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Abstract

Increasing levels of segregation in American schools raises the question: do home buyers pay for test scores or demographic composition? This paper uses Connecticut panel data spanning eleven years from 1994 to 2004 to ascertain the relationship between property values and explanatory variables that include school district performance and demographic attributes, such as racial and ethnic composition of the student body. Town and census tract fixed effects are included to control for neighborhood unobservables. The effect of changes in school district attributes is also examined over a decade long time frame in order to focus on the effect of long run changes, which are more likely to be capitalized into prices. The study finds strong evidence that increases in percent Hispanic has a negative effect on housing prices in Connecticut, but mixed evidence concerning the impact of test scores on property values. Evidence is also found to suggest that student test scores have increased in importance for explaining housing prices in recent years while the importance of percent Hispanic has declined. Finally, the study finds that estimates of property tax capitalization increase substantially when the analysis focuses on long run changes.

Journal of Economic Literature Classification: D1, D4, I2, R2, R5.

Keywords: School District Performance, Test Score, Demographics, House Price, Omitted Neighborhood Attributes. Assessed Value model.

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1. Introduction

The U.S. educational system is characterized by tremendous diversity across school districts in school performance, socio-economic status, and racial and ethnic composition. The segregation of students by socio-economics status, race or ethnicity raises concerns about the extent of equality of opportunity in our society, and these concerns may be increasing in importance as a number of studies have documented growing levels of segregation in American public schools, e.g. Clotfelter, Ladd, and Vigdor [13], Reardon and Yun [33], and Frankenburg and Lee [19].¹ Moreover, racial segregation has been shown to be associated with lower outcomes for minority students (Hanushek, Kain, and Rivken [22], Mickelson [31], Card and Rothstein [8]) and lower school quality (Freeman, Scafidi, and Sjoquist [20]).

Many cross-sectional studies have examined property values in order to assess the value people place on the quality of local schools. Typically, property values from samples of housing transactions are regressed on some measure of school quality, such as standardized test scores. For example, Taylor [38], Cheshire and Sheppard [9], Weimer and Wolkoff [39], Hayes & Taylor [24], Bogart and Cromwell [5], and Haurin and Brasington [23] all find a positive relationship between standardized test scores and housing prices using cross-sectional analyses.² In addition, a few of these studies examine the effect of socio-economic and demographic composition of the student body. For six Louisiana parishes, Norris [32] finds that the representation of African-Americans in local schools either has no effect or even leads to an increase in property values. Similarly, Weimer and Wolkoff [39] finds the unexpected result that the share of students who are eligible for the free-lunch program is associated with higher property values.

A common concern in studies of school quality capitalization is that school quality may be correlated with unobserved neighborhood characteristics. Black [3] examines housing transactions that occur on the boundary between elementary school attendance zones and finds an effect of school quality that is 30 to 40 percent smaller than traditional cross-sectional estimates. Similarly, Leech and Campos [30], Kain, Staiger, and Samms [27], Kain, Staiger, and Riegg [26],

¹ Clapp and Ross [10] find that school segregation would have fallen in Connecticut over the 1990's except that those declines were offset by the increasing share of minority students in the state.

² Taylor [38] reviews the literature on the capitalization of school quality into housing price. Ross and Yinger [37] review the general empirical literature on public service quality and property tax capitalization. One limitation of this literature is that the price depends upon both supply and demand factors. In order to truly identify the effect of preferences a full hedonic demand function must be estimated. This has been made practical in a single market using the nonlinear identifying conditions discussed by Eckland, Heckman and Nesheim [15]; they generalize Epple [17]. Also, see Bayer, Ferrera, and McMillan [1] for structural estimates of demand for school attributes. Norris [32] allows for simultaneity in his model but is forced to rely on troublesome identifying assumptions. In contrast, we rely on the assumption that prices describe a long-run equilibrium implying that our parameters reveal relationships in this equilibrium. We support this assumption by examining changes in housing prices over short and long time-frames.

Gibbons and Machin [21] and Brasington and Haurin [7] also identify the effect of school using across boundary variation finding comparable positive effects of schools on property values.³ Several papers, Bogart and Cromwell [4], Downes and Zabel [14], Kain, Staiger, and Samms [27], Kain, Staiger, and Riegg [26], Figlio and Lucas [18], and Reback [34] identify the effect of school quality on prices using variation across time that allows them to control for neighborhood quality and other time invariant factors. The results of these studies are mixed with a number of studies finding little if any impact of student test scores on property values.⁴ Some of the cross-time studies examine the effect of demographic attributes on prices with Bogart and Cromwell [4] finding no effect of race on prices while Downes and Zabel [14], Kain, Staiger, and Riegg [26], and Reback [34] finding that changes in demographic attributes are important.⁵

This paper examines the effect of school district performance as measured by student test scores and the effect of the student socio-economic and demographic composition on local property values using a panel of housing transactions in the state of Connecticut between 1994 and 2004. We identify the effect of school attributes separately from neighborhood quality by including school district or neighborhood (census tracts) fixed effects exploiting the cross time variation available in the panel.⁶ This decision is primarily driven by the nature of our data relative to other papers that have used the boundary approach. Most studies that use variation across boundaries had detailed information on school attendance zone while our study, like many of the other cross-time studies, has information at the school district level where boundaries are less likely to divide homogenous neighborhoods. Further, in Connecticut, school districts

³ Gibbons and Machin [21] and Brasington and Haurin [7] control for neighborhood quality using a spatial smoother, which retains the discontinuous effect of schools on prices across boundaries, implicitly identifying their models off of price variation across boundaries. Gibbons and Machin also instrument for school quality using lagged values and find much larger effects of school quality on price in their IV models. Similarly, Rosenthal [35] instruments for school quality using the recent occurrence of an external inspection as an instrument, but finds substantially smaller effects than either Black or Gibbons and Machin. Also, see Bayer, Ferrera, and McMillan [1] for a structural model that uses both school district boundary effects and traditional IV approaches to separately identify preferences for school and neighborhood attributes.

⁴ Many of the cross-time studies exploit policy variation, such as a redistricting (Bogart and Cromwell [4], Kain, Staiger, and Riegg [26]), introduction of a system of school choice (Reback [34]), and introduction or release of school report cards (Kain, Staiger, and Samms [27], Figlio and Lucas [18]). However, the specific impact of test scores on housing prices, when estimated, is often identified using cross-time variation in the panel.

⁵ Clotfelter [12] found that racial composition of schools was important for explaining changes in housing prices in the south following school desegregation orders.

⁶ Many of the cross-time variation papers above control for fixed effects using a repeats sales approach. Given that our measures of school quality and demographics do not vary within school districts, however, the correlation of these variables with omitted, time-invariant town, neighborhood, and housing unit attributes should be eliminated by simply controlling for district fixed effects. Moreover, a number of papers have raised concerns that repeat sales analyses may be inconsistent due to selection bias arising from the requirement that a unit sell two or more times during the sample period (Kiel and Zabel [28], Clapp, Giaccotto and Tirtiroglu [11]).

boundaries share boundaries with towns exacerbating concerns that houses on either side of a boundary belong to quite different neighborhoods.

Two significant concerns arise when using cross-time variation to identify the effect of town or school district attributes on housing prices. First, the elimination of fixed effect typically reduces the variation arising from unobservables thereby increasing the relative importance of any measurement error in the data, see Kain and Staiger [25] regarding school test scores. Second, short-term fluctuations in district attributes may not represent permanent changes and as such may not be fully capitalized into housing prices, see Yinger, Bloom, Borsch-Supan, and Ladd [40] concerning property taxes. In order to address the first concern, we follow Gibbons and Machin [21] and Kain, Staiger, and Samms [27] using three-year moving averages of district attributes. Finally, we estimate a series of long-run models comparing changes in housing prices and district attributes over seven, eight, nine and ten year periods.

In our neighborhood fixed effect analysis, we find statistically significant, but very small effects, of test scores on property values with a one standard deviation increase in test scores leading to one and a third percent increase in property values.⁷ While our findings are substantially smaller than the two and half percent effect in Black [3], the results confirm Black's finding that failing to control for neighborhood unobservables leads to an overstatement of the effect of test scores on property values, which is important given recent concerns that capitalization may be lower near boundaries due to the possibility of future boundary changes (Cheshire & Sheppard [9]).⁸ We find a substantial negative effect of percent African-American and percent Hispanic with a 10 percentage point increase in these variables leading to a three and a half and three percent decline in property values, respectively. When moving averages of district attributes are used, the effects of math score and percent African-American on housing prices decline in magnitude, and the effect of a 10 percentage point increase in the Hispanic students increases to over 4 percent.

⁷ It is important to distinguish between our analysis that examines the impact of test scores after controlling for student demographics, and studies that develop and control for a measure of school or school district value-added, such as Downes and Zabel [14], Kain, Staiger, and Samms [27], Kain, Staiger, and Riegg [26], Taylor [38], and Brasington and Haurin [7]. School district value-added is intended to capture the contribution of the school to student performance by examining changes in test scores or by controlling for the expected performance of the student body. The failure to find a relationship between value-added measures of school quality and housing prices does not imply that homeowners ignore school quality, but rather that the intrinsic attributes of the school's student body is the most important determinant of school quality as opposed to educational inputs. Alternatively, in our model, we attempt to test whether homebuyers respond most to average test scores, which of course captures the quality of the student body, or to demographic composition.

⁸ Cheshire & Sheppard [9] argue that Black's [3] findings may not be the result of omitted neighborhood variables, but rather that attendance zones may change over time and as a result parents along zone boundaries may pay a smaller premium for school quality differences due to the possibility of being redistricted into the other school. Cheshire and Sheppard [9] and Brasington [6] provide evidence that capitalization is lower in areas where housing supply is expanding or more elastic.

In our long-run analyses, the negative effect of percent Hispanic increases in importance with a 10 percentage point increase leading to between a five and ten percent decline in prices with the largest changes arising in the models covering the longest time frame, but the negative effect of percent African-American is not robust. The negative impact of property taxes on housing values is substantially larger in the long-run analyses increasing from 37 percent to between 56 and 63 percent of the present value of future taxes being capitalized into property values. The effect of test scores appears sensitive to the time frame with test scores being positive and statistically significant for the shortest time frame. This sensitivity led us to explore whether the effect of test scores and percent Hispanic on property values is changing over time, and we found strong evidence that the influence of percent Hispanic is weakening over time and some evidence that the importance of test scores is increasing.

The remainder of the paper is organized as follows: Section II covers the methodology; Section III describes the data; and Section IV presents the findings. Finally, Section V summarizes and discusses the major findings.

2. Methodology

The hedonic function⁹ for the price (P_{ijkt}) of house i in neighborhood j in school district k at time t can be defined as follows:

$$\ln(P_{ijkt}) = \alpha + \delta Z_{kt} + \omega_t + \Gamma_{ijk} + \varepsilon_{ijkt} \quad (1)$$

where Z_{kt} are the year-specific school district attributes, which includes school district performance as measured by standard test scores, socio-economic and demographic composition of the students, and the local property tax rate, ω_t represents variation in market prices over time, Γ_{ijk} is a term that captures time-*invariant* attributes of the housing unit including attributes of the unit's neighborhood and school district, and ε_{ijkt} is a time-*variant* unobservable that is assumed to be randomly distributed and uncorrelated with Z_{kt} , ω_t , and Γ_{ijk} .

Heterogeneity over time in terms of market conditions (ω_t) and across units (Γ_{ijk}) are primarily addressed by a large number of fixed effects. In the case of market heterogeneity, the level, trends, and seasonality in housing prices are allowed to vary across market. Specifically, the state is divided into labor market areas that represent metropolitan style housing markets, and year and month fixed effects are included for every labor market area. Given that our primary variables of interest are at the school district level, any correlation between district level variables

⁹ This semi-log specification is standard in the literature.

(Z_{kt}) and unit unobservables (Γ_{ijk}) can be eliminated and consistent estimates obtained by the inclusion of district level fixed effects. Specifically, Γ_{ijk} is written as a linear function of housing unit (X_i) and neighborhood (W_j) attributes and district fixed effects (v_k) .

$$\Gamma_{ijk} = \beta X_i + \mu W_j + v_k \quad (2)$$

Combining equation (1) and equation (3), we obtain:

$$\ln(P_{ijkt}) = \alpha + \delta Z_{kt} + \omega_t + \beta X_i + \mu W_j + v_k + \varepsilon_{ijkt} \quad (3)$$

Equation (3) is the district fixed effect model. This specification is closest to one in Black (1999) because it should eliminate any correlation between school performance at the specific scale measured and average neighborhood quality at that scale.

Unlike Black [3], however, our analysis is at the school district level, and the effect of schools may be identified by comparing sales that occurred in different neighborhoods within the same school district. If neighborhood quality varies substantially within districts, a comparison of transaction prices that does not control for the neighborhood unobservable will have higher variance and is likely to provide estimates with larger standard errors. This problem can be addressed by including a full set of neighborhood fixed effects $(\sigma_j)^{10}$ and estimating

$$\ln(P_{ijkt}) = \alpha + \delta Z_{kt} + \omega_t + \beta X_i + \sigma_j + \varepsilon_{ijkt} \quad (4)$$

The models in equations (3) and (4) are estimated for a series annual transaction samples that are pooled over time, and accordingly transactions can be observed in the same school district or neighborhood (census tract) at different times and therefore with different district attributes.

In addition, we estimate models that use three-year moving averages of school district attributes in order to address concerns that district attributes may be measured with error. Specifically,

$$\ln(P_{ijkt}) = \alpha + \delta \bar{Z}_{kt} + \omega_t + \beta X_i + \sigma_j + \varepsilon_{ijkt} \quad (5)$$

¹⁰ Note that the school district/town fixed effects (v_k) are subsumed into the neighborhood fixed effects (σ_j) because census tracts do not cross town/district boundaries in Connecticut. Given that our measures of school quality and demographics do not vary across neighborhoods within a school district, these district variables should be uncorrelated with omitted, time-invariant neighborhood attributes, and both the town and tract analyses should be consistent. As noted in the text, however, the tract fixed effect analysis is likely to yield more precise estimates.

where \bar{Z}_{kt} is the average of Z_{kt-1} , Z_{kt} , and Z_{kt+1} .

The long-run models are estimated by forming pairs of two years, t and $t+d$, where t is the a sample year and d is the period between early and later years in the pair, pooling samples of transactions based on all relevant pairs of years, and including year-pair specific neighborhood/tract fixed effects. These models are also estimated using equation (5) except that fixed effect is designated by t to be pair specific and so the coefficients on district attributes (δ) are only identified based on changes in attributes and prices that occurred over d years.

$$\ln(P_{ijkt}) = \alpha + \delta \bar{Z}_{kt} + \omega_t + \beta X_i + \sigma_{jt} + \varepsilon_{ijkt} \quad (6)$$

$$\ln(P_{ijkt+d}) = \alpha + \delta \bar{Z}_{kt+d} + \omega_{t+d} + \beta X_i + \sigma_{jt} + \varepsilon_{ijkt+d}$$

Clearly, an identification strategy based on across time variation is not perfect in that fixed effects cannot control for unobservable changes in neighborhood quality at the level of the town or census tract. However, the strategy provides a tractable and reasonable approach for identifying the effect of school quality and demographic attributes separately from neighborhood quality. Further, an across time approach is complementary to identification strategies based on boundaries in that the two approaches have very different strengths and weaknesses.

Finally, in terms of inference, standard errors are based on clustering at the district-year level for all models. Unlike a traditional panel where the inclusion of district or tract fixed effects will eliminate within group (district) correlation, our sample contains many observations for the same district and transaction year, and our district attributes are aggregated at this level. The correlation between transactions that occurred in the same district and year will bias traditional standard error estimates upwards and clustering at this level of aggregation is the appropriate response.¹¹

¹¹ The need to cluster at the district-year level raises concerns because we are then unable to cluster across time. Bertrand, Duflow, and Mullainathan [2] argue that standard errors in fixed effect models are biased by heteroscedasticity and autocorrelation, and Kezdi [29] demonstrates using simulations that clustered standard errors are suitable for use with autocorrelated and heteroscedastic panel data. We have estimated standard errors clustered at the tract level, and these errors are smaller than the district-year clustered errors so the district-year clustering is used to be conservative. Further, the long-run analysis is based on comparisons between transactions at the beginning and the end of a period, which is comparable to the before and after approach suggested by Bertrand, Duflow, and Mullainathan [2] for obtaining consistent estimates of standard errors. We have not found any evidence to suggest that autocorrelation in our data creates substantial bias in the standard errors.

3. Data Description and Summary Statistics

This study used a sample of sales of owner-occupied properties with one to four units¹² spanning over eleven years from 1994 to 2004; the data are purchased from Banker and Tradesman for the state of Connecticut. The sample has 356,829 transactions for one to four unit owner-occupied structures after any filtering to eliminate invalid or nonrepresentative transactions. This data set contains information about the unit address, selling price, assessed value and sales date, as well as the detailed listing of the unit characteristics such as internal square footage, number of rooms, bedrooms, bathrooms, building age and lot size.¹³ Table 1 shows the data filters imposed in order to eliminate observations that appear to contain spurious and unreliable information. Observations are not deleted when information on unit characteristics are missing. Rather, dummy variables are included in the specification to allow for a unique intercept for all observations missing the same attribute or set of attributes.

Table 2 gives the summary statistics over all years of the variables that enter into regression analysis. The house sales price is shown under the dependent variable heading. The average sales price over the period is \$235K based on 1994 prices, but with a very high standard deviation of 322K. Further, inflation adjusted prices grew at an average of 5.4 percent per year. Variables under the heading *Hedonic/housing attributes*, indicate the average number of rooms (6.7), bedrooms (2.4), bathrooms (2.0), age of the unit (42 years), and internal square footage (1,698). The *Town/School district characteristics* panel shows the transaction sample average of the standardized 8th grade mathematics, reading and writing scores. We focus on 8th grade test score because most towns in Connecticut have only one middle school/junior high providing a measure of district performance that is uniform across all houses in most towns.¹⁴ The district average mathematics test score is standardized for the state by year in order to address the general upward trends in test scores during the last decade.¹⁵ Within town

¹² We include single-family, two-family, three-family, and residential condominiums. We compare results from the estimation with the sample that excludes the residential condominiums, an exclusion of about 13,500 transactions. Results are robust to the exclusion of condominiums. Note that for many years our data does not distinguish between single-family units and multi-family units with four or less units. Hedonic models that use only later years where single-family units can be identified do not appear to be affected by the elimination of small multi-family units from the sample.

¹³ Some observations have missing information on one or more housing attribute. These observations are retained in the sample and dummy variables are included to control for the fact that a specific attribute is missing.

¹⁴ Key results are robust to dropping the large central city districts, which tend to have multiple, heterogeneous schools that educate 8th graders.

¹⁵ All core findings are robust to alternative approaches for standardizing test scores, as well as being robust to the use of standardized reading or writing test scores.

variation in standardized test scores over time represents changes in the position of a district relative to the distribution of district test scores across the state. The mean is negative capturing the fact that larger central city districts with lower test scores have more housing transactions than individual, smaller suburban towns, and the standard errors are above one capturing across time variation test scores. The sample average of the proportion of students qualifying for the free lunch program is 22.5 percent, proportion of non-English speaking students (NEHL) is 11.6 percent, proportion of students who are African-American is 12.4 percent, and proportion Hispanic is 11.5 percent. All four groups have increased representation over time of between two and three percent per year except for Hispanics who have a seven percent population growth rate per year.¹⁶

The property tax rate (“mill rate”) for each town/school district in each year was obtained from State of Connecticut's Office of Policy Management. The statutory mill rate does not represent the effective tax rate in the town because properties in Connecticut are only reassessed every decade and the reassessment year varies across towns. An effective or equalized property tax rate (EPTR) is generated based on the logic that the actual property tax burden will be substantially below the statutory rate when a town’s properties have assessed values that are well below the properties’ market values. Specifically, EPTR in a town for a given year is calculated by multiplying the town’s statutory mill rate times the average of the ratio of assessed value to sales price for all units sold in that town during the year. Average statutory property tax rate is \$31 per \$1000 of assessed house value. The average ratio of assessed value to sales price is about 72% leading to an average effective tax rate in the state of just over 2% of market value.

The actual variable included in the regressions uses a standard function form for approximating the present value of property taxes per dollar of property value given that effective tax rates are expected to remain the same or

$$\text{PV of Property Taxes} = \log [r + \text{EPTR}/1000] \quad (7)$$

see Yinger, Bloom, Borsch-Supan, and Ladd [40]. The discount rate r is assumed to be 0.03, which is fairly standard in the literature. The estimated coefficient on this variable captures the share of property tax burden that is capitalized into the house price. It

¹⁶ All averages are taken over the sample of units, which disproportionately represents tracts that contain a large number of owner-occupied housing units and tracts in which such units sell more frequently.

should be noted that the estimate of property tax capitalization varies monotonically with the discount rate assumption.

This study uses the census tract as a proxy for neighborhood.¹⁷ Neighborhood fixed-effects are defined based on the 838 tracts in the State of Connecticut during the 1990 Decennial Census. The 1990 census is used to obtain median family income, proportion of African-Americans in tract, proportion of Hispanics in tract, proportion of owner occupied units in tract, and proportion of married couple with children in each tract. The census tract attributes are used as control variables in the simple pooled cross-sectional analysis, as well as the town fixed effects analysis. Census tract control variables are held constant over time, rather than using a weighted average between 1990 and 2000 censuses, in order to be consistent with the neighborhood fixed effect specifications, which control for time-invariant aspects of neighborhood quality. The estimates for district variables, however, do not appear to be sensitive to use of time varying census tract attributes.

Finally, the specification includes both year and month fixed effects based on the sales date in the housing transaction record. Separate year and month fixed effects are estimated for each market or region in the state in order to account for the possibility that housing price appreciation varied regionally. The 10 Labor Market Areas (LMA's) in Connecticut are used to define markets or regions. LMAs are collections of towns defined by the State Department of Labor and are conceptually similar to the U.S. Census defined Metropolitan Statistical Areas (MSAs).¹⁸

4. Results

Table 3 presents the parameter estimates for our baseline models. The first column shows the traditional hedonic regression results where we do not control for the town or tract fixed effects, a pooled cross-sectional analysis. The second and third columns present the hedonic estimation after controlling for the town fixed effects and tract fixed effects, respectively. We have included the physical unit characteristics,¹⁹ town/district characteristics, and in the first two

¹⁷ Alternatively, census block groups might be used as a definition of neighborhood, but the transaction data begins to get quite thin at that level of disaggregation.

¹⁸ LMA has some key advantages over MSA: a. the areas are consistent with town boundaries. b. LMA provides complete coverage of all towns within the state, and c. LMA is defined at a smaller scale and so, better representative of commuting and residential patterns in a small and densely populated state like Connecticut.

¹⁹ To capture the non-linearity in Internal Square Footage, we have used a spline or piecewise variable. We selected to put the 'knot' at 2500 sq.ft.

models neighborhood or census tract characteristics.²⁰ The coefficient estimates on the physical unit characteristics are all reasonable and very robust across the three specifications.²¹

On the other hand, the estimated effects of school district attributes are much more sensitive to the specification. As found by Black [3], the effect of test scores in a model that only controls for neighborhood observables (the hedonic baseline) is substantially overstated relative to fixed effects models. Specifically, in the OLS model, the effect of a one standard deviation increase in math score on property value is 7.4 percent while the fixed effect models indicate only a 1.4 or 1.3 percent effect. While small, this effect is statistically significant in the census tract fixed effect model due to the smaller standard errors in that model. These estimates can be compared to Black's [3] estimate of approximately 2.5 percent based on a one standard deviation change in test scores near Boston, and Gibbons and Machin's [21] finding of a 1.8 percent effect for London, which they estimated specifically for comparison with Black's earlier estimate.²² While noticeably smaller, our estimates are based on an identification strategy that does not focus on housing units near boundaries, and we confirm Black's finding that ignoring neighborhood unobservables leads to a substantial overstatement of the effect school quality on property values. This confirmation is significant given Cheshire and Sheppard's [9] argument that Black's finding may have arisen from uncertainty concerning the future location of boundaries rather than from the inclusion of neighborhood effects. All models are re-estimated using reading and writing test scores, and the results are very similar.

Returning to Table 3, the OLS estimates indicate counter-intuitive, positive effects of percent of students who are non-English speakers and African-American on property values, which are consistent with earlier cross sectional studies by Norris [32] and Weimer & Wolkoff [39]. The fixed effect models, however, suggest that both higher percent African-American and higher percent Hispanic students in a district leads to lower property values in Connecticut. Specifically, the census tract fixed effect models imply that a one percent increase in percent of students African-American or Hispanic leads to a decrease in property values of 0.36 and 0.31 percent, respectively. These tract fixed effect estimates of demographic effects are comparable in magnitude to findings by Brasington and Haurin [7], Downes and Zabel [14], and Kain, Staiger, and Riegg [26]. The estimated effects are smaller and insignificant in the less efficient district fixed effect estimates, but the two sets of estimates, town and tract fixed effects, cannot be

²⁰ We include school spending in some models. It is typically insignificant, generates very unstable estimates and does not affect any of the other estimation results.

²¹ This finding is supportive of the idea that there are no substantial omitted housing attributes that vary systematically across neighborhoods. If omitted attributes vary systematically across towns, the attributes would be expected to be correlated with observed variables like square footage and number of bedrooms,

²² The Gibbons and Machin [21] effect is based on a five percent change in test scores, which was a one standard deviation change in Black [3]. Gibbons and Machin did not provide information on the variation in test scores over their sample.

distinguished from each other statistically. Finally, approximately 30 percent of the property tax obligations are capitalized into housing prices in both the town and tract fixed effect models, which is also consistent with the existing literature.

Table 4 revisits the models in Table 3 using a three year moving average of test scores, district demographic variables, and property tax in order to address concerns about measurement error in these attributes. Focusing on the tract fixed effect model, the estimated effect of test scores and percent of students African-American are relatively unchanged falling from 0.013 and -0.36 to 0.011 and -0.32, respectively. The effect of percent of students Hispanic and property taxes, however, increases in magnitude from -0.31 and -0.30 to -0.43 and -0.37, respectively. These results suggest that in our sample the impact of measurement error is most important for demographic and property tax variables as opposed to standardized test scores.

4.1. Long-Run Effect of School Attributes

Table 5 estimates long-run models that are similar to the tract fixed effect models with moving average district attributes above using transactions drawn from pairs of years that are separated by a specific number of years. Specifically, the four columns in the table present the results for models estimated using the only 10 year sample (1994 paired with 2004); the two 9 year samples (1994 and 1995 paired with 2003 and 2004, respectively) stacked into one regression; the three eight year samples; and the four seven year samples. These models include tract-pair of years fixed effects assuring that the influence of district attributes are captured based on changes in prices over the indicated time periods.²³

The analysis finds robust negative effects of percent Hispanic and property taxes. Specifically, the effect of Hispanics increases from -0.43 with yearly data to between -0.96 and -0.53 for the seven to ten year periods, meaning that a one percentage point change in Hispanic students is associated with a decline of between one-half and one percent in house prices. For the effective property tax variable defined by equation (6), the effect of a one percent change increases from -.37 percent with yearly data to between -0.63 and -0.56 percent in Table 5. The effect for percent African-American is not robust with statistically insignificant estimates for the longest time frame of ten years and reversing sign for a significant positive effect for shorter time frames. The effect of test scores is equally ambiguous with statistically insignificant results except for the shortest time frame of seven years and a clear monotonic relationship between the length of the time frame considered and the value of the test score coefficient. The reader should

²³ As in the short-run models, the errors are clustered at the district-year level because district attributes are aggregated at that level. The resulting standard errors are larger than those arising from a model where errors are cluster at the tract level.

note that the pooled results in Tables 3 and 4 are based on transaction comparisons over both short periods of a couple years and long periods of nine or ten years so that the effective time frame for Tables 3 and 4 is more comparable to the seven year time frame in Table 5 than to the other samples representing longer time frames.²⁴

4.2. Has the Effect of Key District Attributes Changed over Time?

However, the sensitivity of the test score and percent Hispanic student results to changes in the time frame raises questions about whether the property value effects are constant over time. Table 6 presents an additional analysis where both the math test score and the fraction Hispanic students variables are interacted with a year of transaction variable running from zero to ten for both the full sample from Table 4 and the eight and seven year time frame samples from Table 5.²⁵ The effect of percent Hispanic is above 0.90 and similar to the estimates for the longest time frames in Table 5 for all three samples, but the effect declines in magnitude over time and after 10 years the negative effect of percent Hispanic is estimated to be between -0.52 and -0.71. The level effect of test scores is near zero and insignificant, but for the eight and seven year time frame samples the interaction is positive and statistically significant so that the estimated effect size after ten years is between 2 and 4 percentage points for a one standard deviation change in test scores.

5. Conclusions

This paper uses a panel of school districts to examine the effects of school district test scores and demographic composition on housing prices after controlling for the influence of unobserved neighborhood attributes with fixed effects. In general, we find that people in the state of Connecticut during the study period seem to be more concerned about the changes in demographic attributes particularly percent Hispanic students than the changes in test scores when deciding how much to pay for homes. These findings do not necessarily imply that people were indifferent concerning school quality and test scores at the beginning of our sample period. Rather, the findings may reflect the fact that people make judgments about school quality using easily available signals. For example, people may rely on word of mouth recommendations and general reputation, which may not reflect substantial changes in school quality as captured by

²⁴ We also estimated results for shorter time frames and found results similar to the seven year time frame shown in the fourth column.

²⁵ The reader should note that the level effect of the transaction year time trend is captured by a series of fixed effects that are included in all model specifications and were described earlier in the paper.

changes in test scores over time. Further, the ethnicity of the student body in a school district is easily observable and in Connecticut highly correlated with test scores both in a cross-section and in changes. Therefore, school ethnic composition may provide homebuyers with a useful signal concerning school quality.²⁶

However, we find evidence that this pattern has been changing over time with the effect of Hispanic students declining and an increased importance being placed on test scores. These changes may reflect a decline in bias against Hispanics over the decade consistent with general patterns of declining discrimination in housing markets (Ross and Turner [36]). Alternatively, these changes may reflect a more general public awareness of readily available information on school test scores along with possibly greater saliency of test scores following the passage of the federal “No Child Left Behind” Act of 2001.

Our analysis also confirms earlier findings by Black [3] that cross-sectional studies that do not control for unobservable components of neighborhood quality overstate the influence of test scores on property values. This confirmation is important because Cheshire and Sheppard [9] have offered an alternative explanation for Black’s findings; namely that capitalization may be lower along boundaries because homeowners near the boundary may face more uncertainty arising from possible boundary adjustments in the future. While our identification strategy has its own inherent weaknesses, it is useful to confirm the importance of neighborhood unobservables in a model that does not rely on variation across boundaries.

Finally, our long-run analysis indicates that property tax capitalization may be understated in models that focus on year-to-year variation in property tax mill rates. Specifically, capitalization rates rise from around 30 percent to estimates between 56 and 63 percent when considered over a longer time frame. These results confirm an observation of Yinger, Bloom, Borsch-Supan, and Ladd [40] that existing studies may understate the true level of capitalization because households only respond to property tax differences when they expect those differences to persist.

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²⁶ This interpretation of the Hispanic results in our paper would be consistent with recent work on residential segregation, which suggests that white households do not explicitly care about race, but rather use race as a signal for hard to observe aspects of neighborhood quality (Ellen [16]).

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Table 1 Data Filters

Items	Number of Observations
Raw Data Set (with usage equal to Single-Family, Two-Family, Three-Family, Condominiums, Residential Dwelling 1-3 units and no missing tract information)	401,338
Missing town identifier	less: 2,211
Missing town attributes	less: 7,099
Price per square foot, Ratio of Sales price and assessed value beyond 3 std. Dev. Limit	less: 6,829
House Sales Price < \$10,000	less: 2,798
Assessed Value < \$10,000	less: 2,538
Internal Square Footage <= 400 sft, Number of Bedrooms > Number of Rooms, Units built before year 1600, Unit Age > 100 years	less: 30,133
Regression Sample	349,730

Table 2 Summary Statistics: All Years

Variable (Description)	Growth Rate (1994-2004)	Mean	Std. Dev.
<i>Price Variables:</i>			
<i>House Sales Price in \$1,000 ; tax and inflation adj. to 1994 prices</i>	5.40	235.417	322.321
<i>Hedonic/Housing Attributes:</i>			
<i>Number of Rooms</i>		6.719	2.345
<i>Number of Bedrooms</i>		2.438	1.656
<i>Number of Bathrooms</i>		1.974	0.881
<i>Age of the Building in 100s of years</i>		0.424	0.241
<i>Internal Square Footage in 1000s</i>		1.698	1.029
<i>Town/School District Attributes:</i>			
<i>Average Math Exam Score</i>		-0.413	1.309
<i>Fraction of Students qualifying for the Free Lunch Program</i>	2.01	0.225	0.222
<i>Fraction of Non-English speaking students</i>	3.30	0.116	0.135
<i>Fraction of African-American Students</i>	3.09	0.124	0.154
<i>Fraction of Hispanic Students</i>	7.34	0.115	0.137
<i>Effective Property Tax Rate per \$1,000, EPTR/1000 in eqn. (7)</i>		31.472	12.078
<i>Tract or Neighborhood Attributes:</i>			
<i>Median Family Income in 10,000s</i>		5.570	1.968
<i>Fraction of Blacks in Tract</i>		0.057	0.118
<i>Fraction of Hispanics in Tract</i>		0.041	0.069
<i>Fraction of Owner-occupied Units in Tract</i>		0.723	0.195
<i>Fraction of Married couples with Children in Tract</i>		0.322	0.044

Table 3 Math Score

Controls	OLS	Town FE	Census Tract FE
Number of Rooms	0.024 (10.07)	0.023 (9.97)	0.023 (10.79)
Number of Bedrooms	0.015 (4.75)	0.014 (4.66)	0.013 (4.56)
Age in 100s	-0.817 (-20.69)	-0.874 (-23.52)	-0.883 (-25.56)
(Age in 100s) ²	0.411 (10.49)	0.429 (11.54)	0.433 (12.74)
Log(square footage<2,500sft)	0.480 (32.97)	0.490 (34.85)	0.476 (36.01)
Log(square footage>=2,500sft)	0.076 (2.40)	0.057 (1.87)	0.070 (2.25)
Math Test Score	0.074 (8.99)	0.014 (2.53)	0.013 (2.45)
Fraction Student enrolled in Free Lunch program	-0.363 (-6.19)	0.049 (0.75)	0.019 (0.31)
Fraction Student Non-English Speakers	0.419 (4.93)	0.165 (1.24)	0.085 (0.79)
Fraction Student African-American	0.279 (6.64)	-0.152 (-0.77)	-0.364 (-3.81)
Fraction Student Hispanics	0.128 (1.22)	-0.136 (-0.66)	-0.308 (-1.90)
Effective Property Tax Rate	-0.531 (-11.49)	-0.305 (-8.30)	-0.299 (-8.69)
Median Family Income in Tract	0.086 (24.56)	0.063 (20.43)	
Fraction African-American Persons in Tract	-0.265 (-8.89)	-0.391 (-14.61)	
Fraction Hispanic Persons in Tract	-0.295 (-3.91)	-0.464 (-6.53)	
Fraction Owner-occupied units in Tract	-0.011 (-0.50)	0.030 (1.61)	
Fraction Married Couple with Children in Tract	-0.866 (-13.08)	-0.503 (-8.79)	
R²	0.702	0.718	0.733
N		349,730	

Table 4 Math Score, Moving Average

Controls	OLS	Town FE	Census Tract FE
Math Test Score	0.091 (9.65)	0.009 (0.89)	0.011 (1.07)
Fraction Student enrolled in Free Lunch program	-0.349 (-5.80)	0.121 (1.13)	0.072 (0.71)
Fraction Student Non-English Speakers	0.419 (5.06)	0.191 (1.01)	0.075 (0.55)
Fraction Student African-American	0.344 (8.16)	-0.138 (-0.67)	-0.323 (-3.17)
Fraction Student Hispanics	0.225 (2.13)	-0.353 (-1.49)	-0.428 (-2.10)
Effective Property Tax Rate	-0.582 (-11.06)	-0.374 (-7.78)	-0.374 (-8.16)
R²	0.703	0.718	0.733
N	349,730		

Table 5 Math Score, Moving Average, Sub-Samples

Controls	1994 & 2004	1994 & 2003 1995 & 2004	1994 & 2002 1995 & 2003 1996 & 2004	1994 & 2001 1995 & 2002 1996 & 2003 1997 & 2004
Math Test Score	-0.023 (-1.32)	0.006 (0.46)	0.016 (1.48)	0.032 (3.45)
Fraction Student enrolled in Free Lunch program	-0.128 (-0.77)	-0.245 (-1.97)	-0.172 (-2.16)	-0.157 (-1.87)
Fraction Student Non-English Speakers	-0.162 (-1.03)	0.128 (1.10)	0.036 (0.22)	-0.008 (-0.05)
Fraction Student African-American	0.191 (1.07)	0.423 (3.37)	0.262 (2.73)	0.167 (2.01)
Fraction Student Hispanics	-0.945 (-3.09)	-0.959 (-4.32)	-0.771 (-3.76)	-0.531 (-2.74)
Effective Property Tax Rate	-0.627 (-12.60)	-0.584 (-15.80)	-0.559 (-15.46)	-0.601 (-13.15)
R²	0.767	0.761	0.756	0.752
N	63,906	127,166	189,619	257,327

Table 6 Math Score, Moving Average, Paired Sub-Samples

Controls	Full Sample	1994 & 2002 1995 & 2003 1996 & 2004	1994 & 2001 1995 & 2002 1996 & 2003 1997 & 2004
Math Test Score	-0.001 (-0.07)	-0.005 (-0.37)	0.006 (0.54)
Math Test Score interacted with Transaction Year	0.001 (1.02)	0.002 (2.54)	0.003 (2.84)
Fraction Student enrolled in Free Lunch program	-0.043 (-0.49)	-0.229 (-2.72)	-0.265 (-3.24)
Fraction Student Non-English Speakers	0.261 (1.95)	0.146 (0.87)	0.162 (1.20)
Fraction Student African-American	-0.165 (-1.66)	0.273 (2.70)	0.216 (2.48)
Fraction Student Hispanic	-0.934 (-4.52)	-0.981 (-4.60)	-0.914 (-4.69)
Fraction Hispanic interacted with Transaction Year	0.038 (4.20)	0.027 (3.37)	0.039 (5.03)
Effective Property Tax Rate	-0.322 (-6.87)	-0.552 (-11.81)	-0.561 (-12.42)
R²	0.733	0.756	0.752
N	349,730	189,619	257,327

Notes to Table 3: the dependent variable is the natural log of transactions price, $\ln P_{ijkt}$ of house i in neighborhood j in school district k at time t ; t-values are in parentheses. Standard errors are based on town-year clustering.

Notes to Table 4: the dependent is the natural log of transactions price, $\ln P_{ijkt}$ of house i in neighborhood j in school district k at time t ; t-values are in parentheses. Standard errors are based on town-year clustering. Explanatory variables are three year moving averages: \bar{Z}_{kt} is the average of Z_{kt} , Z_{kt+1} , and Z_{kt+2} .

Notes to Table 5: These are tract fixed effect regressions for the pairs of years listed; the fixed effect dummy is specific to each tract and pair of years listed so as to identify parameters from changes over the indicated time frame. Pairs of years are pooled.

Notes to Table 6: Math Test Score and Fraction Student Hispanic have been interacted with a linear time trend based on transaction year. These two variables were selected because of the variation in their coefficients in Tables 3, 4 and 5.