school redistricting, in a single school district (Fayette County, KY), that we find the effects of this reform on housing prices occurs before the policy is implemented is consistent with studies examining anticipatory behavior in environmental policy (Kiel and McClain (1995), Somerville and Wetzel (2021)), labor policy (Malani and Reif, 2015), and welfare policy (Blundell, Francesconi and van der Klaauw, 2011). We find, like these other studies, that failure to consider the possibility of anticipatory behavior can bias estimates of the treatment effects. Future studies examining the effects of educational and other policies on housing markets might be well advised to address the possibility of these anticipatory effects in their experimental framework.

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8 Figures

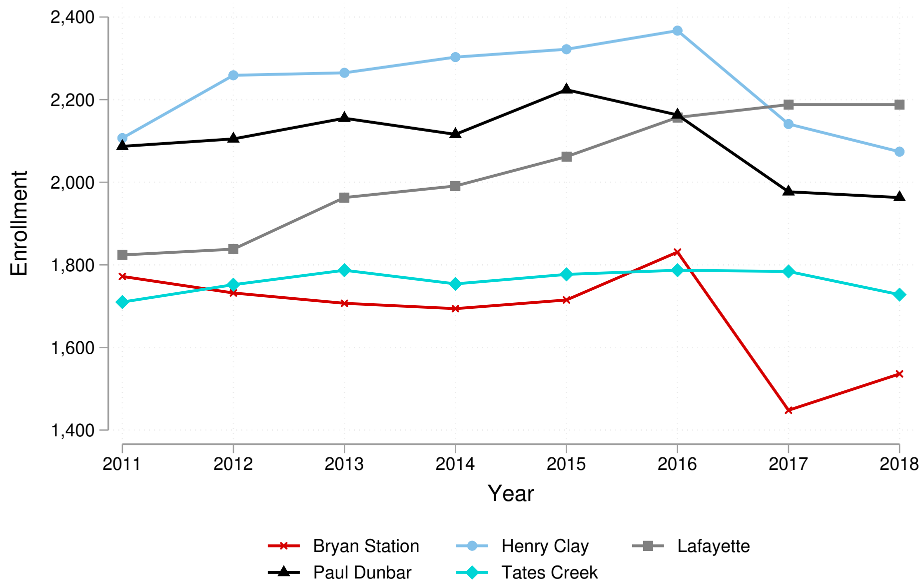


Figure 1: Annual Enrollment in Fayette County High Schools

Figure 2: Change in High School Catchment Area Boundaries

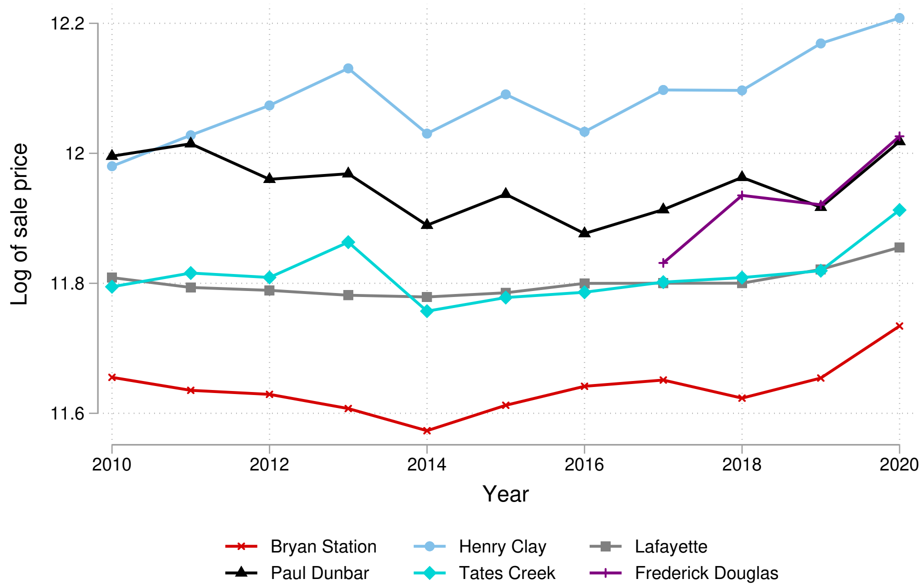


Figure 3: Median House Price by High School Catchment Area and Year

Notes: Price data are adjusted by US Urban Housing CPI.

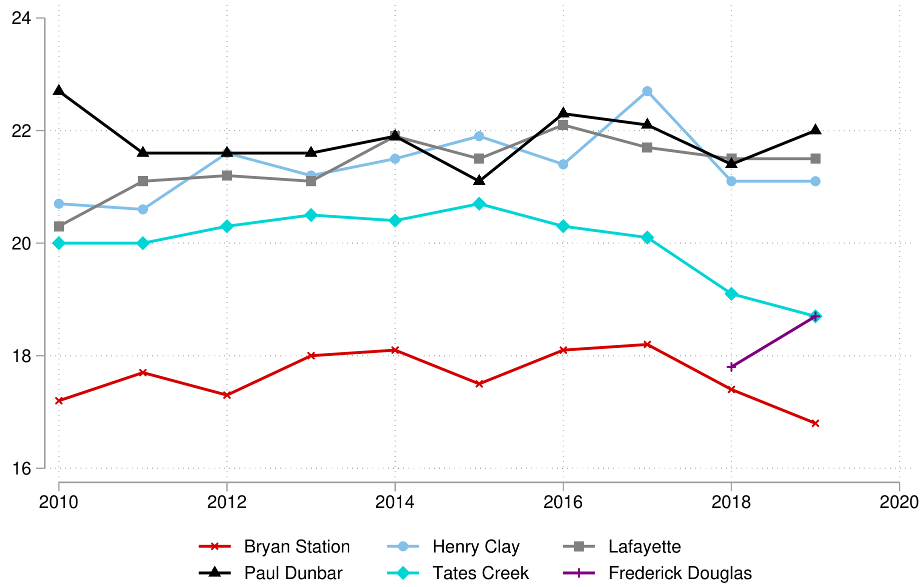


Figure 4: ACT Composite Scores by High School Catchment Area and Year

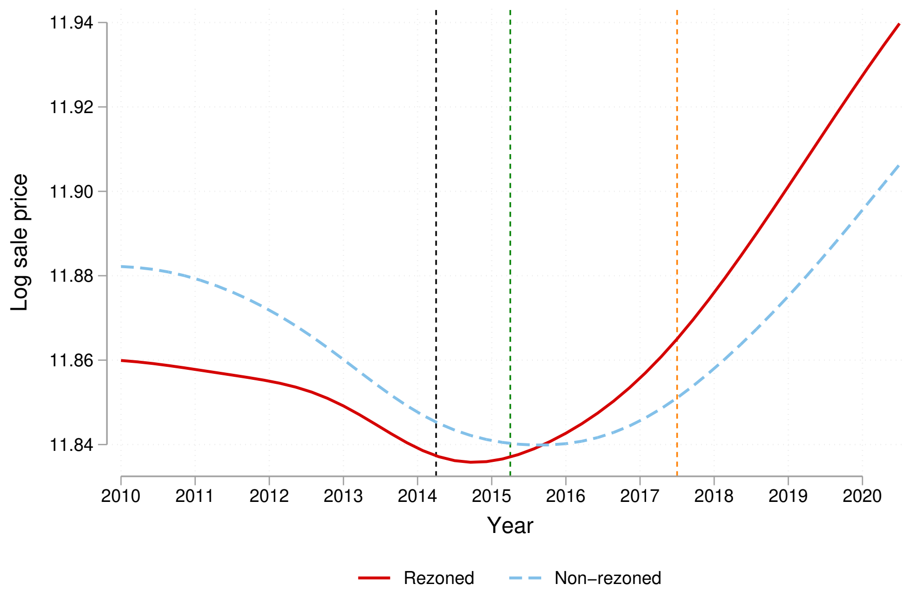


Figure 5: Sales Price Trends for Rezoned and Non-rezoned Groups

Notes: This figure compares the trend of log sales prices in rezoned area and non-rezoned area. Houses sold in areas that are subject to redistricting are in rezoned group and houses that are not subject to redistricting in included in non-rezoned group. We use local polynomial regressions to smooth quarterly data.

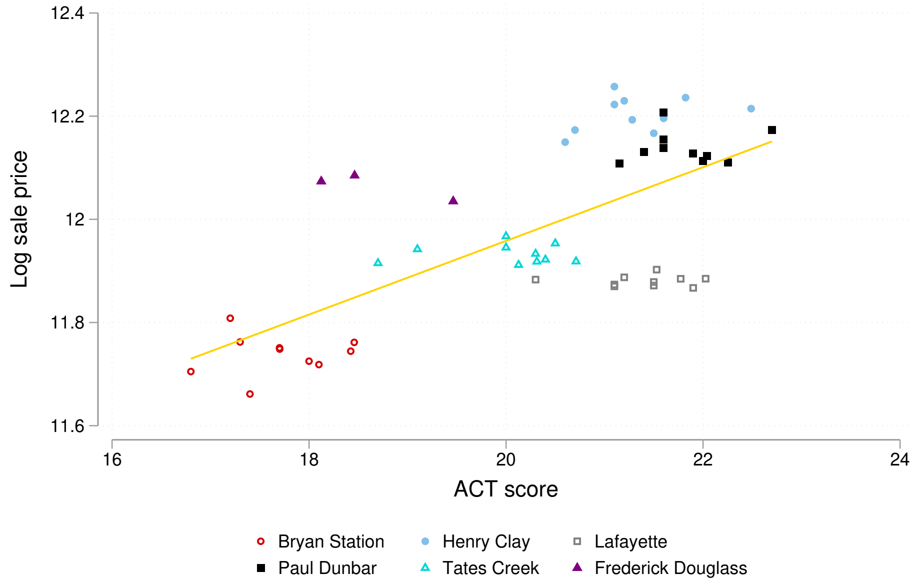


Figure 6: Scatter Plot of Mean Price and Composite ACT Score by High School and Year

9 Tables

Table 1: Timeline for Planning and Implementation of Redistricting

Date	Event	Treatment
April 29, 2014	Announce Plan to Redistrict/Add School	
April 14, 2015	Present Plan to Board/Public	Announcement
April 21, 2015	Board Meets to Get feedback	
June 3, 2015	Approve Plan	Approval
August 16, 2017	Open Fredrick Douglass and Implement New Zones	Opening

Table 2: Summary Statistics, Pre-Treatments (2010 - April 2014)

	(1) Bryan Station	(2) Henry Clay	(3) Lafayette	(4) Paul Dunbar	(5) Tates Creek	(6) Rezoned	(7) Nonrezoned	(8) *t*-statistic	(9) Total
Sale price	126458.1	197244.4	143543.7	190414.5	152898.7	155208.3	159459.6	2.63	158381.9
	(59109.1)	(107295.0)	(57237.5)	(103918.2)	(71911.2)	(81278.5)	(86307.8)		(85078.3)
Log sale price	11.67	12.05	11.81	12.02	11.84	11.84	11.86	1.78	11.86
	(0.381)	(0.536)	(0.365)	(0.524)	(0.422)	(0.445)	(0.475)		(0.467)
Square footage	1654.1	1961.7	1664.6	2005.3	1830.3	1778.2	1808.0	2.37	1800.4
	(531.3)	(741.8)	(532.3)	(779.8)	(689.1)	(624.4)	(674.5)		(662.2)
Log square footage	7.365	7.510	7.371	7.530	7.444	7.428	7.435	1.17	7.433
	(0.297)	(0.382)	(0.300)	(0.383)	(0.370)	(0.328)	(0.356)		(0.349)
Age	0.202	0.370	0.416	0.311	0.255	0.251	0.324	16.03	0.306
	(0.202)	(0.283)	(0.278)	(0.183)	(0.137)	(0.210)	(0.249)		(0.242)
Stories	1.397	1.474	1.343	1.424	1.435	1.394	1.419	2.85	1.413
	(0.451)	(0.446)	(0.428)	(0.461)	(0.470)	(0.450)	(0.453)		(0.453)
No. full bath	1.929	1.980	1.747	2.087	1.969	1.997	1.909	-6.83	1.931
	(0.615)	(0.722)	(0.589)	(0.857)	(0.622)	(0.721)	(0.666)		(0.681)
All brick	0.184	0.462	0.432	0.542	0.358	0.347	0.382	3.86	0.373
	(0.387)	(0.499)	(0.495)	(0.498)	(0.480)	(0.476)	(0.486)		(0.484)
Urban	0.983	0.994	1	0.981	1	0.991	0.991	0.16	0.991
	(0.129)	(0.080)	(0)	(0.137)	(0)	(0.094)	(0.092)		(0.093)
Distance to school	3.548	2.223	2.121	1.711	1.694	3.249	2.113	-42.56	2.401
	(1.729)	(1.217)	(1.242)	(1.048)	(0.734)	(1.303)	(1.440)		(1.490)
Distance to park	0.375	0.359	0.332	0.333	0.282	0.359	0.335	-4.35	0.341
	(0.344)	(0.245)	(0.196)	(0.411)	(0.176)	(0.285)	(0.288)		(0.287)
Distance to USB	0.836	1.651	1.693	0.677	1.004	1.236	1.177	-3.2	1.192
	(0.671)	(1.228)	(1.040)	(0.601)	(0.613)	(0.847)	(1.016)		(0.976)
Observations	3,999	3,123	3,012	2,025	2,531	3,724	10,966		14,690

Notes: This tables shows summary statistics of major variables for houses sold before the approval of redistricting. Standard deviations in parentheses. Sale price is adjusted by U.S. urban housing inflation deflator. Distance to school measures the minimum distance to the actual catchment area school. Distance to park and USB are referring to the minimum distance to nearest park and urban service boundary.

Table 3: Demographics along New and Old School Boundaries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. 2010-2015 (Pre-Approval)	Bryan Station Henry Clay	Bryan Station Lafayette	Lafayette Tates Creek	Henry Clay Lafayette	Henry Clay Tates Creek	Lafayette Paul Dunbar	Bryan Station Paul Dunbar	
White	0.117***	-0.207***	0.029*	-0.168***	-0.085***	-0.049***	-0.085***	
	(0.007)	(0.022)	(0.015)	(0.022)	(0.007)	(0.008)	(0.019)	
Median household income	9,804.464***	-4,712.725***	-25,573.239***	9,959.761***	-1,793.431	6,689.403***	-31,702.515***	
	(1,461.960)	(682.589)	(1,354.408)	(2,209.923)	(1,659.993)	(1,663.063)	(1,148.657)	
B. 2016 (Post-Approval)	Bryan Station Frederick Douglass	Bryan Station Lafayette	Lafayette Frederick Douglass	Henry Clay Lafayette	Henry Clay Tates Creek	Lafayette Paul Dunbar	Bryan Station Paul Dunbar	Henry Clay Frederick Douglass
White	-0.139***	-0.003	-0.315***	0.062***	-0.079***	-0.079***	-0.131***	-0.116***
	(0.047)	(0.096)	(0.025)	(0.009)	(0.007)	(0.020)	(0.017)	(0.015)
Median household income	1,882.091	-2,725.750***	3,504.167***	8,474.734*	-1,713.645	12,543.243***	-13,287.817***	-7,780.134**
	(3,347.690)	(854.059)	(314.930)	(4,426.606)	(1,384.580)	(3,825.862)	(1,745.883)	(3,675.002)

Notes: This table reports the mean differences in percent of white and median household income of census tracts on the two sides of school-paired borders using ACS 5-year data. Sample consists of houses located within 0.25 mile from the boundary. Panel A reports the differences along the old boundaries and Panel B reports the differences in 2016 along the new boundaries. The difference is using the latter school subtracting the former. Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Redistricting Effects for All Sales

	(1) All treatments	(2) All treatments	(3) Approval & opening	(4) Only opening	(5) Approval & opening grouped
Rezoned	0.074	0.085	0.083	0.080	0.083
	(0.059)	(0.060)	(0.061)	(0.061)	(0.060)
PostAnnounce	0.007	0.008			
	(0.006)	(0.006)			
PostApprove	0.022**	0.021**	0.014**		
	(0.010)	(0.010)	(0.007)		
PostOpen	0.012	0.012	0.004	-0.012*	
	(0.011)	(0.012)	(0.010)	(0.007)	
PostApproveOpen					0.014**
					(0.007)
Rezoned × *PostAnnouce*	-0.003	-0.010			
	(0.010)	(0.010)			
Rezoned × *PostApprove*	0.009	-0.010	-0.007		
	(0.009)	(0.012)	(0.011)		
Rezoned × *PostOpen*	0.015	-0.008	-0.006	-0.003	
	(0.019)	(0.023)	(0.024)	(0.024)	
Rezoned × *PostApproveOpen*					-0.007
					(0.013)
BetterRezoned × *PostAnnouce*		0.011			
		(0.016)			
BetterRezoned × *PostApprove*		0.031**	0.028**		
		(0.014)	(0.012)		
BetterRezoned × *PostOpen*		0.038	0.035	0.023	
		(0.025)	(0.025)	(0.025)	
BetterRezoned × *PostApproveOpen*					0.031**
					(0.015)
Observations	35,773	35,773	35,773	35,773	35,773
R^2	0.861	0.861	0.861	0.861	0.861

Notes: This table shows the results using different specifications of treatment and timing of shocks. Column (1) uses all three treatments. Column (2) shows the results of where we interact difference-in-differences estimators with a dummy *BetterRezoned* indicating that the rezoned future school is better than old school. Columns (3) through (5) follow the specification in column (2) with different treatments. Column (3) does not account for announcement shock. Column (4) only uses opening shock. Column (5) groups approval and opening together. All regressions control for log square footage, building age and age square, number of stories, number of full baths, all-brick dummy, urban dummy, distance to school, distance to park, distance to urban service boundary, elementary and middle school effects. Census tract, year, and seasonal fixed effects are also included. Robust standard errors are clustered at census tract level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Redistricting Effects by School-Pair

	(1) Bryan Station to Frederick Douglass (6)⟶(5)	(2) Bryan Station to Paul Dunbar (6)⟶(1)	(3) Henry Clay to Frederick Douglass (2)⟶(5)	(4) Henry Clay to Tates Creek (2)⟶(4)	(5) Lafayette to Henry Clay (3)⟶(2)	(6) Paul Dunbar to Lafayette (1)⟶(3)
$Rezoned \times PostAnnouce$	0.008	0.016	0.001	-0.019*	0.077***	-0.050***
	(0.013)	(0.010)	(0.014)	(0.011)	(0.013)	(0.012)
$Rezoned \times PostApprove$	0.022	0.028**	-0.008	-0.050***	0.050***	-0.008
	(0.014)	(0.013)	(0.014)	(0.013)	(0.009)	(0.013)
$Rezoned \times PostOpen$	0.048*	0.114***	-0.066***	-0.058	0.031**	-0.007
	(0.026)	(0.023)	(0.016)	(0.058)	(0.014)	(0.026)
Observations	9,767	6,442	6,705	5,919	6,595	4,621
R^2	0.854	0.815	0.873	0.881	0.733	0.906
Non-rezoned	5,601	5,601	5,189	5,189	5,830	3,680
Rezoned	4,166	841	1,516	730	765	941

Notes: This table reports estimates based on Equation (2). High school rankings by average ACT score are listed in parentheses. Each column shows a separate regression using sales only from one old school catchment area. Independent variables and fixed effects follow Table 4. Robust standard errors are clustered at census tract level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Redistricting Effects by School-Pair with Opening Treatment

	(1) Bryan Station to Frederick Douglass (6)⟶(5)	(2) Bryan Station to Paul Dunbar (6)⟶(1)	(3) Henry Clay to Frederick Douglass (2)⟶(5)	(4) Henry Clay to Tates Creek (2)⟶(4)	(5) Lafayette to Henry Clay (3)⟶(2)	(6) Paul Dunbar to Lafayette (1)⟶(3)
Panel A: 2010-2020						
$Rezoned \times PostOpen$	0.034	0.099***	-0.061***	-0.027	0.001	0.005
	(0.027)	(0.019)	(0.015)	(0.056)	(0.014)	(0.031)
Observations	9,767	6,442	6,705	5,919	6,595	4,621
R^2	0.853	0.815	0.873	0.880	0.732	0.906
Panel B: 2013-2020						
$Rezoned \times PostOpen$	0.025	0.083***	-0.062***	-0.003	-0.015	0.017
	(0.027)	(0.021)	(0.017)	(0.055)	(0.013)	(0.033)
Observations	8,107	5,392	5,426	4,810	5,218	3,666
R^2	0.857	0.819	0.875	0.882	0.732	0.905

Notes: This table shows the results using only post-opening treatment as compared to Table 5. Robust standard errors are clustered at census tract level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Redistricting Effect on Number of Sales

	(1) Monthly sales	(2) Quarterly sales
Rezoned	-0.738*	-1.307
	(0.388)	(1.034)
Rezoned × *PostAnnounce*	0.557*	1.520
	(0.285)	(1.024)
Rezoned × *PostApprove*	0.984***	2.620***
	(0.241)	(0.790)
Rezoned × *PostOpen*	0.666***	1.829***
	(0.190)	(0.596)
Observations	6,684	2,651
R^2	0.601	0.785

Notes: This table presents the impact of redistricting on number of houses sold at tract level. Dependent variable is number of sales and unit of observation is census tract-month pair in column (1) and tract-quarter pair in column (2). There are 82 tracts and we drop 17 that have both rezoned and non-rezoned houses. Because we use average monthly and quarterly sales data, we omit the approval month (quarter) and opening month (quarter). All specifications control for tract and month (quarter) fixed effects. Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

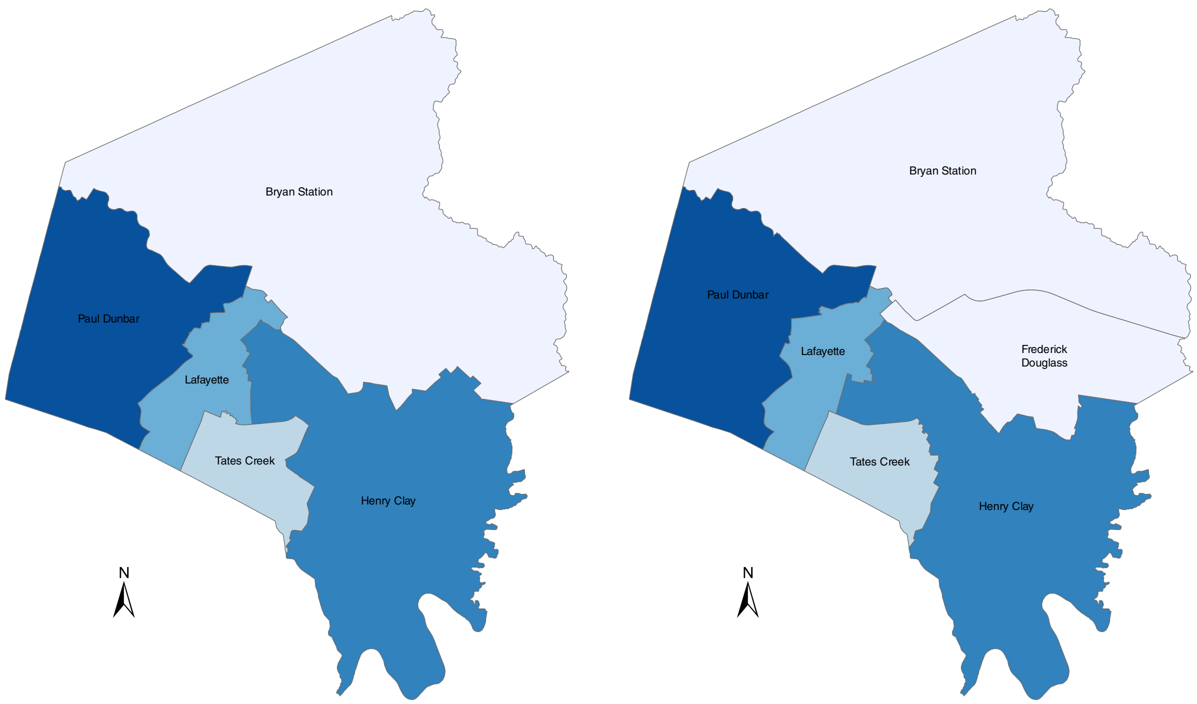
Table 8: ACT Scores and Housing Prices, Boundary Fixed-Effect Estimates

	(1) Excluding demographics	(2) Including demographics
Old Boundary		
A. Before approval		
ACT	0.024*	0.023**
	(0.013)	(0.011)
Observations	4,314	4,314
B. After approval & before opening (current school ACT score)		
ACT	0.025**	0.025**
	(0.010)	(0.012)
Observations	2,790	2,790
C. After approval & before opening (expected school ACT score)		
ACT	0.041***	0.045***
	(0.009)	(0.010)
Observations	2,169	2,169
New Boundary		
D. Before approval		
ACT	0.011	0.013*
	(0.008)	(0.007)
Observations	4,234	4,234
E. After approval & before opening (current school ACT score)		
ACT	0.009	0.009
	(0.012)	(0.011)
Observations	2,758	2,758
F. After approval & before opening (expected school ACT score)		
ACT	0.016	0.019
	(0.014)	(0.015)
Observations	2,293	2,293

Notes: This table shows test score effects within 0.35 mile of school boundaries. The first three panels define boundaries based on old boundaries. The last three panels define boundaries based on new boundaries. Panel A and D use sales prior to the approval of redistricting plan. Panel B and E use sales between the approval day and the implementation day of the rezoning plan. For these panels, the scores we use are current school ACT scores. Panel C and F use the same sample following B and E but with expected future school ACT scores after approval. Dependent variable is log sale price. We include high school boundary fixed effects, elementary and middle school effects, and year and seasonal fixed effects. Robust standard errors are clustered at census tract level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendices

A Additional Figures



(a) Old School Attendance Zones

(b) New School Attendance Zones

Figure A1: Pre-Approval (Old) and Post-Approval (New) Fayette County High School Catchment Areas

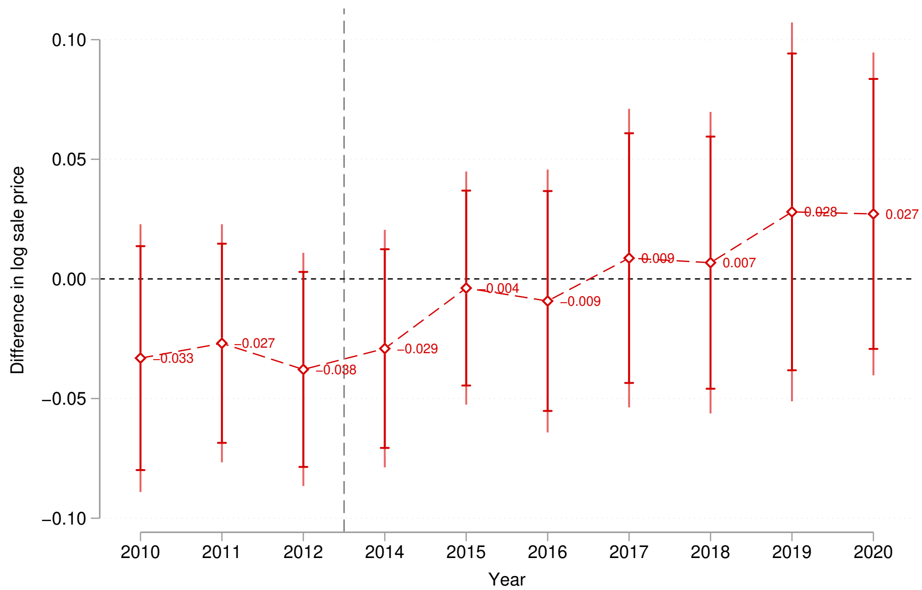


Figure A2: Parallel Trend Test

Notes: This figure plots the event-study style parallel trend test of the difference in log sale price between rezoned and non-rezoned homes relative to 2013.

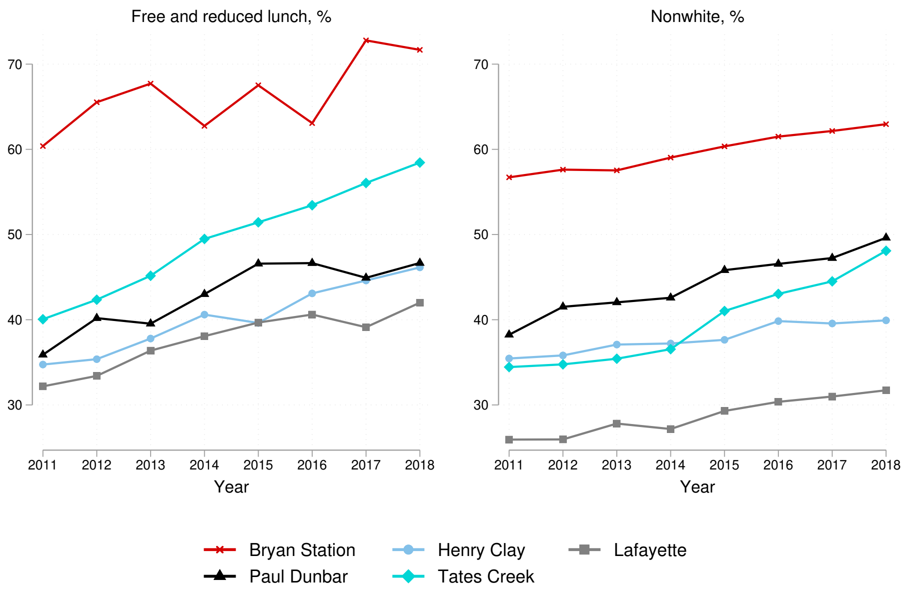


Figure A3: School Characteristics

Notes: This figure plots the percentage of students that are taking free and reduced lunch (left panel) and the percentage of students that are nonwhite (right panel) in each high school.

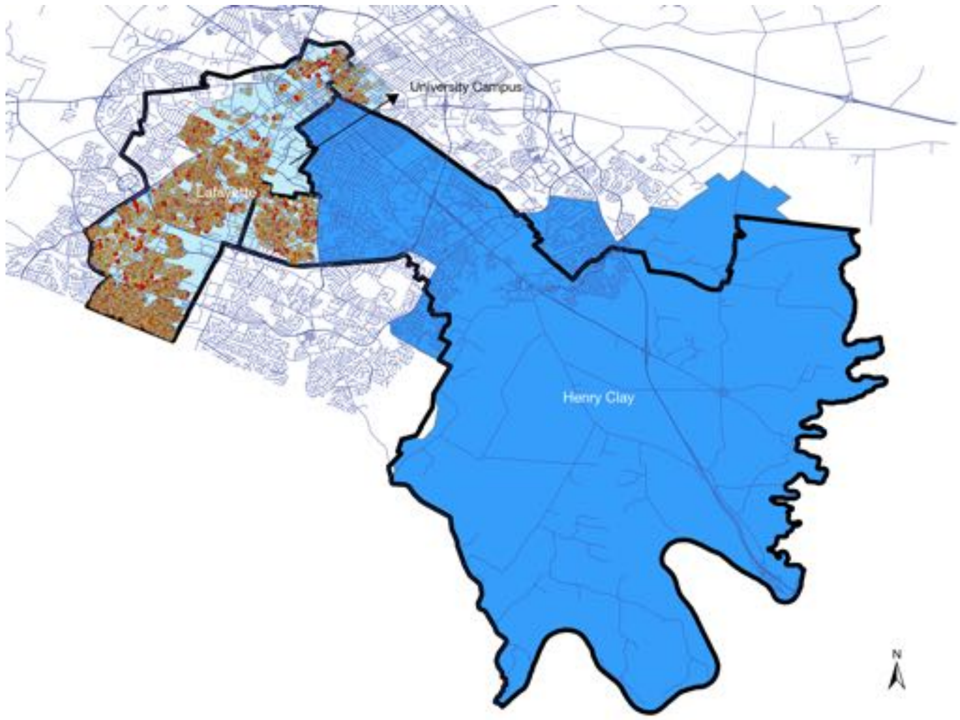


Figure A4: Lafayette to Henry Clay Redistricting

Notes: This map shows the redistricting of Lafayette to Henry Clay. We also overlap the school zones with major roads and sales points in Lafayette. Colored regions represent pre-redistricting school zones where solid black lines draw the post-redistricting school boundaries. Red, orange, and grey dots represent sales happened in post-announcement, post-approval, and post-opening stages in old Lafayette zone.

B Additional Tables

Table B1: Number of Sales Based on the Rezoned High School Zones, 2010-2020

	Rezoned School Zones						
	Bryan Station	Henry Clay	Lafayette	Paul Dunbar	Tates Creek	Proposed	Total
A. Before announcement							
Bryan Station	1,442	0	0	227	0	1,187	2,856
Henry Clay	0	1,564	0	0	190	479	2,233
Lafayette	0	248	1,949	0	0	42	2,239
Paul Dunbar	0	0	278	1,189	0	0	1,467
Tates Creek	0	17	0	0	1,839	0	1,856
Total	1,442	1,829	2,227	1,416	2,029	1,708	10,651
B. After announcement & before approval							
Bryan Station	588	0	0	82	0	473	1,143
Henry Clay	0	626	0	0	84	180	890
Lafayette	0	87	667	0	0	19	773
Paul Dunbar	0	0	120	438	0	0	558
Tates Creek	0	11	0	0	664	0	675
Total	588	724	787	520	748	672	4,039
C. After approval & before opening							
Bryan Station	1,596	0	0	247	0	1,142	2,985
Henry Clay	0	1,409	0	0	216	386	2,011
Lafayette	0	198	1,561	0	0	52	1,811
Paul Dunbar	0	0	268	942	0	0	1,210
Tates Creek	0	23	0	0	1,668	0	1,691
Total	1,596	1,630	1,829	1,189	1,884	1,580	9,708
D. After opening							
Bryan Station	1,976	0	0	285	0	1,365	3,626
Henry Clay	0	1,590	0	0	240	471	2,301
Lafayette	0	232	1,654	0	0	89	1,975
Paul Dunbar	0	0	276	1,111	0	0	1,386
Tates Creek	0	28	0	0	2,062	0	2,090
Total	1,976	1,850	1,929	1,396	2,302	1,925	11,378

Notes: This table shows number of sales in each school catchment area in terms of its relative location before and after the redistricting. The first column lists the original five high schools and the top row shows the six schools under the approved redistricting plan. Diagonal numbers represent sales in a catchment area that is not subject to redistricting.

Table B2: Redistricting Effects for Paul Dunbar to Lafayette

	(1)
Rezoned	-0.179***
	(0.031)
Buffer	-0.091***
	(0.023)
PostAnnounce	0.008
	(0.024)
PostApprove	0.042**
	(0.017)
PostOpen	0.051*
	(0.024)
Buffer×*PostAnnounce*	0.021
	(0.018)
Buffer×*PostApprove*	0.022
	(0.013)
Buffer×*PostOpen*	0.013
	(0.008)
Rezoned × *PostAnnouce*	-0.036
	(0.023)
Rezoned × *PostApprove*	0.007
	(0.013)
Rezoned × *PostOpen*	0.019
	(0.026)
Rezoned×Buffer	0.067**
	(0.028)
Rezoned×Buffer×*PostAnnounce*	-0.021
	(0.031)
Rezoned×Buffer×*PostApprove*	-0.037***
	(0.012)
Rezoned×Buffer×*PostOpen*	-0.057**
	(0.019)
Observations	4,621
R^2	0.908

Notes: This table shows the analysis of triple-difference-in-differences for homes in Paul Dunbar that are rezoned to Lafayette. Buffer is a dummy variable and is equal to one if a house is located within 0.35 mile from the Paul Dunbar-Lafayette old boundary. All control variables and fixed effects follow the main specification. Robust standard errors are clustered at census tract level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3: A Placebo Test: Random Assignment of Treatment

	(1) Bryan Station to Proposed	(2) Bryan Station to Paul Dunbar	(3) Henry Clay to Proposed	(4) Henry Clay to Tates Creek	(5) Lafayette to Henry Clay	(6) Paul Dunbar to Lafayette
$Rezoned \times PostAnnouce$	0.013	0.018	-0.023	0.002	0.014	-0.005
	(0.013)	(0.021)	(0.014)	(0.022)	(0.030)	(0.030)
$Rezoned \times PostApprove$	-0.007	-0.031*	-0.007	0.024	-0.030	-0.013
	(0.010)	(0.018)	(0.013)	(0.030)	(0.020)	(0.012)
$Rezoned \times PostOpen$	-0.008	-0.011	-0.025	0.043	0.005	0.013
	(0.006)	(0.020)	(0.017)	(0.030)	(0.020)	(0.008)
Observations	9,739	6,340	6,887	5,797	6,563	4,621
R^2	0.852	0.846	0.879	0.880	0.726	0.905

Notes: We randomly assign paired treatment status to house sales in each old school catchment area based on the uniform distribution. All regressions follow the previous specifications controlling for house attributes, distance to parks and schools, elementary and middle schools, as well as census tract, year, and seasonal fixed effects. Robust standard errors are clustered at census tract level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$