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School Quality, House Prices, and Liquidity: The Effects of Public School Reform in Baton Rouge

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SCHOOL QUALITY, HOUSE PRICES, AND LIQUIDITY: THE EFFECTS OF PUBLIC SCHOOL REFORM IN BATON ROUGE

BY

VELMA ZAHIROVIC-HERBERT

A Dissertation Submitted in Partial Fulfillment
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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Andrew Young School of Policy Studies of Georgia State University.

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ABSTRACT

SCHOOL QUALITY, HOUSE PRICES, AND LIQUIDITY: THE EFFECTS OF PUBLIC SCHOOL REFORM IN BATON ROUGE

By

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After a court imposed desegregation plan ended in 1996, the Baton Rouge, Louisiana school district created neighborhood attendance zones for its schools, followed by a series of attendance zone changes. We use data from 1994 to 2002 to examine the impact of changes in school characteristics on simultaneous determination of house prices and liquidity in the market. A simultaneous equations model of sales price and tine-on-market is adopted that extends the hedonic price model by controlling for localized neighborhood market conditions. Our empirical results show that improving and declining school performance can have asymmetric capitalization effects. Further, as indicated by the search-market model, liquidity absorbs part of the capitalization of school quality; for example, declining school performance prolongs houses' marketing time.

Chapter 1: School Quality, House Prices, and Liquidity—The Effects of Public School Reform in Baton Rouge

A house is typically a person's largest asset, and the quality of local public schools is often a major consideration when a family with school-age children looks for a house to buy. To attract potential house buyers, real estate agents prominently feature which school district a house is in along with other characteristics such as the features of the house and proximity to parks, shopping, etc. Since information on schools is readily available to the public, house buyers can easily include school quality in their assessment of a house's value. With so much importance given toward housing and public schools, any relationship between them merits investigation.

This dissertation uses data from East Baton Rouge Parish, Louisiana, from 1994 through 2002 to study the relationship between property values and school performance and school racial composition. While numerous studies look at house buyers' valuations of school quality, there has been little emphasis on which measures of school quality they consider when making choices about where they live and how that affects their children's education. In addition, this research investigates the impact of school performance and school racial composition on liquidity.

Liquidity is a property of an asset that reflects how long traders must wait in order to trade at market prices. Most theories of asset pricing, based on modeling financial assets, assume that assets are perfectly liquid since buyers and sellers are matched instantaneously. However, the matching process between buyers and sellers can be quite slow in the residential housing market. By taking into account the interrelationship between selling prices and time-on-market, this dissertation provides a more complete analysis of the impact of changes in school characteristics on the housing market than previous research offers.

Many studies have examined property values in order to assess the value people place on the quality of local public services and property taxes.[1] Most of the studies that are concerned with school quality use the data on housing sales transactions and regress them on a measure of school quality. Studies such as Haurin and Brasington (1996), Hayes and Taylor (1996), and Black (1999) measure school quality through standardized test scores. Using cross-sectional analysis, they show a positive relationship between test scores and housing prices.

Yet, in addition to test scores, parents care about the peer effects and the environment in which their children are learning (Hanushek, Kain, & Rivkin, 2002; Hoxby, 2000). A school environment can be characterized by factors that include socio-economic and demographic composition of the student body. While Hanushek, Kain, and Rivkin (2002), and Hoxby (2000) examine peer effects and their relation to school performance, few recent studies consider direct student peer effects as measured by the socio-economic characteristics of the students in the school and their impact on house values. For example, Weimer and Wolkoff (2001) use the percent of an elementary school's student body that receives reduced-price lunch to show that excluding this factor substantially increase the coefficients for elementary test scores. A more recent study by Clapp, Nanda, and Ross (2005) finds strong evidence that the percentage of Hispanic students and the percentage of free lunch students have significant long-run negative effects on house values.

The hedonic price model and conventional capitalization theory suggest that the value of the characteristics of a house is fully capitalized into the house price. In the short run, the supply of owner occupied housing is fixed and the market response to demand shocks should be

[1] Ross and Yinger (1999) provide a review of the empirical literature on the capitalization of public service quality and property taxes into house prices.

symmetric: positive shocks resulting in price increases and negative shocks resulting in price decreases. However, these markets typically respond to large negative demand shocks with long periods during which asset liquidity declines but house prices change relatively little.[2] A few studies examine the impact of locational amenities on selling time.[3] It is well recognized that there is a tradeoff between an acceptable price and the time a seller has a house on the market (Belkin, Hempel, & McLeavey, 1976; Haurin, 1988). Nevertheless, previous housing market studies examine locational amenities' impact either on property values or on selling time. The simultaneous determination of sales price and time-on-market is overlooked in estimating the benefits of locational amenities. Failure to account for the simultaneity of the time-price relationship can result in biased estimates of different attributes that affect house prices.

In sum, the impact of public policies that alter locational amenities such as neighborhood school quality needs to be examined through not only sales prices but also the liquidity of the housing market.

Several events make East Baton Rouge Parish an ideal place to study the effect of school test scores and school racial composition on housing prices and time-on-market. First, under a court-imposed desegregation plan in place from 1981 through 1996, the district imposed random school assignments, which resulted in mandatory busing for its students. In an effort to achieve racial balance, formerly white and formerly black schools were paired or clustered, and students were bused to their clusters based on the need to create racial balance. These kinds of desegregation orders created strong public resistance and a migration of white students from the public school system. Finally, 15 years after court-ordered random school assignments started,

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[2] Stein (1995) and Genesove and Mayer (1997) explain the decline in asset liquidity that follows a negative demand shock by sellers being equity constrained.

[3] Nelson (1982) reviews studies that look into impact of highway noise on property values and selling time.

the district adopted a plan that eliminated random school assignment in favor of "community sensitive" attendance zones, which were drawn to maximize a sense of community and ownership of the schools.[4] The move to community sensitive attendance zones implies that the school attended by the student is strictly determined by residence location. For the period of random school assignments, school quality cannot be considered a locational amenity, yet when school attendance is determined by residence location, we can include school quality as one of the measures of locational amenities.

Second, because the district tried to promote racial desegregation, it implemented a series of attendance zone changes that included different neighborhoods often segregated along racial lines. Changes in attendance zones, or redistricting, affected the housing market in two ways. First, many houses were assigned to new schools, changing their locational attributes. Second, even for those houses that had stable school assignments, changes in attendance zones boundaries in other neighborhoods led to large changes in the characteristics of the students assigned to their schools.

It is often difficult to provide statistical evidence in the social sciences because most events are generated by actions that people undertake deliberately. We argue that events that occurred in East Baton Rouge Parish provide a rare opportunity to study how a sudden exogenous change in public policy impacts the housing market. The changes in school assignments implemented by East Baton Rouge Parish School System are a natural experiment in education policy. The school district was operating under a court-imposed desegregation order. This desegregation order caused changes in the housing market locational amenities in the form of test scores and school demographic composition. Such exogenous change allows us to

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[4] Consent Decree, page 2.

use classical statistical theory that works only if variations in data occur randomly. The uniqueness of our data set and empirical methodology avoid common difficulties in housing market studies. While looking within one school district enables us to eliminate variations in property tax rates, school spending, and other public services, two different sources of variation along boundaries of school attendance zones and following the change in school assignments provide for an ideal situation to study the effects of school quality measures and racial composition on housing prices. Similarly, controls for the localized housing market supply and demand conditions ensure that price and time-on-market equations are identified in the 2SLS estimation, and remove a potential source of spatial correlation in housing data.

This dissertation uses a unique data set to provide the first empirical study that considers the impact of changes in school quality on simultaneous determination of selling price and time-on-market in an empirical environment that controls for the neighborhood supply and demand conditions. By taking into account the interrelationship between prices and time-on-market, this dissertation provides a complete estimate of the impact of changes in school characteristics on housing market. The dissertation offers empirical evidence relevant to answering the following questions. What is a good school worth? Which school characteristics do parents find most important when examining school quality? How is the housing market affected by public policy that changes school quality? How does a change in school quality impact both components of the housing market: selling price and liquidity?

The dissertation is organized as follows; Chapter 2 presents the background information on the history of school desegregation in East Baton Rouge Parish. Its main focus is the events that took place after the end of court-ordered mandatory busing and their impact on school racial composition.

Chapter 3 is concerned with the capitalization of different measures of school quality. Its purpose is to evaluate the effect of the end of court ordered school desegregation on housing prices using traditional hedonic price models. First, it presents the review of literature that examines capitalization of public services in owner occupied houses. Second, it lays out the theoretical framework and model that relaxes the assumption of a vertical supply curve for the stock of housing. This is an essential assumption for the bid rent model adopted here and in previous studies as the basis for estimation. In the section that reviews the data and methodology implemented, we discuss the importance of adequately measuring the quality of the neighborhood and school, and separating those two effects. We estimate different specifications of hedonic price models and use Black's (1999) approach focusing on differences in housing price effects near attendance zone boundaries. In focusing on school boundaries, we assume that unobserved factors affecting house prices are not systematically correlated with school test scores across the boundaries themselves. However, residential choice models imply that there would be considerable sorting along these stable school boundaries.[5] For example, families who are willing to pay more to live in a school attendance area with better schools may be better educated and have higher income. Even if houses and neighborhoods are very similar on either side of a school attendance boundary when the boundary is initially established, the resemblance may not last long as properties are traded in the market. To the extent that this sorting occurs, it biases boundary estimates toward finding a positive relationship between school quality and property value. Nevertheless, the uniqueness of our data allows us to focus on the time period

[5]Using an equilibrium model of residential sorting, Bayer, Fferreria, and McMillian (2004) provides clear evidence that the full effect of school quality on residential sorting is significantly larger than the direct effect -- four times as great for education stratification, twice for income stratification. This is due to a strong social multiplier associated with heterogeneous preferences for peers and neighbors; initial changes in school quality set in motion a process of re-sorting on the basis of neighborhood characteristics that reinforces itself, giving rise to substantially larger stratification effects

when the move to community-sensitive attendance zones is originally implemented and include school quality as one of the measures of locational attributes while controlling for the possibility of this type of residential sorting.

Chapter 4 is concerned with the impact of a change in school quality on both components of the housing market: selling price and liquidity. Its purpose is to account for a simultaneous determination of price and time-on-market. First, the chapter presents a review of literature that examines the determinants of housing market liquidity. Second, it lays out the theoretical framework and search-theoretic model where prices and time-on-market are derived from the maximizing behavior of both buyers and sellers. We then follow with the discussion of data and the empirical methodology. We adopt a simultaneous equations model of sales price and time-on-market developed in Turnbull and Dombrow (2006) extending the hedonic price model used in Chapter Three by controlling for neighborhood market conditions.

The final section of this dissertation, Chapter 5, offers concluding remarks based on findings in the two previous chapters.

Chapter 2: Background on Schools in East Baton Rouge Parish

The East Baton Rouge Parish School System (EBRSS) serves the Greater Baton Rouge area. It is the third largest district in the state and among the top 75 nationally in student enrollment. The EBRSS comprises 88 schools with an enrollment of approximately 45,000 students in pre-kindergarten through grade 12. The EBRSS has gone through many changes because of its battle with school desegregation law suits. Table 1 represents EBRSS's desegregation timeline.

The constitutionality of Baton Rouge's de jure segregated school system was first challenged in 1956 in the case of *Davis et al. v. East Baton Rouge Parish School Board* (78 F.3d 920, 926, 5th Cir. 1956). The first federal court order mandating school desegregation came in 1960, but it did not include any specific timetable. Baton Rouge schools continued to be segregated on a de facto basis throughout the 1970s (Baird & Luster, 1990). In 1980, U.S. District Judge John Parker found that the school system had not done enough to create a racially integrated school system. As a result, in 1981, Judge Parker was presented with different plans that tried a variety of strategies to ensure racial balancing. For example, the district submitted a plan that called for the creation of more than 30 new magnet schools and centers of excellence to attract white students to predominantly black schools and vice versa. The Justice Department submitted a plan that focused on mixing the students in pairs and clusters of racially imbalanced schools.[6] The NAACP endorsed the Justice Department plan even though it required long-distance busing.

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[6] Magnet programs are special interest programs for the high achieving student in grades K-12. They offer advanced study, extended day services (elementary), expanded elective offerings, and educational choice.
Centers for excellence are highly-specialized programs operating within-a-school featuring a voluntary, open-admissions policy. Both are specialized programs to entice parents to voluntarily send their children to integrated schools.

Table 1. *Desegregation Timeline*

Year	***The Desegregation Process in East Baton Rouge Parish***
1956	Desegregation lawsuit filed on behalf of 37 African-American students
1981	Judge Parker institutes a desegregation plan that closes 13 schools and results in widespread busing. The Elementary school's part of the plan is implemented, while the secondary school's part of the plan follows next year.
1995	Superintendent Gary Mathews proposes a desegregation plan calling for community-sensitive attendance zones. The plan is debated but never goes to a vote.
1996	In late summer, the board, U.S. Justice Department and local NAACP agree on a plan that eliminates mandatory cross-town busing in favor of community sensitive attendance zones. Judge Parker orders it implemented in the form of a consent decree in time for the opening of schools.
1997	Voters turn down a $2 billion tax plan to pay for new schools.
1998[7]	Voters approve a $280 million tax plan.
1999	Parker orders the school system to change attendance zones because of over-enrollment in some schools.
2001	Judge Parker approves new attendance zones that results in the transfer of more than 2,000 students. Also, in December, the residents of the cities of Baker and Zachary reach an agreement with the EBRSS that allows Baker and Zachary schools to separate from the parish wide system.
2003	The 47-year old desegregation case is settled.

[7] In 2003, the voters renewed the collection of the sales tax for another five years.

Judge Parker found neither plan acceptable on its own and designed a new plan that borrowed partly from the other two plans.[8] Judge Parker's desegregation orders provoked strong public resistance and an immediate withdrawal of many white students from the public school system. The system lost about eight thousand students immediately following the court order, making it even harder to desegregate the system. The drastic shift of the white students from public to private schools that began at the time of mandatory busing was the best indicator that the white flight was a result of the changes brought by an aggressive desegregation effort, and not by a tendency toward suburbanization.[9] For example, one of the city's largest private schools, Parkview Baptist, was founded in 1981, the first year of mandatory busing. Over 1600 students started the 2005-06 school year there. The white flight from Baton Rouge's public school system extends to teachers as well (Bankston & Caldas, 2002).

The Louisiana Department of Education data indicate that the percentage of the student body that was African American jumped from 41 percent in 1980 to 44 percent in 1981. By October of 2000, almost 70 percent of the students in the public school system were black. Also, the percentage of white students in private schools went from 20 percent in 1980, to 25 percent in 1981, and by 1998 this percentage was at 48 percent.[10] In addition, the percentage of black students significantly increased over the next five-year time period, rising from 66 percent in 1998 to 76 percent of total student enrollment; statewide, the black student enrollment

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[8] In this plan, students are randomly assigned among schools in a cluster. Paired schools draw all of their students from the same attendance zone, and students attend one campus for certain grades and other campus for the remaining grades.

[9] EBR has reported that a recent slight increase in student enrollment might suggest that the outmigration of students from the school system may be slowing. However, as reported by the U.S. Census Bureau, East Baton Rouge Parish experienced a decline in population from 2000 to 2003. During the same time, Ascension Parish grew by 10.2 percent, Livingston Parish grew by 11.1 percent, and the state grew by 0.6 percent. EBR's population decline not only impacts the potential size of the public school student population, it may also weaken the tax base that supports the school system.

[10] Enrollment data cited throughout this section are from Louisiana Department of Education, *Annual Financial Report*, various years.

remained at 47 percent. The percentage of at-risk students increased by twenty percentage points, from 51 percent in the 1998-99 school year to 72 percent in 2003-04; in contrast, the state average only increased four percentage points, from 58 percent to 62 percent. These changes in demographics are reflected in achievement scores. The Louisiana Department of Education disaggregates testing data based on student subgroups such as race/ethnicity or poverty status. The difference in performance or the achievement gap between black and white students in EBR is 47.4 in 2003, with whites having an average performance score of 109 and blacks having an average performance score of 61.6.[11] East Baton Rouge Parish also has a considerable poverty achievement gap—slightly over 40 points—which measures the difference in performance between students who pay for their lunch and those who receive free or reduced price lunch. In their analysis of school desegregation in Louisiana, Bankston and Caldas (2002) suggest that the primary cause of the enormous shift of white students from public to nonpublic schools was a direct result of the dismantling of neighborhood schools. By 1995, school system officials had tried and failed to develop a "redesign plan" that would help desegregate schools as well as improve the quality of education.

Finally, 15 years after court-ordered busing started, the board adopted a plan that eliminated busing in favor of "community sensitive" attendance zones and introduced magnet programs at inner-city majority black schools to attract white students. Several years later, the board was forced to reassign students and change attendance zones in order to comply with the attendance limits at the public schools set in a desegregation agreement reached in 1996.

Throughout this period, the EBRPSS experienced a significant erosion of public support for their schools. As families leave the EBR school district, they take their political and financial

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[11] The performance score is out of 140.

support, further eroding public confidence in the system. Even though the Consent Decree of 1996 calls for increased school spending, voters turn down a two billion tax plan to pay for new schools in 1997. However, in 1998, a much smaller tax proposal of 280 million is approved.[12]

These events provide a rare opportunity to study the impact of changes in school assignments and school quality as measured by test scores, and racial composition on housing prices and time-on-market. The move to community sensitive attendance zones allows us to include school quality as one of the measures of locational attributes. Also, the subsequent changes in attendance zones or redistricting affect housing market in two ways. Many houses are assigned to new schools, changing their locational attributes. In addition, the houses that were not reassigned could be affected through peer effects to the extent that redistricting changed the demographic compositions of the student bodies at their school.[13] Even for those houses that had stable school assignments, changes in attendance zone boundaries in other neighborhoods led to large changes in the characteristics of the students assigned to their school.

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[12] This is the first tax plan in more than 25 years. In the article that appeared in *The Advocate* on *October 11th* voters are urged to approve the tax bill which they call "a test of our willingness to grasp a better future for our community, not just in the next 18 months, but in the next 18 years, and beyond.

[13] Racial composition and socio-economic characteristics of student body are used to represent peer effects.

Chapter 3: School Quality and Housing Prices

Capitalization Literature Review

The capitalization of local public services and property taxes into house values has been at the center of local public finance literature for several decades. Capitalization literature and its connection to community selection are often traced back to Tiebout's (1956) argument that households shop for communities by comparing the different fiscal packages in different jurisdictions. The process of community selection drives differences in house values reflecting local public service quality and property tax rates.

Property tax capitalization arises because a house value, just like the value of other assets, is equal to the present value of the net benefits from owning it. Before reviewing the literature it is useful to briefly explain what it is that studies try to measure.

Let $R(S)$ be before tax rental value per unit of housing services. This value is a function of local public service quality, S. Similarly, r the real discount rate, and T annual tax payment, then the value of the house, V, is given by

$$V = (R(S)/r) - (T/r).$$ [14]

The equation is simply saying that the amount someone is willing to pay for a house is the present value of the rental benefits minus the present value of the cost or property tax payments. Since, by definition, tax payment is equal to the nominal tax rate, τ, multiplied by the assessed value of the house, then the above equation can be rewritten as

$$V = (R(S)/r) - (\tau Va/r).$$

Also, since the effective tax rate, t, is equal to nominal tax rate multiplied by the ratio of assessed to market value of a house the equation transforms into the following

[14] Rather than talking about housing as a single commodity, urban economists have traditionally talked about "housing services" which are all the attributes and the characteristics of the house and its location.

$$V=(R(S)/r) - (tV/r)$$

Solving this equation for V yields

$$V = R(S)/(r + t).$$

The empirical literature on capitalization attempts to determine whether capitalization exists and to estimate the degree of capitalization. The estimating equation is derived from the asset value model and implies that the house value V is:

$$V= (R(S)/r) – \beta(tV/r)= R(S)/(r+\beta t),$$

Here β stands for the degree of capitalization, so that if β equals 0.5 then a $1 increase in the present value of property taxes leads to a $0.50 decrease in the value of a house.

The objective of tax capitalization literature is to estimate β. Full capitalization is considered to happen when, after controlling for all other housing and location characteristics, differences in housing prices exactly equal the present value of variations in tax liabilities. Partial capitalization (overcapitalization) is said to happen when differences in property values are less than (greater than) the differences in the present value of tax liabilities. Fischel (2001) argues that partial capitalization can usually be explained by two factors: an agent’s expectations and inherent limitations in the data and econometric method. For example, partial capitalization occurs when relevant differences among communities, such as school quality or other environmental attributes, are known to buyers and sellers but not to researchers, or homebuyers may not expect the current annual differences in taxes to last long.

Most of the early tax capitalization studies find varying degrees of tax capitalization. Ross and Yinger (1999) provide an excellent survey of both the theoretical and empirical capitalization studies.

Tax capitalization is difficult to estimate for several reasons, even though the equation that captures it is fairly simple. First, it cannot be estimated with linear regression methods because it shows a non-linear relationship between *t* and *V*. To avoid this problem researchers have used various approximations or non-linear estimating techniques. Second, the value of the discount rate, *r*, is not observed and most studies typically assume a value for *r*.[15] Third, the asset-pricing logic behind capitalization equations requires assumptions about house buyers' expectations. For example, this assumption predicts that a $1 increase in the present value of future property taxes will lead to a $1 decline in house value, given $\beta=1$. But it does not say that current tax differences will be fully capitalized if they are not expected to persist.

The studies that attempt to estimate the capitalization of publicly provided services face the difficulty of measuring the quality of local public services. Existing data often do not provide information on many dimensions of service quality. One approach to overcoming this challenge is to use government spending per capita as a measure of public service quality (Oates, 1969, 1973)

However, several studies, including Ladd and Yinger (1994), Caroll and Yinger (1994), Duncombe and Yinger (1996), argue that spending is a poor measure of service quality. They show that equal per pupil expenditures among districts do not necessarily lead to equal educational quality because environmental conditions, service factor prices, and service production functions might differ among communities. For instance, environmental factors in education include student body characteristics, such as the percentage of students with disabilities, the percentage of students living in poverty, and the family background of students. Researchers have shown that a district with a higher percentage of students with disabilities

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[15] The most extreme estimates in the literature, in either direction, are driven largely by strong assumptions about *r*.

needs more per pupil expenditures to achieve the same level of educational quality, all else equal. Also, a district could have higher per pupil expenditures as a result of higher input prices in that district. Prices of capital, labor, and other inputs differ across geographical areas. All of the above mentioned concerns about using education spending to capture school quality arise because expenditures are an input into the education process rather than a measure of the output.

McDougall (1976) is the first to adopt an output measure of the local services. He uses the sum of median test scores for twelfth grade students, the personal crime rate, the property crime rate, a recreation index, and a fire insurance index as output measures of local services. [16] Even though his study shares some of the problems of macro data studies, it is a step forward in the treatment of public service variables.[17]

Some of the more recent service capitalization studies use student test scores, crime rates, or other similar data to measure local public services capitalization (Black, 1999; Bogart & Cromwell, 1997, 2000; Brasington, 2002b; Haurin & Brasington, 1996; Hayes & Taylor, 1996; Hilber & Mayer, 2001b; Weimer & Wolkoff, 2001).

Bogart and Cromwell (1997) focus on house prices in three neighborhoods in the Cleveland metropolitan area, where children in each neighborhood attended public schools in two different districts. In each neighborhood, all the houses were in the same municipality, and home owners are assumed to have enjoyed the same level of public services provided by the municipality. But each neighborhood was partly in one school district and partly in another, so that educational services and school taxes differed among home owners in the same

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[16] Some authors argue that the test scores do not necessarily represent what the school contributes to the student's academic achievement. They show that the test scores are influenced by school resources, family characteristics, and peers. See Hanushek (1996) for various measures of school resources and their effect on student performance. For evidence on specific family characteristics, see Hanushek (1992) and Baum (1986).
[17] Studies that use municipality or census tract as a unit of observation are considered macro data studies. The dependant variable in these studies is usually Median House Value. These studies tend to have few control variables.

neighborhood. Bogart and Cromwell do not have a direct measure of school quality, but in each neighborhood, one school district clearly had a better reputation than the other. After accounting for differences in the size and quality of the houses, the authors estimate the remaining difference in the value of houses in what was considered the better school district in each neighborhood.[18] The estimated differences are $5,600 in the first neighborhood, $10,900 in the second, and $12,000 in the third. Since Bogart and Cromwell do not control for variation in school district taxes, these differences in house values represent the combined effect of differences in school quality and taxes. Even though Bogart and Cromwell do not have a direct measure of school quality, the difference in house prices between school districts implies that a better reputation for local schools translates into a measurable difference in house prices and outweighs the additional taxes incurred.

Bogart and Cromwell's (2000) house price study addresses redistricting effects. For the data they consider, the redistricting occurred in order to improve racial integration in public schools. They estimate a hedonic house price equation using a difference-in-difference regression technique to determine the effects of losing a neighborhood school due to the change in district boundaries for the Shaker Heights School District. Their findings reveal that redistricting resulted in a decrease of $5,738 for an average priced house. In order to determine if the unobservable neighborhood characteristics are driving their results, the authors also model repeat-sales in this area. Repeat sales analysis provides another means for completely controlling the location-based effects while not having to define neighborhood boundaries. This technique is infrequently used in empirical models because limiting the data to repeat sales diminishes the sample size significantly. After reducing their sample to houses that sold twice,

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[18] In particular, house size hardly controls for the structural housing characteristics which leaves studies vulnerable to left-out variable bias.

once before the change in boundaries and once after, Bogart and Cromwell are left with 634 home sales. They find that mean house prices still decrease, but by $7,593 compared to the $5,738 found in the difference-in-differences technique. This finding indicates that the unobservables from the difference-in-difference regression were not perfectly controlled.

Even with the most accurate measure of school quality, critics argue that a reliable estimate of the value of a school cannot be differentiated from the location-based effects unless these effects are precisely controlled. The difficulty with controlling for location-specific effects stems from the fact that most are unobservable and others are difficult to quantify. Most of the studies use census tracts to provide neighborhood demographics, and while there is a lot of demographic information by tracts, they are relatively large geographic areas. It is safe to say that defining a neighborhood by a census tract is more convenient than accurate.

Black (1999) argues that properly controlling for neighborhood influences is the key to producing reliable estimates of any school effects; not adequately controlling for neighborhood characteristics inflates the positive effects of a higher quality school because better public schools tend to be located in better neighborhoods. When researchers look across different school districts the estimated differences in house values represent the combined effect of differences in school quality and taxes. Rather than compare houses in different communities as her standard of comparison Black uses houses within the same community but in different school attendance zones. Consequently, Black is able to construct a model that controls for neighborhood effects while at the same time avoiding the problems associated with defining neighborhood boundaries. Her data contains houses on different sides of elementary school attendance boundary lines, but within the same district. Thus, homes presumably have the same neighborhood effect, and the only difference between the homes is the elementary school that

children attend. Black uses block group census data containing broad estimates of neighborhood characteristics such as ethnic characteristics of the population, average parent's education, average age, and median household income to capture some of the variability in location. Block groups are smaller geographic areas than census tracts, yet even with these controls, Black shows that block groups alone as neighborhood controls are not enough to provide unbiased estimates for the value of education.

Black finds the coefficient on the test scores decreases by half due to the inclusion of neighborhood effects as captured by the boundary indicators. With no controls other than the census characteristics, the average-priced house gains $9,212 for a 5 percent increase in test scores, but when controlling for homes within 0.35 miles of the school attendance boundary, the additional value for the increased test scores decreases to $4,324. Overall she finds that, all else constant, parents are willing to pay about 2.1 percent more for a home where the quality of education, as measured by standardized test scores, increases by 5 percent.

While the above mentioned studies examine either elementary outputs (Black, 1999; Bogart & Cromwell, 1997) or middle school outputs (Haurin & Brasington, 1996), they do not allow for separating the impact of school quality as measured by test scores and direct student peer effects as measured by the socio-economic characteristics of the students in the school.[19]

Hayes and Taylor (1996) construct four possible indicators of school quality: current expenditures per pupil, average sixth-grade achievement in mathematics on the Iowa Test of Basic Skills, the marginal effect of the school on sixth-grade mathematics achievement, and the expected achievement of the student body in sixth-grade mathematics. The first two of these

[19] Hanushek, Kain, and Rivkin (2002), and Hoxby (2000) examine the impact of racial and ethnic school composition on performance. They find that the segregation by race has a strong adverse effect on school performance.

indicators are common measures of school quality in the housing literature. The second two indicators represent a decomposition of average mathematics achievement into school effects and peer group effects. The marginal effect of the school measures the increase in student achievement in mathematics that can be attributed to the school. The expected achievement of the student body is also known as the peer group effect. In Hayes and Taylor (1996), the peer group effect operates through test scores and is not included directly into the regression equation. The peer group effect serves as a possible indicator of school quality because research has shown that a high-achieving peer group in a school can have a positive effect on individual student performance (Hanushek et al., 2002; Hoxby, 2000; Summers & Wolfe, 1977).

Peer group effects are measured by the socio-economic characteristics of students in a school and have been examined in the earlier studies of school desegregation decisions. These studies are designed to estimate the effect of changing racial composition of local schools (Clotfelter, 1975; Evans & Rayburn, 1991; Gill, 1983; Jud, 1985; Jud & Watts, 1981; Vandell & Zerbst, 1984). For example, Clotfelter (1975), using census tract data, looks at the changes in house values during the period from 1960 to 1970. The variable of interest in this study is the census tracts' changes in the proportion of blacks in census tract high schools. The study finds statistically significant and inverse relationships between house values and the proportion of blacks in the tract.

More recently, Kane, Staiger, and Samms (2003) use data from North Carolina and find that long-run measures of school test performance (school test scores averaged over many years) are related to higher house prices, but they also point, to the fact that there is no evidence of volatility in housing prices to match the annual volatility in test scores. They argue that the annual volatility in the test scores makes it difficult for home buyers to distinguish the signal

from the noise, and home buyers start to focus on characteristics that are unlikely to change quickly, such as socioeconomic characteristics of schools. In addition, they evaluate the housing market's response to the categorical ranking of school performance, created by the school accountability system, and find no effect from the North Carolina categorical rankings.

Several other more recent studies that examine both the academic quality and the racial composition of local schools (Briggs, Clapp, & Ross, 2002; Clapp et al., 2005) find that test scores have no effect on housing price in a model that controls for census tract fixed effects. However, they find that racial, ethnic, and socio-economic composition all influence housing prices.

Even though the public service capitalization literature is voluminous, there are only few studies that take into account the effect of the housing stock adjustment (Brasington, 2002a; Edel & Sclar, 1974; Hilber & Mayer, 2001a, 2002). Edel and Sclar (1974) use a sample of Boston municipalities and look at the nominal tax rate for the time periods 1930, 1940, 1950, 1960 and 1970. They assume that expanding the data over several decades allows for supply adjustment. They use school expenditure per student and highway maintenance per square mile as public service variables. Edel and Sclar (1974)conclude that capitalization disappears in the long-run because of the supply adjustment. While their study overlooks simultaneity, uses an inappropriate tax variable, and has few control variables, it received some positive recognition because it emphasizes the long-run supply adjustments.

Brasington compares capitalization rates at the edge and center of an urban area. His house price hedonic estimation is based on 27,748 houses in 122 communities in Ohio. He suggests that the rate of capitalization should depend on the elasticity of housing supply. Because housing developer activity is stronger toward the edge of an urban area, there should be

a weaker rate of capitalization of taxes and public services into house prices in communities at the edge of an urban area. There should be a stronger rate of capitalization toward the interior of an urban area where the housing supply is less elastic. His study tests for the capitalization of taxes, crime, and school quality at the edge and interior of an urban area. He consistently finds that school quality is positively capitalized into house values and crime is negatively capitalized into house values. The study also finds that public services are always capitalized into house values at a considerably stronger rate toward the interior of the urban area than toward the edge, where developers are more active and the housing supply is more elastic.

In another study that links the extent of house price capitalization to local spending decisions, Hilber and Mayer (2001a), argue that capitalization of fiscal variables and local amenities is higher in urban areas where there is little available land relative to capitalization in rural areas where land is more readily available. Their data set of Massachusetts communities includes a measure of available land that varies among different communities. Their results show that not only are fiscal variables and amenities capitalized to a greater extent in localities with little available land, but also that these localities spend more on schools and their voters are more likely to approve costly spending programs.

In a subsequent study, Hilber and Mayer (2002) argue that capitalization of school spending into house prices can encourage residents to support spending on schools, even if the residents have no school age children. The authors build on their earlier study by first extending the analysis to include data from school districts in 49 states to show that per pupil spending is positively related to population density, a proxy for the availability of land. They show that a community with a density of 1,500 people per square kilometer spends $170 (3.3 percent) per pupil more than a community with a density of 150 people per square kilometer. The results of

this study also demonstrate that a positive relationship between density and spending is even more significant in places with high home ownership rates. They then show that communities with a higher percentage of residents above 65 years old have increased school spending only in places with high population densities.

Theoretical Framework

The impact of the quality of public schools on housing values can be explained intuitively through two components: bidding and sorting.[20]

Bidding analysis builds on a number of assumptions that approximately describe urban areas in the United States. Each urban area is assumed to have many neighboring jurisdictions, which have fixed land area and provide different bundles of local public goods and taxes. When choosing a residential location, each household maximizes its utility given its income; its preferences for consumption of public goods and private goods; taxes and the prices of private goods.

This analysis first assumes that households fall into separate income/taste classes. Households within a class are considered to be identical in their demands for these things, but many classes may exist. Households are also assumed to be mobile and able to move costlessly from one jurisdiction to another. This assumption implies that an equilibrium cannot exist unless all people in a given income/taste class achieve the same level of utility. In other words, any household that does not reach as high a utility level as similar households will have an incentive to move, and this type of moving behavior will lead to a situation in which all similar households have the same utility (and no household has an incentive to move). A residence in a jurisdiction

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[20] This framework is presented in more detail in Ross and Yinger, 1999. Our discussion draws from their study.

is assumed to be a precondition for the receipt of public services there, and it is assumed that all households that live in a jurisdiction receive the same level of public services. Finally, households are homeowners, not renters, and local public services are financed through a local property tax. In this model, households compete with each other for access to the most attractive locations. These are assumed to be locations with the best combination of high-quality public schools and a low property tax rate. Households compete for entry into desirable locations by bidding against each other for housing.

In the simplest case, one can consider a single income/taste class. Because households are mobile, as well as alike, each household must reach the same utility level. As a result, households that live in jurisdictions with relatively attractive service-tax packages must pay for the advantage in the form of higher housing prices. If the housing prices did not reflect the attractiveness of local service-tax packages then these households would be better off than households in other jurisdictions. In this case, the households in other jurisdictions would have an incentive to move. The argument so far can be summarized in the form of a bid function, which indicates the maximum amount a household would pay to live in a jurisdiction as a function of the attractiveness of the service-tax package there.

Figure 1 describes the housing bids for one type of household, but, it does not tell how different types of households are sorted into jurisdictions. The key to understanding sorting is to recognize that bid functions like the one in Figure 1 are steeper for some types of households than for others. The steepness of a bid function indicates the extent to which a household type's bids for housing increase when the quality of public services increases. The steepness of a bid function matters because landlords (or housing sellers) prefer to sell to the household type that is willing to pay the most per unit of housing services. Thus, as shown in Figure 2, households

with relatively steep bid functions win the competition for housing in locations where the quality of public services is relatively high, and households with relatively flat bid functions win the competition for housing in locations where the quality of public services is relatively low. For example, the group with the steepest bid function in this figure wins the competition for all levels of public service quality above *S*3. Under normal circumstances, high-income households have steeper bid functions than low-income households. In other words, high-income households are willing to pay more for an increment in public service quality. This relationship between income and bid-function steepness implies that high-income households live in locations with relatively high quality-public services. This situation is illustrated by Figure 2, in which the steeper bid functions (the ones to the right) belong to higher-income classes and the flatter bid functions (the ones to the left) belong to a lower-income class.

Figure 1. Housing Bids as a Function of Public Service Quality (School Quality)

(Holding Property Tax Rate Constant)

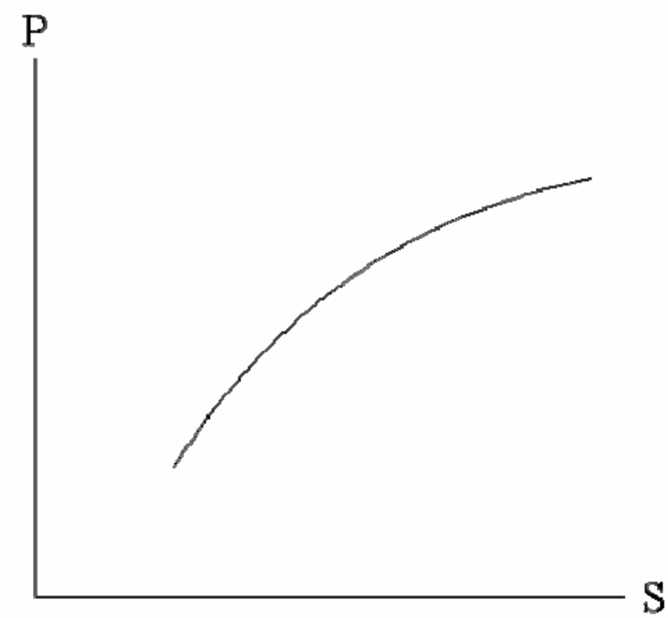
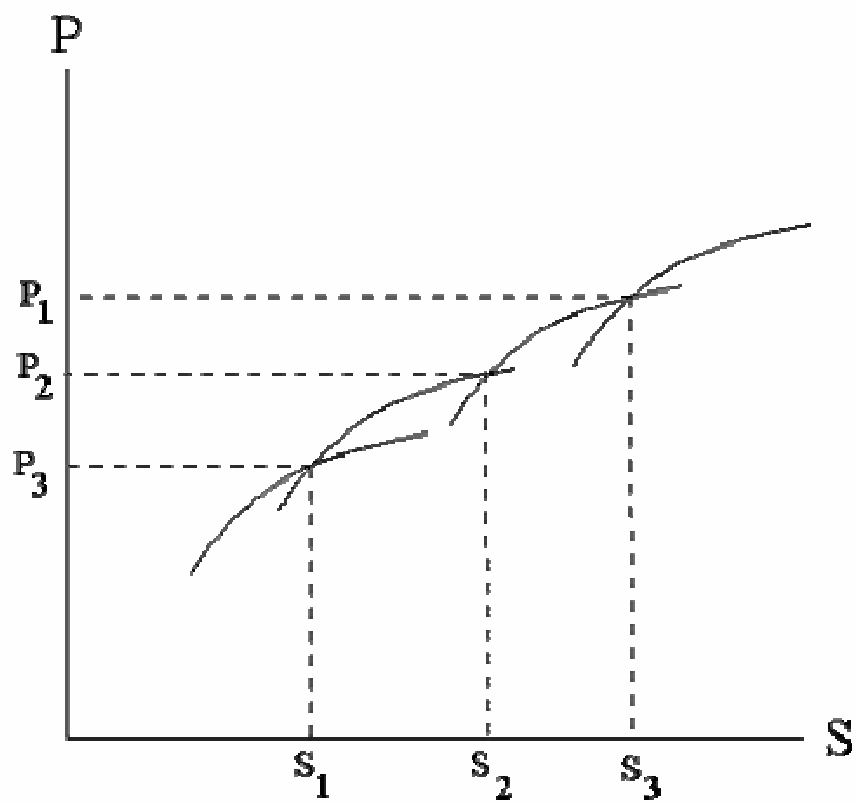


Figure 2. Bidding and Sorting



The more formal model is shown in the following part. Hilber and Mayer (2001a) use the same model in their study that links the extent of house price capitalization to local spending decisions. The following discussion draws heavily from their study.

We start with a model that satisfies the standard location and land market equilibrium conditions and then incorporate the land supply elasticity into the examination of school quality capitalization:

1) No household can increase its utility by moving to another school zone;
2) The sum of the populations of the school zones must equal the entire population of the metropolis and no community can have negative population;
3) The demand for housing in each school zone equals the supply of housing; and
4) No household can increase the utility by changing the consumption bundle.

For the simplicity, the model presented here considers a framework in which there are two communities j=1,2 and N residents. Communities in our example are equivalent to neighborhoods defined by school attendance boundaries. If, in equilibrium, households cannot increase their utility by moving from one community to another, then there is an income level, y*, such that

$$V(e_1, p_1(1+\tau_1), y^*) = V(e_2, p_2(1+\tau_2), y^*). \qquad (1)$$

This condition is also called a boundary condition. Two more equilibrium conditions are related to the land market or housing market

$$n_j h_j(p_j(1+\tau_j)) = H(p_j) \qquad (2)$$

and

$$n_1(p_1, \tau_1) + n_2(p_2, \tau_2) = N. \qquad (3)$$

where e is the school quality or education services provided by local public schools; h_j is the demand for housing per resident; and $H(p_j)$ is the housing supply function.[21] These two conditions require that the demand for land by households with y<y* equal the supply of land in community 1 and the demand for land by households with y>y* equal the supply of land in community 2.

To evaluate the impact of higher school quality in one community to prices in both communities the above mentioned equations form a system that is differentiated with respect to e_1 as follows:

$$V(e_1, p_1(1+\tau_1), y^*) = V(e_2, p_2(1+\tau_2), y^*), \qquad (1)$$

using (2) and (3) we obtain

$$\frac{H_1(p_1)}{h_1(p_1(1+\tau_1))} + \frac{H_2(p_2)}{h_2(p_2(1+\tau_2))} = N. \qquad (4)$$

These two equations are the equilibrium conditions that determine p_1 and p_2. After some manipulation we get

$$\begin{bmatrix} \dfrac{\partial V_1}{\partial p_1} & \dfrac{-\partial V_2}{\partial p_2} \\ \dfrac{n_1}{p_1}(\varepsilon_1^s - \varepsilon_1^d) & \dfrac{n_2}{p_2}(\varepsilon_2^s - \varepsilon_2^d) \end{bmatrix} \begin{bmatrix} dp_1 \\ dp_2 \end{bmatrix} = \begin{bmatrix} \dfrac{-\partial V_1}{\partial e_1} \\ 0 \end{bmatrix} [de_1]. \qquad (5)$$

Here $\varepsilon_1^s = \dfrac{\partial H_1}{\partial p_1}\dfrac{p_1}{H_1}$ is the price elasticity of housing supply

and $\varepsilon_1^d = \dfrac{\partial h_1}{\partial p_1}\dfrac{p_1}{h_1}$ is the price elasticity of housing demand in community 1.

Similarly, ε_2 denotes elasticity in the community 2.

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[21] The results are analogous to the case with an elastic supply of land. Housing supply is used here to simplify the analysis.

Solving (5) gives the following comparative static results:

$$\frac{dp_1}{de_1} = \frac{\frac{-\partial V_1}{\partial e_1}\left(\frac{n_2}{p_2}\left(\varepsilon_2^s - \varepsilon_2^d\right)\right)}{|D|} \,, \tag{6}$$

$$\frac{dp_2}{de_1} = \frac{\frac{-\partial V_1}{\partial e_1}\left(\frac{n_1}{p_1}\left(\varepsilon_1^s - \varepsilon_1^d\right)\right)}{|D|} \,. \tag{7}$$

Here $|D| = \frac{\partial V_1}{\partial p_1}\frac{n_2}{p_2}\left(\varepsilon_2^s - \varepsilon_2^d\right) + \frac{\partial V_2}{\partial p_2}\frac{n_1}{p_1}\left(\varepsilon_1^s - \varepsilon_1^d\right) < 0$

We assume that $\left(\varepsilon^s - \varepsilon^d\right)$, population sizes and prices are positive so that that $\frac{dp_1}{de_1} > 0$ and $\frac{dp_2}{de_2} < 0$. In another words, higher public school quality in the community 1 will drive house prices in that community to be higher than those in the community 2, all else equal.

To evaluate the impact of land supply elasticity on the extent of capitalization (6) and (7) can be differentiated with the respect to ε_1^s using the quotient rule.

$$\frac{\partial \frac{dp_1}{de_1}}{\partial \varepsilon_1} = \frac{0|D| - \left[\frac{-\partial V_1}{\partial e_1}\left(\frac{n_2}{p_2}\left(\varepsilon_2^s - \varepsilon_2^d\right)\right)\right]\frac{\partial V_2}{\partial p_2}\frac{n_1}{p_1}}{|D|^2} \tag{8}$$

If we assume that $\left(\varepsilon^s - \varepsilon^d\right)$, population sizes and prices are positive and given that the denominator of (8) must always be positive, it follows that $\frac{\partial \frac{dp_1}{de_1}}{\partial \varepsilon_1}$ is always negative. In another words, the extent of school quality capitalization in one community decreases with increasing housing supply elasticity in that community.

When comparative statics of the model equilibrium are simplified to include only two communities, they provide some important insights. The higher public school quality in one community will drive house prices in that community to be higher than in the other community, all else equal. However, the extent of capitalization depends on the elasticity of the housing supply; the capitalization of an increase in public school quality in community one decreases with increasing housing supply elasticity in that community.

In short, the theoretical model predicts that if communities can freely expand their housing stock in response to an increase in the public school quality, then a change in demand for housing causes little or no change in house prices. In this environment, the change in school quality is not capitalized into prices.

Data and Empirical Methodology

In the hedonic price model, the price of a house is a function of its physical characteristics and neighborhood characteristics, such as public school attendance areas. Housing is an example of a good that is unique and that has many quality dimensions. Houses are modeled as single commodities that differ in the amount of various characteristics they contain (building materials, number of bedrooms and bathrooms, etc.). Consumers derive utility from the different characteristics of the commodity, and producers incur the costs that depend on the varieties they provide. The interaction of consumers and producers in this type of market determines the equilibrium hedonic price schedule.

In a model developed by Rosen (1974) in which certain products are a composite of several characteristics represented by a vector $\mathbf{x} = (x_1, x_2, \ldots, x_n)$, the equilibrium price for any one product is a function of the different characteristics of the product. This function is called an

hedonic price function $P = P(x)$. The hedonic price model allows us to isolate the effects of individual characteristics on a composite good. Coefficient estimates of the hedonic model can be translated as the implicit prices, or as consumers' willingness to pay for different characteristics of the composite good.

In the literature on school characteristics and house values, the primary challenges have been to adequately measure the quality of the neighborhood and school and then empirically separate those two effects. Selecting appropriate measures of neighborhood quality has proven difficult, especially because the polycentric nature of the modern metropolitan area makes the simple measures, such as distance to the central business district, inappropriate. Several approaches have been used to address this issue.

Black (1999) uses the across-the-street estimation approach focusing on differences in housing values near school boundaries. Presumably, houses studied with this approach have the same neighborhood effect, and the only difference between the houses is the elementary school that children attend. Similarly, Figlio and Lucas (2000) use a fixed effects specification that captures any characteristics about properties in a given subdivision that change together over time. These fixed effects are defined at the neighborhood calendar year level.

Empirical Specifications

The empirical hedonic price function can be defined as follows:

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

where P_{inkt} is the price of house i in neighborhood n in school k at time t. Z_{kt} are the year-specific school level attributes, which includes school district performance as measured by standard test scores and socioeconomic and demographic composition of the students.

Γ_{ink} is a term that captures non-school time-invariant observable attributes of the unit including the neighborhood. ε_{inkt} is a time-variant unobservable that is assumed to be randomly distributed and uncorrelated with Z_{kt} and Γ_{ink}, ω_t's are the time fixed effects like year, season, and month the house sold . Equation (1) is the baseline hedonic model.

We define the time-invariant unit attributes as a function of observed housing unit attributes (X_i) and neighborhood attributes (W_n).

$$\Gamma_{ink} = \beta X_i + \mu W_n \tag{2}$$

Equation (2) requires the assumption that unobserved unit and neighborhood attributes are uncorrelated with X_i as well as W_n. This specification uses neighborhood controls based on the decennial census.

We also estimate our results by considering only those houses that are geographically close to the school attendance boundary. We do this by rewriting equation (2) as

$$\Gamma_{ink} = \beta X_i + \phi K_b, \tag{3}$$

where K_b is the vector of boundary dummies that represent the unique boundary that house *i* is associated with, the nearest boundary. The estimating equation now becomes:

$$ln(P_{inkt}) = \alpha + \delta Z_{kt} + \beta X_i + \phi K_b + \omega_t + \varepsilon_{inkt}. \tag{4}$$

Equation (4) is equivalent to calculating differences in house prices on opposite sides of attendance boundaries while accounting for house characteristics and relating the differences in prices to school quality information. In this approach, the boundary dummies allow us to account for any unobserved neighborhood characteristics of houses on either side of an attendance boundary.

In the next specification, we focus on the existence of nonlinear effects of school quality. Chiodo, Hernandez-Murillo and Owyang (2005) argue that the linear specification of

specification (4) presupposes that the marginal valuation of below-average schools is equal to the valuation of above-average schools and results in a constant premium on school quality. They reexamine this assumption and consider the possibility that the capitalization premium varies over the range of school qualities. The nonlinearity in their model reflects two aspects of the market for public education via housing. First, alternative schooling arrangements (e.g., private school, home schooling, magnet schools, etc.) can provide home buyers with high quality education even if they choose to live in below average school districts. Second, if house buyers have positive valuations for education, they may concentrate their efforts among the highest quality attendance zones, yielding increasing market tightness as school quality increases. Buyers may face increased competition for the highest quality schools and a rapidly increasing premium for houses in those attendance zones. Thus, linear valuations for education can induce a nonlinear education premium. To allow for this possibility we rewrite (4) as

$$ln(P_{inkt}) = \alpha + f(z_{kt}) + \beta X_i + \phi K_b + \omega_t + \varepsilon_{inkt} \qquad (5)$$

where $f(z_{kt})$ represents a potentially nonlinear function of school quality. We call this specification a nonlinear boundary fixed effects model.

Finally, we examine the theoretical prediction that the degree to which house prices capitalize local amenities varies depending on the supply of land for new housing. To do this, we split the sample into two groups, based on an indicator of land supply elasticity. Our most direct measure of the land supply elasticity is the percentage of new residential construction in each community, census tract. We expect the coefficients on the school quality characteristics in the capitalization equation to be larger in the group of communities with little available land.

An alternative approach to comparing houses with stable school assignments at a point in time is to compare houses affected by redistricting over time. [22] Redistricting affected locational amenities in two distinct ways. First, and most obviously, many houses were assigned to new schools. In addition, even houses that were not reassigned may have been affected by redistricting through peer effects if, by changing boundaries elsewhere, the redistricting significantly altered the mix of students attending a school.

To analyze the effect of redistricting on housing vales, we use the full sample of housing transactions from 1999 to 2002, including both houses with original school assignments and houses that were reassigned. This specification is similar to using analysis of original school assignments except that a new measure of school quality is used. This new measure is school's categorical ranking and is based on the school performance score, SPS.[23] The SPS, a tool used in the Louisiana School Accountability Program, is the primary measure of overall school performance.

In summary, this chapter estimates four models to examine the original establishment of the community sensitive attendance boundaries, the standard hedonic model, equations (1) and (2); the attendance boundary fixed effects model, equations (1) and (3); the nonlinear standard hedonic and boundary fixed effects models, equation (5); and one model that examines redistricting: the standard hedonic model, equations (1) and (2). In addition, we also estimate the same models for two different sub-samples that differ by their housing supply elasticities.

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[22] Since the district faced the court order to achieve a racial mix of students in the schools, the school assignment areas crossed many existing neighborhood boundaries, which helps us separate the effects of school quality and neighborhood amenities.

[23] Starting in 1999, Louisiana Department of Education published school performance scores (SPS) for every public school. The SPS is based on the attendance and test performance of all students.

School and Housing Data

We restrict our analysis to detached single family houses and elementary school attendance zones. Each unit of observation is described by variables reflecting its physical characteristics, the quality of local elementary school to which children in the household are assigned, and the characteristics of the neighborhood in which the house is located.

This study uses housing data that draws from the Multiple Listing Service (MLS) sales reports for Baton Rouge, Louisiana for nine years from 1994 through 2002. Each house is geocoded to a specific elementary school and census tract. The house characteristics include common features such as Bedrooms, Bathrooms, Age, Living area, and Net area. Living area and Net area are measured in thousands of square feet (Net area = Total area under the roof – Living area). The house characteristics also include location, which is indicated by dummy variables for MLS areas.[24]

Our analysis considers two different sources of variation to separate the effects of schools and other neighborhood characteristics: differences in housing prices along attendance zone boundaries and changes in housing prices following the change is school assignments. The first approach uses data from 1994 through 1998. We use the percentage of students at the proficiency level on standardized tests, the percentage of students qualifying for the free lunch program, and the school racial composition to assess the quality of schools. We obtain school quality data from the State of Louisiana Progress Profiles for the years 1994 through 2002. These variables take on a value of zero prior to September 1996 since East Baton Rouge Parish was under mandatory busing and students were not assigned to elementary schools based on their residence location. The EBRPSS provided us with the maps of the school attendance areas as

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[24] The subject area covers contiguous region and excludes houses in Baker and Zachary.

they were designed by the Consent Decree in 1996, as well as the new attendance zones implemented after redistricting in 2001.

This study uses the census tract as proxy for neighborhood. The neighborhood characteristics are defined based on 89 tracts in East Baton Rouge Parish during the 2000 Decennial Census. The data used include median household income, percent black in tract, percent of owner occupied housing units, and percent of children of preschool and school age.

Finally, to capture market conditions, the specification includes year, season, and month fixed effects based on the sales date in our housing data.

Figures 3 and *4* plot the locations of the elementary schools in 1996 and identify East Baton Rouge Parish's school attendance boundaries as described in the Consent Decree. Figures 3 and 4 also show the geographical area of census tracts. In addition, Figure 4 highlights the boundary sample used in the boundary fixed effects specification.

Table 2 gives the summary statistics over 1994-1998 of the variables that enter into regression analysis. The dependent variable, house sales price, is adjusted for inflation and the mean of $124,812 is in year 1999 dollars. Variables under the heading *House Attributes,* include *num_beds*, number of bedrooms (3.28), *fullbath*, number of full bathrooms (2.04), *livarea*, living area in thousand square feet (1.912), and *netarea,* net area (.688). *School Attributes* are the percent of students passing on standardized tests, *test*, (mean of 90.06 percent, standard deviation of 6.30 percent); the percent of blacks, non-Hispanic, *black_school*, (mean of 50.50 percent, standard deviation of 24.01 percent); and the percent of students qualifying for free lunch, *lunch_school*, (mean of 47.90 percent, standard deviation of 21.10 percent). Even after years of court ordered desegregation, the percent black in school ranges from 6.7 percent to 100 percent. The range of free lunch students is similar to percent black students with minimum at 6.6 percent

and maximum of 94.4 percent. This demonstrates substantial variations in school characteristics.[25]

The variables used to describe neighborhood characteristics are under *Tract Attributes* and include: *medHH99*, median household income in thousands of ’99 $ (mean of $50. 016); *blackP*, percent black (mean of 22.52 percent); *kidsP1*, percent preschoolers (mean of 7 percent); *kidsP2*, percent school age children (mean of 18.49 percent); and *ownerP*, percent of owner occupied housing units (mean of 66.70 percent). In addition, the average percent enrolled in private schools in the census tract, *enrollP*, is 5.2 percent with standard deviation of 8.3 percent.[26]

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[25] School averages are calculated using only houses sold after the publication of the Consent Decree document containing school attendance zones. These cover sales made after June, 1996.

[26] Private school enrollment data comes from National Center of Education Statistics’ (NCES) Common Core Data (CCD).

Figure 3. East Baton Rouge Parish: Elementary School Attendance Zones and Census Tracts.

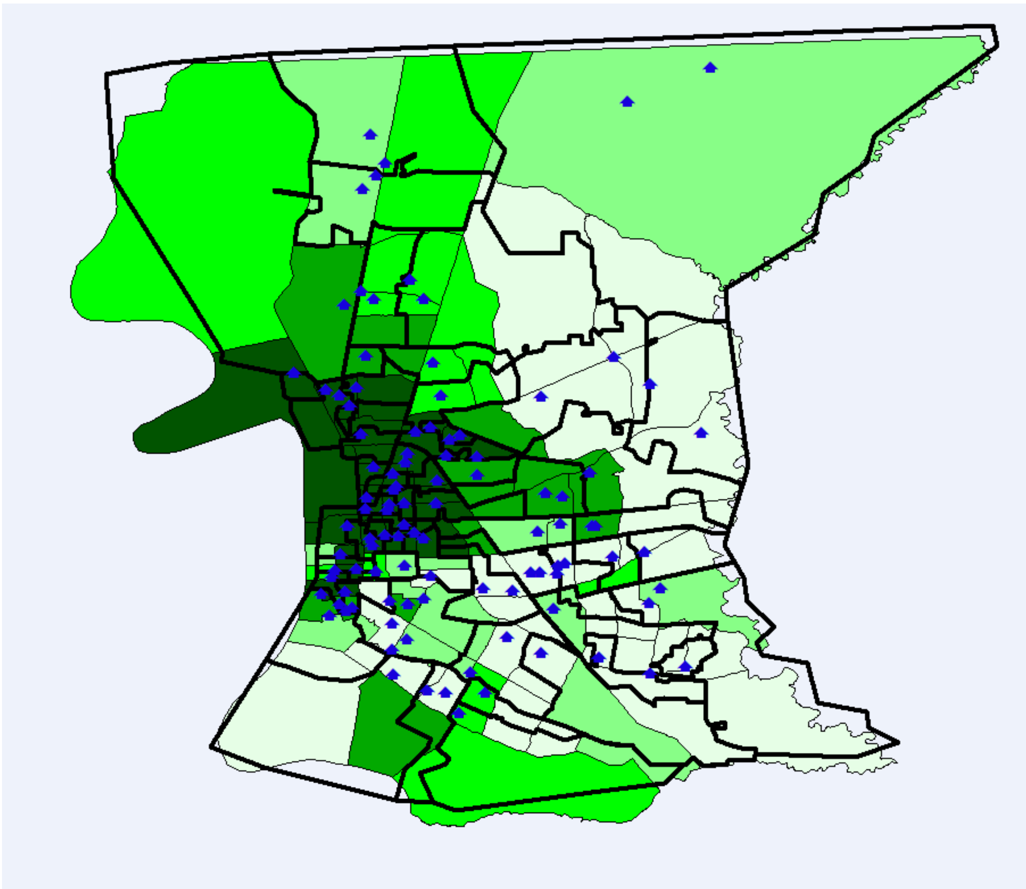

Figure 4. East Baton Rouge Parish: Boundary Sample.

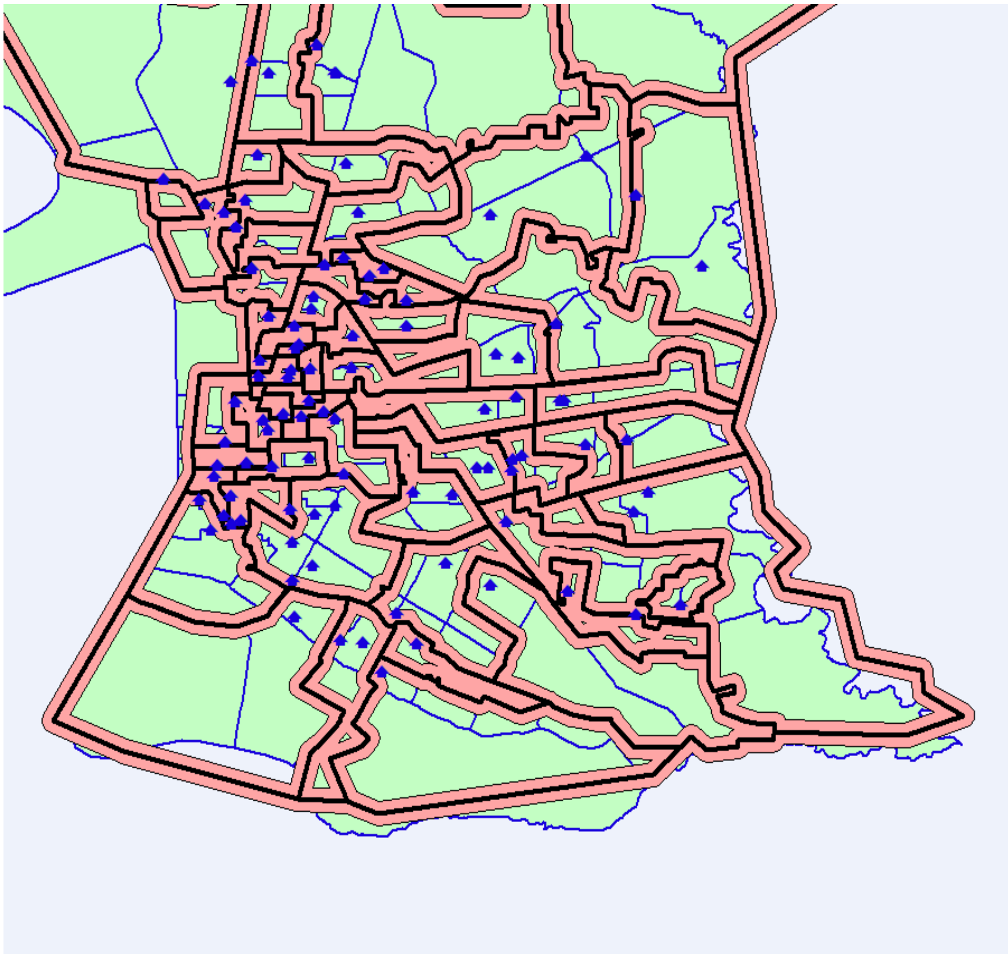

Table 2. *Summary Statistics: 1994-1998*[27]

Variable (Description)	Number of Obs.	Mean	Std. Dev.	Min	Max
Dependent Variable					
soldprR (sold price in '99$)	10640	124812.2	57246.1	40000	358146.5
School Attributes					
test (percent passing CRCT)	7533	90.055	6.272	60.750	99.750
black_school (percent black in school)	7533	0.505	0.240	0.067	1.000
lunch_school (percent on free lunch)	7533	0.479	0.211	0.066	0.944
House Attributes					
tom (time-on-market)	10640	78.581	63.208	14.000	365.000
num_beds (number of bedrooms)	10640	3.277	0.632	1.000	6.000
fullbath (number of fullbath)	10640	2.041	0.484	1.000	4.000
livarea (living area in thousand sq. feet)	10640	1.912	0.569	0.555	4.460
netarea (total area-living area)	10640	0.688	0.287	0.100	1.995
Tract Attributes					
ownerP (percent of owner occupied housing)	10640	0.667	0.188	0.051	0.909
blackP (percent black in tract)	10640	0.225	0.238	0.010	0.984
kidsP1 (percent kids under 5)	10640	0.070	0.018	0.018	0.126
kidsP2 (percent kids 5-17)	10640	0.185	0.042	0.032	0.326
medHH99 (median household income in thousand '99$)	10640	50.016	15.323	11.397	78.509
enrollP (percent enrolled in private schools)	10640	0.052	0.083	0.000	0.373

[27] School averages are taken over the units sold after the Consent Decree was made public, so that they cover sales made after June, 1996.

Table 3 gives the summary statistics over 1999-2002 of the variables that enter into the regression analysis following the school reassignments. The dependent variable, house sale price, is adjusted for inflation, and the mean of $129,283 is in year 1999 dollars. Variables under the heading *House Attributes,* include the number of bedrooms (3.23), number of full bathrooms (2.02), living area in thousand square feet (1.898), and net area (.675). *School Attributes* include the change in categorical ranking based on a change in the SPS; the change in percent of blacks, non-Hispanic (mean of 5.14 percent, standard deviation of 8.20 percent); and the change in percent of students qualifying for free lunch (mean of 6.03 percent, standard deviation of 6.70 percent). Starting in 1998-99 school year, Louisiana's School and District Accountability System reports a SPS for every public school. This score is calculated using index results from three parts: the LEAP 21 tests, the *Iowa Tests* and the Attendance Index. School Performance Labels are assigned based on this score. There are six performance categories: School of Academic Excellence, 0 percent in the district; School of Academic Distinction, 1 percent in the district; School of Academic Achievement, 5 percent in the district; Academically Above Average, 33 percent in the district; Academically below average, 57 percent in the district; and Academically Unacceptable, 4 percent in the district.[28] For each school we construct a set of dummies "SPS Improve" and "SPS Worse" that use the information about the school's performance category between two accountability cycles. For houses that are in the areas affected by re-assignments we construct a set of dummies "SPS Improve" and "SPS Worse" that use the information about the school's performance category before and after the re-assignment. In this case, "SPS Improve" equals one for a unit of observation if the school's performance category improves between two periods, under 1996 school assignment and 2001 school

[28] All schools receive an annual growth target and are expected to reach a score of 120 by the 2013-14 school year.

Table 3. *Summary Statistics: 1999-2002*

Variable (Description)	Number of Obs.	Mean	Std. Dev.	Min	Max
Dependent Variable					
soldprR (sold price in '99$)	6414	129283.6	54784.23	40000	320000
School Attributes					
sps Improve (school improved rating)	6414	0.188	0.390	0.000	1.000
sps Worse (school lowered rating)	6414	0.061	0.240	0.000	1.000
reassign (reassignment dummy)	6414	0.126	0.332	0.000	1.000
blackChange (change in percent black in school)	6414	0.051	0.082	-0.183	0.666
freelunchChange (change in percent on free lunch)	6414	0.060	0.067	-0.216	0.381
House Attributes					
tom (time-on-market)	6414	68.608	44.559	14.000	180.000
num_beds (number of bedrooms)	6414	3.232	0.626	1.000	5.000
fullbath (number of fullbath)	6414	2.024	0.503	1.000	5.000
livarea (living area in thousand sq. feet)	6414	1.870	0.545	0.703	4.435
netarea (total area-living area)	6414	0.675	0.282	0.110	1.995
Tract Attributes					
blackP (percent black in tract)	6414	0.208	0.231	0.010	0.984
kidsP1 (percent kids under 5)	6414	0.069	0.018	0.018	0.126
kidsP2 (percent kids 5-17)	6414	0.184	0.042	0.032	0.326
medHH99 (median household income in thousand '99$)	6414	50.331	14.774	11.397	78.509
enrollP (percent enrolled in private schools)	6414	0.054	0.084	0.000	0.373

assignment. In our sample, 18.6 percent sees an improvement in their school's categorical ranking, while only a little over 6 percent sees a decline in their school's standing. This improved ranking is due to reassignment in 10 percent of our sample. Over 70 percent of our sample does not see any changes in their school's categorical ranking even though 12.6 percent of them are reassigned to different schools.

The variables used to describe neighborhood characteristics, *Tract Attributes*, are the same as in the first regression analysis that considers the original school assignments.

Results

Results Based on Original School Assignments.[29] Table 4 presents the results of the parameter estimates. The first column shows a pooled cross-sectional analysis using baseline or traditional hedonics with linear specification and neighborhood controls drawn form census tract variables. The second column uses traditional hedonics with non-linear specification. Here, we consider a possibility that the capitalization premium varies over the range of school qualities. The nonlinearity in our model might be necessary to capture the alternative schooling arrangements (e.g., private school, home schooling, magnet schools, etc.) that can provide home buyers with high-quality education even if they choose to live in below-average school districts. The last two columns present regression results using boundary fixed effects. For this analysis, we determine the attendance boundaries for 60 elementary schools in East Baton Rouge Parish. We follow Black (1999) and include in the sample only houses within a 0.35 mile buffer of the attendance boundary. In this restricted sample there are 6,801 single family residences.

[29] This section covers the time period 1994-1998.

Table 4. *Regression Results Dependent Variable: ln(sold price in '99$)*

	(1) BASELINE HEDONIC	***(2) BASELINE HEDONIC***	***(3) BOUNDARY FIXED EFFECTS***	***(4) BOUNDARY FIXED EFFECTS***
Regressors	**Linear**	**Non-linear**	**Linear**	**Non-linear**
School Attributes				
Test	-0.000246	-0.00246	0.000766	-0.00447
	(0.00069)	(0.0079)	(0.00085)	(0.011)
test sq		0.0000103		0.0000310
		(0.000046)		(0.000062)
black_school	0.0362	0.0269	0.0650*	-0.128
	(0.025)	(0.068)	(0.039)	(0.13)
black_school sq		-0.00825		0.157
		(0.064)		(0.11)
lunch_school	-0.0629**	0.182**	-0.0639	0.205
	(0.030)	(0.080)	(0.050)	(0.14)
lunch_school sq		-0.239***		-0.233*
		(0.080)		(0.13)
House Attributes				
TOM	-0.000253***	-0.000254***	-0.000231***	-0.000231***
	(0.000027)	(0.000027)	(0.000034)	(0.000034)
num_beds	0.00143	0.00198	0.0194***	0.0195***
	(0.0041)	(0.0041)	(0.0053)	(0.0053)
Fullbath	0.0194***	0.0184***	0.00648	0.00639
	(0.0051)	(0.0051)	(0.0061)	(0.0061)
Livarea	0.472***	0.471***	0.449***	0.449***
	(0.0065)	(0.0065)	(0.0083)	(0.0084)
Netarea	0.151***	0.150***	0.150***	0.149***
	(0.0080)	(0.0080)	(0.0098)	(0.0098)

Robust standard errors in parenthesis
Significance levels: *** p<0.01, ** p<0.05, * p<0.1
Coefficients are not reported for the following variables: house age, mls area, year and season sold.

Our results in the Table 4 show that housing comparables enter the house pricing equation with the expected sign. Increases in the living area, net area and the number of bathrooms increase the price of a house, on average. The coefficient on the time-on-market (*TOM*) variable that measures marketing time is consistently negative and significant at a 1 percent level across all of the specifications. This implies that house sellers in Baton Rouge lower their reservation price as the marketing duration increases.

In summary, the coefficients on the house attributes are very stable across different specifications.

On the other hand, the estimated effects of school attributes are sensitive to the model specification. The coefficient on the test scores is positive in the boundary fixed effects model, column III in the Table 4 but is negative in baseline hedonic specification and both non-linear specifications, columns I, II and IV respectively. Yet, it is statistically insignificant across all four specifications. It could be argued that this coefficient understates the school-quality capitalization, in part, because the district does not consistently publish the student achievement data for its six within-school magnet programs, wherein magnet and traditional students attend the same school but different classes. Approximately 8 percent of the district’s black population and 12 percent of its non-black population are enrolled in the magnet program. A brief analysis conducted by the district reveals that magnet students perform significantly better than the total student population in schools offering within-school magnet programs. This line of argument is supported by Hoyt (2003), which looks at the impact of open enrollment programs on property values in the districts participating in the program. Since open enrollment program eliminates the need to reside in a higher quality district to receive its educational services it reduces

property values there while increasing them in the lower quality districts. Hoyt's study finds evidence that property values are lower in cities and townships where school districts have had a net influx of students after the introduction of choice programs and higher where the net transfer has been out of the district.[30]

Another possible explanation arises from the approach used in the analysis. The most important feature of attendance boundaries that make them useful for this estimation is that they are unchanging. The existence of this feature is what homeowners use when forming their expectations about the local school. It is plausible that, since the attendance boundaries were drawn in August of 1996, EBR homeowners do not have enough time to evaluate the information about local schools and include that information in their pricing decisions. Similarly, according to school district administrators, when attendance boundaries were first determined, the district made every "reasonable good-faith effort" to desegregate the system while considering the size of the school, the distribution of students by grade level, natural boundaries, and, in some cases, family economics and neighborhoods. Anecdotal evidence points that the boundaries, once drawn, were not meeting the requirements spelled in the Consent Decree and needed to be redrawn.[31] We use this implication of instability of the boundary sample and look at the school

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[30] The predicted impacts of the open enrollment programs on property values found using Hoyt's model are consistent with those found by Epple and Romano (1995) using a model that incorporates peer group effects and is numerically solved. Also, Nechyba (1999; 2000) examines the impacts of vouchers for private schools programs and Nechyba (2003) examines public school choice using a calibrated computable general equilibrium model of a metropolitan area. His models generate reductions in property values in wealthy school districts when either a private-school voucher or public school choice program is introduced.

[31] For example, on September 27, 1996, shortly after the Decree was implemented, The Board sought permission to exceed the proposed enrollment in 17 schools. Similar motions were filed on September 24, 1997 and October 23, 1998. It became apparent that the Board will have to redraw the boundaries in order to comply with Consent Decree requirements.

quality capitalization while excluding the boundary sample.[32] Even after such an exercise, we do not find any evidence of test score capitalization.

Additionally, our results indicate that the representation of blacks in local public schools either leads to an increase in property values after controlling directly for the test scores or has no effect. This finding is similar to Norris (2002), which examines the school quality capitalization in six Louisiana parishes.[33] Norris argues that when the enrollment of low-income minorities in a school increases, the test scores suffer and the property values fall. But, for the most part, families don't tend to move away from schools simply because they have a growing enrollment of minorities. We can conclude that property values are not significantly influenced by racial integration, but they do respond negatively to increases in students qualifying for the free lunch program. When looking at the baseline hedonic regression, specification (1), the coefficient suggests that an increase of one standard deviation of students on free lunch is associated with a 1.3 percent decrease in housing prices, or a decrease of approximately $1,623 at the mean (the mean house price is $124,812). This figure is very alarming since the percentage of at-risk students in the school system increased by 20 percentage points, from 51percent in the 1998-99 school year to 72 percent in 2003-04. [34]

Another interesting result in Table 4 is that the percent of school-age children enrolled in private schools has a negative effect on property values, possibly indicating that some houses must be sold at discounted prices to capture the cost of private education. This result is consistent across all specifications and it shows that one standard deviation increase in the enrollment in private schools is associated with about 0.7 percent decrease in housing prices.

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[32] These results are reported in the Appendix A.
[33] Norris (1999) data covers six parishes with large shares of ethnic minorities, blacks in particular. He does not include East Baton Rouge Parish is his analysis.
[34] Students are classified as at-risk if they qualify for either free lunch or reduced-price lunch.

When looking at boundary fixed effects regression, specification (3) and (4), the coefficient suggests even larger impact of private schools enrollment, about 1.03 percent.

Table 5 shows the results of regression analysis where we consider the possibility that land availability affects the extent of house value capitalization.[35] In examining differential capitalization, we divide the sample into two groups based on an indicator of land supply elasticity. Our most direct measure is the percentage of new construction in each census tract. Our first group includes observations in all census tracts where the new construction was less than 25 percent of all houses offered for sale, and it is twice as big as the second group where the new construction is greater or equal to 25 percent. Contrary to the theoretical discussion, school variables are always capitalized into house values at a significantly stronger rate where housing supply is more elastic. School variables are generally not related to housing prices in communities where the new construction is less than 25 percent of all houses on the market.

On the other hand, school variables appear to be capitalized into house values in communities where the new construction is more than 25 percent of all houses on the market. We see the same pattern as in the earlier estimation: increasing the percent of blacks in schools increases housing prices while increasing the percent on free lunch decreases the housing values. It is also important to note that the coefficient in private school enrollment enters house price equations with different signs. It is negative and statistically significant in the sample with less elastic housing supply. On the other hand, it is positive, but with no statistical significance, in the sample with more elastic housing supply.

In conclusion, our results indicate that house buyers are sensitive to differences in school quality and school racial composition, but the amount they are willing to pay depends on a

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[35] *Table 5* focuses only on school and neighborhood quality measures. All other regression results are presented in the Appendix B.

Table 5. *Regression Results: Proxy for Land Supply Elasticity is New Construction in the Census Tract: Dependent Variable: ln(sold price in '99 $)*

	(1) NEW HOUSING <.25	***(2) NEW HOUSING >.25***
Regressors	**Baseline Linear lnsoldprR**	**Baseline Linear lnsoldprR**
School Attributes		
test	-0.00112	0.000250
	(0.00069)	(0.0011)
black_school	-0.0208	0.249***
	(0.030)	(0.040)
lunch_school	-0.0541	-0.125**
	(0.037)	(0.051)
Tract Attributes		
enrollP	-0.133***	0.00532
	(0.030)	(0.073)
Observations	7171	3469
R-squared	**0.85**	**0.91**

Robust standard errors in parenthesis
Significance levels: *** p<0.01, ** p<0.05, * p<0.1
Coefficients are not reported for the following variables: House Attributes, Tract Attributes, house age, mls area, year and season sold.

number of factors and the parameter estimates are sensitive to the specification of the model. Another important set of results from this study relates to the subject of race and public schools. The data illustrates that in the area of East Baton Rouge Parish with larger shares of ethnic minorities, after controlling for the effect of test scores, the representation of blacks in public schools either leads to an increase in property values or has no effect. In short, the housing market is not directly discounting schools on the bases of race alone.

Results Based on Re-assignments.[36] Table 6 reports estimates of the relationship between school quality measures and house prices while focusing on school re-assignments. We present results of pooled cross-sectional analysis using baseline or traditional hedonics with log-linear specification and neighborhood controls drawn from census tract variables. Consistent with the analysis based on the original school assignments, we again show that housing comparables enter the house pricing equation with the expected sign. Increases in the living area, net area and the number of bathrooms increase the price of a house, on average. The coefficient on the time-on-market (*TOM*) variable that measures marketing time is consistently negative and significant at a 1 percent level across all of the specifications. For a second time, this would imply that house sellers in Baton Rouge lower their reservation price as the duration of sale increases. Instead of test scores, we use a set of binary variables (*SPS Improve, SPS Worse*) that is equal to one if the house is in the school attendance zone that has a positive/negative change to its categorical performance measure.[37] Many schools in the EBRSS have long been low performing schools and we have a reason to believe that buyers might be interested in trends in school quality. Using these variables allows us to examine not just short-term fluctuations in test scores but also longer-term progress. We also use another binary variable that captures the change in school

[36] This section covers the period over 1999-2002.
[37] We present our results using year specific level values in the Appendix C.

Table 6. *Regression Results Based on School Reassignments: Dependent Variable: ln(sold price in '99$)*

	(1) Baseline hedonic	***(2) Baseline hedonic***
		With dummy variable interactions
Regressors		
School Attributes		
sps Improve	0.0516***	0.0561***
	(0.0070)	(0.0075)
sps Worse	-0.000666	-0.00253
	(0.0093)	(0.011)
blackChange	0.222***	0.182***
	(0.058)	(0.068)
sps Improve * Reassign		-0.0585***
		(0.022)
sps Worse * Reassign		0.0135
		(0.019)
blackChange * Reassign		0.0937
		(0.11)
freelunchChange	-0.0948	-0.0515
	(0.061)	(0.10)
freelunchChange * Reassign		-0.167
		(0.13)
Reassign	0.00940	0.0212**
	(0.0056)	(0.0099)
House Attributes		
TOM	-0.000163***	-0.000164***
	(0.000045)	(0.000045)
num_beds	0.00236	0.00240
	(0.0050)	(0.0050)
Fullbath	0.0274***	0.0268***
	(0.0066)	(0.0066)
Livarea	0.426***	0.425***
	(0.0084)	(0.0084)
Netarea	0.135***	0.135***
	(0.0099)	(0.0099)

Table 6 (continued).

	(1) Baseline hedonic	*(2) Baseline hedonic* **With dummy variable interactions**
Regressors		
Tract Attributes		
blackP	0.0136	0.00625
	(0.023)	(0.023)
kidsP1	0.275*	0.239
	(0.17)	(0.18)
kidsP2	-0.406***	-0.354***
	(0.11)	(0.12)
medHH99	0.00398***	0.00382***
	(0.00034)	(0.00035)
enrollP	-0.00994	-0.0166
	(0.034)	(0.035)
Constant	10.82***	10.83***
	(0.025)	(0.025)
Observations	6414	6414
R-squared	0.86	0.86

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Coefficients are not reported for the following variables: house age, mls area, year, season, and month sold.

reassignments, so that it is equal to one if the house has been reassigned to a different school after the 2001 change in attendance boundaries. Our results in Table 6 indicate that, holding other factors fixed, an improvement in categorical ranking of school performance is associated with a 5.61 percent increase in housing prices. On the other hand, we see no penalty for schools that see a decline in their categorical ranking. We can conclude that house prices in these school zones are based on comparables.

Table 6 also shows the regression result when we allow for interaction between dummy variables for schools' categorical ranking change and reassignment. The base group consists of houses that are in the school attendance areas that have not changed their categorical ranking and have not been reassigned. Even though the coefficient on reassignment indicator, *reassign*, is positive, our results indicate that the estimated return of improved categorical ranking is somewhat lessened if a house is re-assigned to a different school. The differential between those houses that are reassigned to schools with higher categorical ranking than their previous schools, relative to those who have not changed either school or its ranking, is about 2 percent. This differential is equivalent to an increase of about $2,582 at the mean (the mean house price is $129, 115). We conclude that the decrease in the premium for better schools indicates parents' dislike of abrupt changes in their school environment.

Our results, once again, suggest that the representation of blacks in local public schools leads to an increase in property values after controlling directly for the test scores. An increase of one standard deviation in change of percent blacks in a school is associated with an increase of 1.5 percent in the house price. At the same time, changes in student body eligible for free lunch are not capitalized into house prices.

In addition, Table 7 shows the results of regression analysis when we consider the possibility that land availability affects the extent of house value capitalization.[38] Following the earlier procedure, we divide the sample into two groups based on an indicator of land supply elasticity, or the percentage of new construction in each census tract. As before, the first group includes observations in all census tracts where the new construction was less than 25 percent of all houses offered for sale, and it is more than twice as big as the second group where the new construction is greater than 25 percent. The estimates reveal different capitalization rate for two groups.

First, considering the neighborhoods with a less elastic supply of housing, column I of Table 7, we report that the improved categorical ranking of a school is associated with a 7.8 percent increase in the house price. At the mean, this is equivalent to $9,227 (the mean house price in this sub-sample is $118,300). We also see that there is a penalty equivalent to a 5.5 percent of house price associated with houses in the schools that saw a decrease in their categorical ranking relative to those houses that saw no change in their school rankings. Within these neighborhoods, for given levels of school and house characteristics, the difference in log(price) between a house that changes school assignment and one that does not is 0.023. This means that a house that is reassigned to a different elementary school is predicted to sell for about 2.3 percent more, holding other factors fixed.

Consistent with our earlier findings, these results suggest that the representation of blacks in local public schools leads to an increase in property values after controlling directly for the test scores, while in this sub-sample a positive change in student body eligible for free lunch lowers housing prices.

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[38] Once again, we focus on school quality variables; full regression results are presented in the Appendix.

Table 7. *Regression Results Based on School Reassignments: Proxy for Land Supply Elasticity is New Construction in the Census Tract: Dependent Variable: ln(sold price in '99 $)*

	(1)NEW HOUSING<=.25	***(2)NEW HOUSING>.25***
Regressors		
School Attributes		
sps Improve	0.0779***	0.0583***
	(0.011)	(0.022)
sps Worse	-0.0548***	0.0126
	(0.017)	(0.012)
blackChange	0.474***	-0.488***
	(0.088)	(0.25)
freelunchChange	-0.193**	-0.337
	(0.077)	(0.54)
reassign	0.0226***	0.144***
	(0.0071)	(0.053)
Tract Attributes		
enrollP	-0.0617	0.688***
	(0.038)	(0.11)
Observations	4544	1870
R-squared	0.84	0.91

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Coefficients are not reported for the following variables: House Attributes, Tract Attributes, house age, mls area, year, season, and month sold.

As predicted by the theoretical model, the neighborhoods with a more elastic supply of housing show evidence of weaker rates of school quality capitalization. Column II of the Table 7 reports that the improved categorical ranking of a school is associated with a 5.8 percent increase in the house price. However, this is equivalent to about $9,028 at the mean, only $200 less than in the sample with a less elastic housing supply. The mean house price in our sample of more elastic housing supply is a $155,670.[39] Figure 5 shows the location of houses in this sample. We also find no penalty associated with houses in the schools that see a decrease in their categorical ranking relative to those houses that see no change in their school rankings. Within these neighborhoods, for given levels of school and house characteristics, the difference in log(price) between a house that changes school assignment and one that does not is 0.144. This means that a house that is reassigned to a different elementary school is predicted to sell for about 14.4 percent more, holding other factors fixed.[40] This finding seems conceivable since EBR homeowners were aware that the EBRPSS will have to redraw the boundaries in order to comply with Consent Decree enrollment requirements. The reassignments sent kids from overcrowded schools to a different school in their neighborhood proximity.

Conflicting with the earlier findings, our results here suggest that the increase in percent of black students in school leads to a decrease in property values after controlling directly for the test scores, while in this sub-sample a positive change in student body eligible for free lunch is negative but not statistically significant. It is also important to note that the coefficient on private school enrollment enters house pricing equations with different signs. While it is negative and very small in the sample with less elastic housing supply, this coefficient is positive

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[39] We plot this sample and show that it mostly consists of suburban homes.
[40] EBRPSS administrators confirmed that following the attendance zones changes, some schools in the parish outskirts saw a significant increase in student enrollment.

in our suburban sample. It indicates that an increase of one standard deviation in the percent of children in the census tract that attend private schools leads to a 3 percent increase in house price. We suspect that this coefficient captures the additional value parents place on the availability of private schooling options.

Sensitivity Tests

One of the challenges in the housing literature is separating the value of school test scores from other neighborhood amenities. Researchers have to account for a complication that arises because better schools tend to be located in better neighborhoods. As a result, not controlling adequately for neighborhood characteristics may overestimate the value of better schools. Black (1999) argues that any differences in unmeasured neighborhood characteristics would be minimal if one considers properties very close to each other but on the opposite sides of attendance zone boundaries. Others have argued that the similarity in neighborhood characteristics that might exist when the boundaries are initially drawn may not last long as those houses are bought and sold. They suggest that potentially unobserved differences in neighborhoods near school attendance boundaries are relevant and still bias the estimates for the effects of test performance on housing prices. This would imply that the areas being compared are not really the same neighborhoods.

Black (1999) runs a number of sensitivity tests to investigate this concern including creating artificial attendance boundaries. We do not worry about school attendance boundaries being potential neighborhood partitions since, under a court-imposed desegregation plan in place from 1981, the district imposed mandatory busing for its students, and it was not until 1996 that the district adopted community sensitive attendance zones.

We test the results' sensitivity in a number of ways. First, we compare the results obtained for data subsets for one-, two- and three-bedroom houses with the results for four- or more bedroom houses. We assume that people who live in houses with more bedrooms are more likely to have children, and are therefore willing to pay more for better schools than people in houses with fewer bedrooms.

Table 8 reports the estimates from the model that examines school reassignments, specification (1), along with the results we obtained when the sample is divided into sub-samples based on a number of bedrooms. Focusing on the second and third column, we note different rates of capitalization. Here, we examine changes in schools' categorical ranking and observe that there are some major differences between the two sub-samples. For example, negative changes in schools' categorical ranking, and percent free lunch are statistically significant in the sub-sample of houses with three- and fewer bedrooms (column II). The coefficients on these variables indicate that lowering school's categorical ranking is associated with a 2.2 percent decrease in house value, while increasing the change in percent free lunch is expected to lower house values by 13 percent. Neither one of these two coefficients appear to be statistically significant in the house price equation for our sub-sample of houses with more than three-bedrooms. Other school variables enter both equations with the same signs but different magnitudes; however, once interpreted at the mean, their impact is very similar.

Figure 5 plots the locations of houses divided in our sub-samples based on number of bedrooms and percent of new construction for the estimation that considers original school assignments. These sub-samples appear to be very comparable and divide the data into inner city and suburban samples. Consequently, our results are similar to the results from regression

analysis where we consider the possibility that land availability affects the extent of house value capitalization.

Second, if the quality of the local public school affects the value of houses in that locality, then homeowners will vote for better schools. We argue that homeowners' concerns about the values of their major asset make them more attentive to the benefits and costs of public education. Fischel (2001) suggests that people who are motivated by house values are more likely to vote in school related elections and have more knowledge of how schools are actually performing. If a capitalization phenomenon is in part explained by homebuyers' expectations and knowledge about locational amenities, we propose that capitalization rates revealed by more informed communities are better estimates of true capitalization. Thus, our findings in Table 9 reinforce the idea that the capitalization results are due to the differences in elementary schools. We collect voting returns from the school tax proposal in November 1998. Each house is geocoded to a specific elementary school, voting precinct and census tract. Next, we divide the sample based on precinct vote into: vote "yes" and, vote "no." These results are presented in Table 9. Similarly, Figure 5 plots the locations of houses in these two voting sub-samples. Our results indicate stronger capitalization of improvement in the categorical ranking for those houses that are located in precincts voting "yes" to the tax bill. For example, an improvement in a categorical ranking is associated with about a \$9,100 increase in the house price at the mean (the mean house price is \$130,129) as compared to about \$5,300 increase at the mean for houses located in precincts voting "no" (the mean house price is \$106,659).

Finally, we consider a specification test to determine whether the nonlinear model in the regression based on original school assignments is preferred to the linear model. Table 10 shows the comparison. The explanatory power as computed by the adjusted R^2 of each of the

specifications is identical but according to the p-value, we cannot reject the null hypothesis that the two specifications are different. This suggests that the quadratic terms are not important.

Table 8. Regression Results when sample is divided based on a number of bedrooms:

Dependent Variable: ln(sold price in '99 $)

	(1) ***Full sample***	***(2)*** ***num_beds<=3***	***(3)*** ***num_beds>3***
Regressors			
School Attributes			
Sps Improve	0.0516***	0.0557***	0.0477***
	(0.0070)	(0.0092)	(0.010)
Sps Worse	-0.000666	-0.0222*	0.0226
	(0.0093)	(0.012)	(0.014)
blackChange	0.222***	0.291***	0.152*
	(0.058)	(0.076)	(0.088)
Sps Improve * reassign			
Sps Worse * reassign			
blackChange * reassign			
freelunchChange	-0.0948	-0.130*	-0.0233
	(0.061)	(0.078)	(0.11)
freelunchChange * reassign			
reassign	0.00940	0.00582	0.000467
	(0.0056)	(0.0070)	(0.0090)
Constant	10.82***	10.65***	11.45***
	(0.025)	(0.036)	(0.097)
Observations	6414	4432	1982
R-squared	**0.86**	**0.81**	**0.86**

Table 8 (continued).

	(4) ***Full sample***	*(5)* ***num_beds<=3***	*(6)* ***num_beds>3***
Regressors			
School Attributes			
Sps Improve	0.0561***	0.0563***	0.0521***
	(0.0075)	(0.010)	(0.011)
Sps Worse	-0.00253	-0.0232*	0.0202
	(0.011)	(0.014)	(0.016)
blackChange	0.182***	0.330***	-0.0245
	(0.068)	(0.085)	(0.12)
Sps Improve * reassign	-0.0585***	-0.00245	-0.0369
	(0.022)	(0.032)	(0.038)
Sps Worse * reassign	0.0135	0.0111	-0.00486
	(0.019)	(0.027)	(0.037)
blackChange * reassign	0.0937	-0.0986	0.400**
	(0.11)	(0.14)	(0.21)
freelunchChange	-0.0515	-0.211	0.396**
	(0.10)	(0.12)	(0.20)
freelunchChange * reassign	-0.167	0.137	-0.674***
	(0.13)	(0.18)	(0.21)
reassign	0.0212**	0.00192	0.0167
	(0.0099)	(0.015)	(0.016)
Constant	10.83***	10.65***	11.45***
	(0.025)	(0.036)	(0.097)
Observations	6414	4432	1982
R-squared	**0.86**	**0.81**	**0.86**

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Coefficients are not reported for the following variables: House Attributes, Tract Attributes, house age, mls area, year and season sold.

Figure 5. Sub-Samples

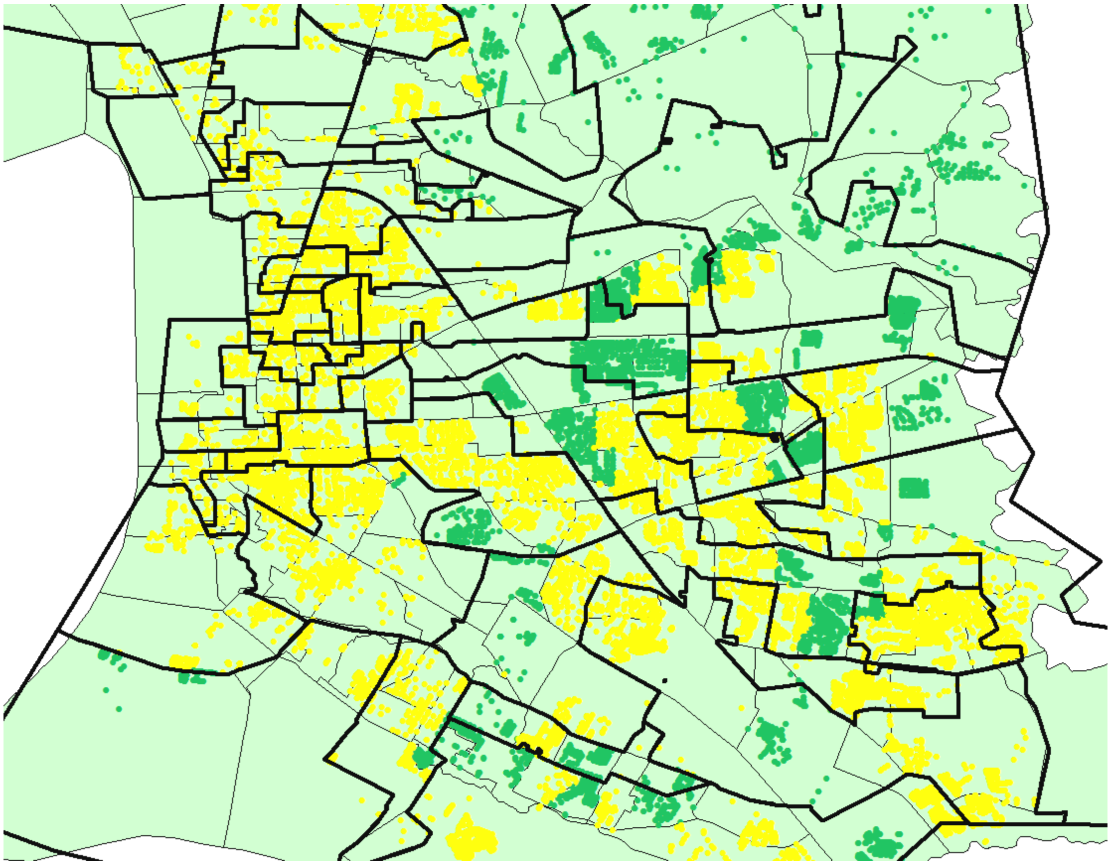

Table 9. *Regression Results when sample is divided based on a school vote:*

Dependent Variable: ln(sold price in '99 $)

	(1) Full sample	***(2) Vote Yes***	***(3) Vote No***
Regressors			
School Attributes			
Sps Improve	0.0516***	0.0708***	0.0494*
	(0.0070)	(0.0086)	(0.031)
Sps Worse	-0.000666	0.000667	-0.0467
	(0.0093)	(0.0096)	(0.038)
blackChange	0.222***	0.189***	0.408***
	(0.058)	(0.067)	(0.12)
Sps Improve * reassign			
Sps Worse * reassign			
blackChange * reassign			
freelunchChange	-0.0948	-0.0573	0.264*
	(0.061)	(0.068)	(0.14)
freelunchChange * reassign			
reassign	0.00940	-0.0104	-0.00983
	(0.0056)	(0.0063)	(0.015)
Constant	10.82***	10.90***	11.52***
	(0.025)	(0.036)	(0.23)
Observations	6414	4600	1083
R-squared	0.86	0.87	0.82

Table 9 (continued).

	(4) ***Full sample***	*(5)* ***Vote Yes***	*(6)* ***Vote No***
Regressors			
School Attributes			
Sps Improve	0.0561***	0.0813***	0.0168
	(0.0075)	(0.0096)	(0.040)
Sps Worse	-0.00253	-0.0159	-0.00338
	(0.011)	(0.011)	(0.059)
blackChange	0.182***	0.120	-0.192
	(0.068)	(0.083)	(0.24)
Sps Improve * reassign	-0.0585***	-0.103***	-0.0820
	(0.022)	(0.025)	(0.10)
Sps Worse * reassign	0.0135	0.0629**	0.00760
	(0.019)	(0.019)	(0.12)
blackChange * reassign	0.0937	0.149	0.791***
	(0.11)	(0.13)	(0.28)
freelunchChange	-0.0515	0.262**	1.162***
	(0.10)	(0.12)	(0.41)
freelunchChange * reassign	-0.167	-0.551***	-1.376***
	(0.13)	(0.15)	(0.47)
reassign	0.0212**	0.0182*	0.0632
	(0.0099)	(0.011)	(0.043)
Constant	10.83***	10.91***	11.46***
	(0.025)	(0.036)	(0.23)
Observations	6414	4600	1083
R-squared	0.86	0.87	0.82

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Coefficients are not reported for the following variables: House Attributes, Tract Attributes, house age, mls area, year and season sold.

Table 10. *Specification Test on Boundary Fixed Effects.*

MODEL	*ADJUSTED R-SQUARED*		
Linear boundary fixed effects	0.88	LR test =	4.08
Nonlinear boundary fixed effects	0.88	Prob>χ^2 =	0.2528

Conclusion

This study uses data from East Baton Rouge Parish, Louisiana from 1994 through 2002 to explain the relationship between property values and variables that include school performance and school racial composition. The choice of East Baton Rouge Parish enables us to deal effectively with a number of important issues in the housing literature.

First, public schools are only one of the public services attached to any particular location. Since we consider a single school district and political jurisdiction, we can adequately control for the provision of public services other than elementary education.[41] Second, the factors that determine neighborhood quality are hard to identify and compute. In order to control for neighborhood effects, we follow the approach introduced first by Black (1999), where we restrict our sample to houses in close proximity to elementary schools' attendance boundaries.

Additionally, several events make East Baton Rouge Parish an ideal place to study the effect of school test scores and school racial composition on house prices. First, under a court-imposed desegregation plan in place from 1981 through 1996, the district imposed random school assignments for its students.[42] In an effort to achieve racial balance, formerly white and formerly black schools were paired or clustered, and students were bused to their clusters based on the need to create racial balance. These kinds of desegregation orders created strong public resistance and a migration of white students from the public school system. Finally, 15 years after court-ordered random assignments started, the district adopted a plan that eliminated busing in favor of "community sensitive" attendance zones, which were drawn to maximize a sense of community ownership of the schools.[43] The move to community sensitive attendance zones

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[41] We focus on elementary schools because only these schools allow for enough within district variation.
[42] The school district is governed by East Baton Rouge Parish School Board.
[43] Consent Decree, page 2.

allows us to include school quality as one of the measures of locational amenities.

Our findings, based on the initial school assignments, show that the housing market does not seem to be sensitive to increases in test scores. We attribute this to many changes that East Baton Rouge Parish School System has been through because of its battle with school desegregation law suits. As suggested by Kane et al.(2003), a school that is improving has a difficult time signaling that improvement to the buyers in the housing market. Similarly, the availability of choice programs and instability of school attendance boundaries would also contribute to underestimation of school quality capitalization.[44] However, when considering race, the statistical result is encouraging. We find that the housing market is not directly discounting schools based on race. There is an indication that the representation of blacks in local public schools either leads to an increase in property values or has no effect, after controlling directly for the test scores. On the other hand, the housing market shows that prices do respond negatively to increases in students qualifying for the free lunch program.

Our findings based on reassignments show that housing prices respond to improvements in the categorical ranking of school performance but do not penalize for schools whose categorical rankings decline. The results indicate that the estimated return of improved categorical ranking is somewhat lessened if a house is reassigned to a different school. Earlier work by Figlio and Lucas (2000) about Florida finds some evidence that public disclosure of school report cards has an impact on house values.[45] We show that the improvement in categorical ranking has large impact on housing prices. Yet again, we find that the housing market is not directly discounting schools based on race.

[44] The district runs a number of choice programs such as magnet program, and majority-to-minority transfers.
[45] Florida schools were assigned grades A-F based on test performance.

When considering the impact of housing supply elasticity on capitalization we split the sample into two parts based on the percentage of new construction, a proxy for available developable land. The coefficients on school variables are less stable and contrary to the theoretical predictions in the house price equation that considers the initial establishment of school attendance boundaries. School variables are generally not related to house prices in communities where the new construction is less than 25 percent of all houses on the market. On the other hand, school variables appear to be capitalized into house values in communities where the new construction is more than 25 percent of all houses on the market. We argue that since our sample with lower housing supply elasticity represents inner-city housing, these schools have been low performing schools for some time and were known as such to house buyers. We do see that house prices in this sample account for private school enrollments and discount house values.

When education policymakers are pondering investments in education they must consider the costs involved as well as the benefits. The results of this research provide valuable information for evaluating the economic benefits of a current political issue such as school testing and accountability. The housing market reveals that the type of grading system used or the indicators of quality can have a large effect on property values. For example, our study indicates that in considering a neighborhood with a less elastic supply of housing, concentrated mostly in a central city, the improved categorical ranking of a school is associated with a 7.8 percent increase in the house price. At the mean, this is equivalent to $9,227 (the mean house price in this sub-sample is $118,300). Similarly, there is a penalty equivalent to a 5.5 percent of house price associated with houses in the schools that saw a decrease in their categorical ranking relative to those houses that saw no change in their school rankings. This result implies that

central city house values are more elastic with respect to improvements in elementary school categorical rankings. Thus, improving elementary schools has a great potential for increasing house values, and, as a consequence, revenue from property taxes.

Our unique data provides a rare opportunity to study how a sudden exogenous change in public policy impacts the housing market. The changes in school assignment implemented by East Baton Rouge Parish School System are a natural experiment in education policy. Because the school district was operating under a court-imposed desegregation order, we can observe the effects of these exogenous changes on housing market locational amenities. Such exogenous change allows us to use classical statistical theory that works only if variations in data occur randomly. Furthermore, the empirical findings of the effect of land availability on the extent of school quality capitalization have strong implications for future theoretical and empirical studies in the housing literature.

A house is typically a person's largest asset. The quality of local public schools is often a major consideration when a family with school-age children looks for a house to buy, and a child’s placement in public elementary school is based on a family’s residential location. Thus, a family with school-age children makes two investment decisions when it chooses a residential location: the first is the investment in housing, and the second is the investment in the human capital of their child. Most families are risk-averse agents who are, at once, investing in housing and education, both long-term and illiquid portfolio investments. Even though numerous studies look at house buyers’ valuations of school quality, there is little attention given to its effect on liquidity. In the next chapter we turn our focus to the impact of school performance and school racial composition on liquidity. By taking into account the interrelationship between prices and

time-on-market, this dissertation offers a more complete estimate of the impact of changes in school characteristics on the housing market than previous research offers.

Chapter 4: School Quality and Housing Market Liquidity

Time-on-Market Literature Review

Housing is a heterogeneous good that is spatially distinct. Buyers and sellers must expend resources to find potential matches and complete a transaction. Thus, in addition to pricing, the time component of the search process, or liquidity, is also relevant. Liquidity is usually defined as an asset characteristic that reflects how quickly the asset can be sold at a given price. In essence, the price-setting problem is an exercise in how to balance the desire to sell at a high price with the reality that high priced houses are likely to stay on the market for a long time. Thus, a common measure of liquidity is the time-to-sale under optimal pricing, or time-on-market (TOM).

The literature concerning the contribution of house characteristics or locational attributes to marketing time can be broken down into the theoretical and empirical studies. The observation that exchange in the housing market takes place only after agents conduct a search suggests that it is possible to borrow models developed in other areas of economics, such as labor economics, to study asset pricing. [46] However, in this summary, we focus our attention only on the empirical studies of TOM and its determinants. The body of work on this issue is less extensive and more recent than the price capitalization literature. This is in part due to the lack of agreement over the proper methodology to be employed in estimating TOM.

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[46] Lippman and McCall(1986) are among the first to adapt such models to real estate asset pricing. Haurin (1988) adopts a very similar model. One shortcoming of both models is that the analysis is conducted in a partial equilibrium framework. The authors take the behavior of house buyers as given and model only the behavior of a house seller. Arnott (1989) introduces the buyer's problem into the model, but he simply assumes that they take the house with the lowest price. Wheaton (1990) is one of the first authors that jointly model the buying and selling decision. Even though Wheaton (1990) incorporates both buyers and sellers into his model, one shortcoming is that the analysis is conducted exclusively in the steady state. Williams (1995)extends Wheaton's model to a dynamic setting.

Cubin (1974) examines the relationship between price and TOM for home sales in Coventry, England, between June 1968 and June 1970. He initially develops a “quality adjusted” price, which represents the difference between the actual sales price and expected sales price generated by a hedonic-type estimation based on specific home characteristics. Cubin assumes a geometric distribution for TOM.

He hypothesizes that houses with positive quality adjusted prices will take longer to sell. The study uses the log of TOM as a dependent variable and uses the least square technique to regress it on the quality adjusted price and house characteristics. Contrary to his hypothesis, the results show that a house with a higher quality adjusted prices sells faster. Cubin argues that this result is possible since a buyer might use price as a signal of home quality. For example, the buyer assumes there is superior quality and lower repair expenses in a higher priced home. Also, Cubin raises the possibility that a least squares regression model is not capturing the simultaneity between price and TOM.

Belkin et al.(1976) introduce the effects of submarkets on TOM. In this study, buyers are limited to a specific geographic area and price level, resulting in separate supply and demand characteristics for each submarket. The authors use a price level submarket of about 1000 transactions in the Hartford, Connecticut, area in 1970 and 1973. In order to maintain an identical information level for all transactions they limit the study to MLS sold homes. They specify TOM as an exponential process.

The main argument of this study is that TOM measures value and submarket performance. In essence, similar houses with the same price in the same submarket should have the same TOM. They also argue that the probability of selling a house is not influenced by TOM. The main findings reveal that price concessions made by an owner increase over time,

making the home more attractive to buyers. Another interesting finding of this study is that housing features do not influence TOM within a particular submarket.

Trippi (1977) argues that price and TOM should be positively related since the probability of selling a property is inversely related to the price of the property. He also contends that TOM follows an exponential process. This study uses residential income property units sold in San Diego County between April 1973 and October 1974. Trippi uses canonical analysis and argues that this method avoids a simultaneity problem between price and TOM. He chooses the log of TOM and the log of the ratio of income to price as dependent variables. The empirical results support his hypothesis and show that price and TOM are positively related.

Miller (1978) uses a multiple regression model to examine the relationship between TOM and price for 91 residential units sold in Columbus, Ohio, in the latter half of 1976. His model uses selling price as the dependent variable. His argument, which says that a seller with lower search or opportunity costs can wait for a higher offer, also, calls for a positive relationship between TOM and price. The study's empirical results support his argument. Miller also argues that since both variables, selling time and price, are influenced by the characteristics of the property (size, location, quality of public services), the simultaneous influence makes the study of the relationship between time-on-market and selling price difficult. He states that unless a market can be located where the equilibrium or average time-on-market is stable and equal across all price ranges, locations, and sizes within the sample, traditional statistical approaches and empirical tests are questionable.

Zuehlke (1987) examines the sale probability of a home, given its elapsed TOM. The analysis is based on a sample of 290 single-family properties in Tallahassee, Florida, in February 1982. Zuehlke employs a Weibull hazard model to show that an owner becomes more risk

averse over time and lowers his reservation price. He also finds that this is more evident for vacant homes.

Haurin (1988) tests the impact of price dispersion on TOM for 219 sales in a neighborhood in Columbus, Ohio, between April 1976 and April 1977. The central argument of this study is that atypical units, the units that have odd features or characteristics when compared to other homes in the area, are subject to a greater dispersion of offering prices, resulting in a longer TOM. The argument arises from the assumption that the seller is aware that buyers value atypical characteristics differently, thus, the seller expects a wider distribution of offers. Haurin argues that the seller believes it is worthwhile to wait longer in hope of receiving a higher offer. The author uses survival regression to analyze TOM and finds that atypical houses take longer to sell. His findings also reveal that TOM falls when a house is listed with a large broker.

Kang and Gardner (1989) employ OLS estimation techniques to explore how property marketing time is influenced by the complex relationship between selling price, listing price, property characteristics, and market conditions. Using data from the Mclean County, Indiana, the authors find a positive relationship between new loan rates and marketing time, shorter marketing time for newly constructed properties, and the lack of a size effect on property marketing time.

Ferreira and Sirmans (1989)examine two different market regimes to determine whether home sellers concede assumption financing premiums to buyers in order to reduce TOM. Their data covers 51 assumption-financed home sales and 66 conventionally financed home sales in 1975 and 1976, and 68 assumption-financed home sales and 62 conventionally financed home sales in 1980 in Greenville, South Carolina. They model TOM using two-stage least squares. In the first stage, they model the log of time as a function of the ratio of list price to selling price

and average conventional mortgage rate. The second stage, then, includes a hedonic price model, where the log of price is regressed against home characteristics, TOM, and the cash equivalent of the financing premium. Their findings are mixed. For the first time period, they report that sellers did not negotiate away the financing premium to reduce TOM. However, in 1980, the financing premium is conceded to buyers to achieve a faster sale. The authors attribute the difference in the seller strategy to the depressed market conditions in 1980.

Even though the tradeoff between selling price and TOM is well recognized, most of the existing literature examines the impact of housing attributes on either selling price or TOM. Several recent studies estimate a property’s selling price and TOM jointly (Huang & Palmquist, 2001; Knight, 2002; Sirmans, Turnbull, & Benjamin, 1991; Turnbull & Dombrow, 2005). To capture the possibility that selling price and TOM are interactive variables, some studies estimate simultaneous or two-stage models. Various aspects of the market environment, including both economic market factors and property characteristics, affect the liquidity of the housing market as well as selling prices. For example, age of the structure sometimes acts as a proxy for housing condition; as a house ages, it deteriorates physically. Additionally, a house’s design might be outdated, and the demand for such a house is likely to be reduced. It is anticipated that the marketing time for older houses would be longer. Similarly, higher selling prices are anticipated for Spring and Summer sales. Furthermore, it is shown that seasonality affects the marketing time in the residential real estate market (Haurin, 1988; Kluger & Miller, 1990). For instance, families with children are less motivated to either buy or sell houses when school is in session. Consequently, technical problems arise because the specifications of both the price and TOM models are similar. The following is a brief summary of such studies.

Forgey, Rutherford, and Springer (1996)focus on the impact of search effort and liquidity when they estimate a two-stage least squares model of house prices and TOM. They use data from 3358 single-family house sales in Arlington, Texas, between May 1991 and June 1993. In the first stage, the dependent variable is the log of TOM. Consistent with earlier TOM studies, their results of the first stage show that TOM depends on the seller's search effort, market conditions, physical characteristics of the property, the size of the brokerage firm, and listing price. They then use the predicted values and residuals from stage one to create the expected time-on-market variable and the relative difference of the actual selling time and expected time-on-market. In the second stage, the dependent variable is the log of the selling price. The findings of the second stage indicate that increases in expected TOM result in higher sales prices. This result supports the notion that a sales price will increase as a seller more throughly searches the market for the highest offer. The findings of the second stage also indicate that deviations from the expected time-on-market are inversly related to selling prices. This result supports the notion that buyers will pay a premium for properties that are more liquid relative to other properties.

Another study that implements OLS models for selling price and TOM is Haag, Rutherford and Thomson (2000). The hedonic price model of this study makes the typical assumption that the log of the sales price of a house is a function of housing characteristics, location, seasonality controls, TOM, and the real estate agents' comments.[47] The TOM equation is very similar. The log of the marketing time of a house is a function of housing characteristics,

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[47] Many studies examine a role of real estate agents or brokerage on the sales price (Benjamin, Jud, & Sirmans, 2000; Yavas & Yang, 1995). The provision of a multiple listing service (MLS) allows agents to search for properties that will fit the client's needs. This listing contains information regarding age, size, number of bedrooms, number of bathrooms, and other physical characteristics. For each listing on MLS, a section is provided for agents to furnish additional information about the property. Examples of these remarks include "Well maintained home," "Ready to sell," and "New paint."

location, seasonality controls, listing price, and the real estate agents' comments. They find that TOM has a significant negative effect on selling price, but the list price is shown to be not significant in the TOM equation. According to their results, motivated sellers accept lower selling prices. Updated properties produce a higher selling price and a shorter selling time. However, the authors find that some other improvements such as new paint and roof work decrease price and increase TOM.

Huang and Palmquist (2001) investigate the total impact of an enviromental disamenity, in this case highway noise, on property values and TOM. They first estimate the reservation price by using the hedonic reservation price model and assuming that the reservation price is determined by characteristics of a house and a random component that captures the price variation not explained by housing characteristics. They then describe the TOM model using survival analysis. The empirical analysis of the Kingsgate, Washington, housing market shows that highway noise has no significant impact on TOM, but it has a significant negative impact on reservation and sale prices.

In examining the effect of exclusive agency and exclusive-right-to-sale contracts, Rutherford, Springer and Yavas (2001) estimate a two-equation simultaneous equations model for selling price and TOM. The first stage regresses TOM against various factors, and the second stage regresses selling price against a similar set of factors. The only difference between the two equations is that the seasonality controls are constructed based on the list date in the TOM equation and sales date in the price equation. The results show a positive relationship between selling price and selling time and that exclusive agency listings and builder-owned listings have a shorter selling time than exclusive-right-to-sale listings and owner-held properties. Their findings support the theorethical model that shows the seller being better off with an exclusive

agency contract than an exclusive-right-to-sell contract because the former results in greater broker effort which, in turn, leads to faster sale. However, exclusive agency listings are associated with lower selling prices while builder-owned properties have higher selling prices.

A 2001 study by Johnson, Salter, Zumpano and Anderson examines the effect of artificial stucco on house prices and selling time.[48] They use a game theoretic framework to model the interaction between buyers and sellers. They first run a probit model to relate the presence of artificial siding to explanatory variables. Next, they estimate the selling price using atypical explanatory variables with artificial stucco included. Finally, they use duration modeling to measure the effect of artificial stucco on selling time. Their results suggest that properties with artificial stucco sell at a premium although the selling time is longer.

Knight (2002) considers the causes and effects of changes in list price on the selling price and TOM connection. Following Yavas and Yang (1995) and Forgey et al. (1996), Knight employs a two-stage least squares model to control for possible simultaneity bias in the selling price and TOM models. In general, the model regresses the log of selling price on TOM, marketing choices of the seller, physical characteristics of the house, location, and time of sale. Marketing choices of the seller are the size of commission offered by the seller and the size of the listing firm used by the seller. Similarly, their model of TOM includes signals of seller motivation, aspects of the home that affect its marketability or increase the seller’s search costs, and a time trend to control for market conditions. Specifically, the factors signaling seller motivation include the list price markup over expected selling price, owner financing, size of commission offered by the seller, and the size of the listing firm. Knight proposes that by using heterogeneity as a composite representation of the principal attributes, the study is able to

[48] Artificial stucco is formally known as Exterior Insulation and Finish Systems.

employ the individual house's physical characteristics to identify the time-on-market equation and permit two-stage least squares estimation.

In the first stage, he estimates predicted values of the two endogenous variables, selling price and TOM, and in the second stage he makes a substitution of these predicted values as explanatory variables in each of the individual structural equations. The study finds that the two most important determinants of price revision are the total length of time the home is marketed and the amount by which the home is overpriced initially. He also reports that homes with large percentage adjustments in listing price not only had longer selling times but also ultimately sold at lower average selling prices.

Anglin, Rutherford and Springer (2003) use a two-stage process to estimate the impact of the list price on the trade-off between selling price and TOM. In the first step of their analysis, they estimate the expected list price based on house characteristics and market conditions. They then use this information to create the degree of overpricing, the percentage difference between the actual listing price and the expected listing price.[49] Their theoretical model shows that there is no direct tradeoff between selling price and selling time but that market conditions affect how the expected selling price and the expected selling time vary jointly based on the initial listing price. They estimate a TOM model using a hazard model with a Weibull distribution. Their study finds that increases in the list price increase TOM.

Most recently, Turnbull and Dombrow (2006) examine how spatial competition and shopping externalities affect house selling prices and TOM. They base their empirical model on the simultaneous equations model, and improve on previous studies that use the hedonic price approach by controlling for localized demand and supply conditions. The different elements in

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[49] Other papers that focus on the degree of overpricing include Glower, Hendershott and Haurin (1998), Anglin and Wieber (2004).

the neighborhood supply and demand conditions vectors ensure that both regression equations are identified in the 2SLS estimation, thus, solving price-TOM equations identification problems. In addition, using a measure for spatial competition removes source of spatial correlation in housing data.[50] Their study finds that housing prices and TOM reflect both competitive and shopping externality effects from neighboring houses.

In summary, the literature on asset liquidity yields important insights into the sources of liquidity. It is possible that the market illiquidity arises because of the fact that real estate buyers are heterogeneous. Some buyers attach higher valuations to a given house than others. Therefore, a seller has an incentive to wait for the buyers with the highest valuations. For example, buyers who care about education may concentrate their efforts in the highest quality school attendance zones, creating an increasing tight housing market as school quality increases. These buyers might also face increased competition for the highest quality schools and rapidly increasing premiums or lower illiquidity for houses in those attendance zones.

In the next section we investigate the relation of locational amenities and liquidity. In particular, we study how changes in school performance and school racial composition impact simultaneously determined house price and marketing time. By taking into account the interrelationship between prices and time-on-market, this dissertation provides a more complete estimate of the impact of changes in school characteristics on the housing market than previous research offers.

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[50] Such measure is appropriate because, among other reasons, when a house is put on the market, the list price is often set with the knowledge of selling price of similar houses in the neighborhood.

Theoretical Framework

The search theory originates in labor economics (Kiefer & Neumann, 1979; Lippman & McCall, 1986; Mortensen, 1970), and it has wide applications for understanding the natural unemployment rate, unemployment insurance, and government policies such as the minimum wage. The standard search theory can also be applied to describe house sellers. Indeed, the problem facing a consumer looking for the lowest price or an unemployed agent looking for the best paying job is structurally the same as the problem faced by a homeowner looking for a buyer.

On the theoretical side, Arnott (1989) establishes a one-sided search model to examine a seller's search behavior and the vacancy rate. Arnott's results show that vacancies are socially useful because they give households more choices. Wheaton (1990) uses a two-sided search model to match up sellers and buyers to study the equilibrium vacancy rate in the housing market.

The housing market is such that there is no central marketplace where investors can trade. Buyers must search for sellers. Search is costly because agents are not able to instantly complete the trades. For example, a potential buyer cannot value a house without actually walking through it. Two agents can walk through the same house, yet attach very different subjective values to it. Buyers and sellers meet and determine whether there is an incentive to trade. If there is no incentive, the agents wait for another pairing. The process of identifying houses on the market and then visiting them can be expensive both in terms of money and time. This heterogeneity of preferences plays an important role in determining how liquid the market is.

The model used here is a search-theoretic model, developed in Krainer and LeRoy (2002), where prices and TOM are derived from the maximizing behavior of both buyers and

sellers. The main purpose of the model is to generate state-dependant liquidity. In this case, the state variable describes the quality of local public schools and takes on just two values, low and high. State-varying liquidity implies that prices do not absorb all of the gains (losses) in asset values when the environment switches from state to state. The model offers two important observations. First, the probability of sale in the high state is greater than it is in the low state; expected TOM is shorter in the high state. Second, prices are higher in the high state.

The model and its properties are fully developed in Krainer and Leroy (2002). The discussion below draws heavily from their study.

The main assumption in such a model is that agents form expectations about the kinds of transactions that are realistic in the economy and then meet prospective trading partners consecutively. The main purpose of the model is to describe agents' decision rules in this setting. For example, a seller must decide how much to charge for a house. In fact, a seller forms expectations about how much buyers are willing to pay for a house, and the seller must decide when to accept an offer and when to reject it. The trade-off for a seller, then, is to weigh the benefits of further searching against the costs of delaying the sale. The benefits of further search are based on the possibility that a buyer may arrive who attaches greater value to the house. On the other hand, the costs of sale delay include the agent's delay of consumption and uncertainty that arises from the fact that once the agent rejects an offer it is unclear when the next satisfactory offer will arrive. Similarly, a buyer can compute the value of owning a house by capitalizing the expected housing services the house provides and comparing this value to the selling price, taking into consideration the opportunity to continue to search for another house.

It is assumed that agents who live in houses have a "match" with their houses and consume housing services. In the real world it is uncommon for people to live in the same house

for an entire lifetime. Agents can lose a “match” with their houses. The arrival of children may cause a family to leave a small house in favor of a bigger one. A homeowner may sell a house because he takes a new job in another city. When an agent loses his match, he moves out immediately and puts the old house up for sale. An agent who leaves the house must specify a pricing rule for the old house and a search strategy that is utility maximizing. To make the problem more realistic, we assume that not all agents have the same preferences for houses that they visit. Differences in their preferences mean that the search process may take time.

More formally, assume there are a large number of agents in an economy and they consume two goods: housing services and a background good. They are risk neutral in both goods. Also assume that the consumption of the background good at any date equals the negative of their net expenditures on housing at that date. There is a fixed number of houses in the economy and no depreciation of the existing housing stock.

An agent who owns and lives in a house enjoys a per period housing service flow, λ. This service flow is constant for as long as an agent lives in the house. It is assumed that agents leave their houses because agents lose their “match” with their houses. We capture the notion of mobility by assuming that the “match” of an agent with a house persists each period with probability π. When an agent leaves a house and searches for a new one, she draws a new λ from the uniform distribution F on the interval [0,1].[51] Draws from this distribution by potential buyers are independent.

Once an agent loses the “match”, the house does not provide a service flow to its owner, and the owner puts it on the market. As a seller, an agent views the house merely as an asset and attempts to sell the house for as much as possible. Each period, a potential buyer visits the

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[51] For the simplicity of the discussion sellers of houses will be male and buyers female.

empty house and determines how much she likes the house. She either pays the asking price posted by the seller or chooses not to buy, in which case, she does not consume any housing services in that period and searches again in the next. The steady state equilibrium in this economy consists of utility maximizing decision rules for both buyers and sellers.

The price setting decision is made before the seller has any knowledge of the dividend that the house will provide to the visitor. Thus, the seller cannot be sure how much the visitor is willing to pay for the house. This combination of asymmetric information and asset heterogeneity is the source of illiquidity in the market.

The seller sets a price on a take-it-or-leave-it basis. If the visitor chooses to buy, the seller collects the sales price immediately. If the visitor chooses not to buy the house, the house stays empty for this period and the seller tries to sell the house in the next period.

Additionally, let q be the expected value of having a house on the market and let $\mu(p)$ be the probability that a house will sell when the list price is p. The seller chooses a price to solve

$$q = max_p \{\mu(p)p + (1 - \mu(p))\beta q\} \qquad (1)$$

The first part states that with probability μ the seller receives the asking price for the house. The second part relates to the possibility of re-listing the house in the next period. The seller puts the house back on the market and tries to sell it again in the next period. Here, the parameter β is a discount factor.

The first order condition that gives the optimal price p is

$$\frac{d\mu}{dp}(p - \beta q) + \mu(p) = 0 \qquad (2)$$

The selling price of housing, p, and the expected value of having a house on the market, q, are determined in equations (1)–(2) in terms of μ, the probability of sale function.

We now consider the optimal behavior for the agent in his role as buyer. We start first with an agent who currently has a "match" and will consume the housing service flow λ at the beginning of the next period. After this period, the homeowner will continue to consume λ if the match persists for another period, an event that happens with probability π. If, on the other hand, the match fails, the agent must put the house on the market and begin to search again, an event that happens with probability $1 - \pi$. Define $v(\lambda)$ to be the lifetime expected utility of owning a house yielding service flow λ, then

$$v(\lambda) = \beta(\lambda + \pi v(\lambda) + (1-\pi)(q+s)) \qquad (3)$$

The first and the second part of the equation state that an agent will consume housing service flow with certainty for the first period and with the probability of π for the second period. The third part relates to the house selling process, which we saw above, yields q in expected value. The agent also has an option to search for a new house at this point. The value of this search option is represented by s.

Under the optimal buy rule the agent buys the house with service flow λ for price p only if the expected value of the house net of price is greater than the option to search again next period. That is,

$$v(\lambda) - p \geq \beta s . \qquad (4)$$

Since v is strictly increasing in λ and βs is constant, there exists a λ^* such that a searching agent is indifferent between buying a house for the asking price p and searching again next period. That is, there exists an λ^* such that

$$v(\lambda^*) - p = \beta s . \qquad (5)$$

A buyer keeps searching if she draws $\lambda < \lambda^*$ and buys if she draws $\lambda > \lambda^*$. Therefore, we can write the expected value of search as

$$s = F(\lambda^*)\beta s + (1 - F(\lambda^*))\left(\int_{\pi^*}^{1} v(\lambda)dF(\lambda) - p\right) \quad (6)$$

Here, the probability of sale is simply the probability of drawing λ>λ*. Given that *F* is the uniform distribution on [0,1] so that μ = 1 – *F*(λ*), or

$$\mu = 1 - \lambda^* \quad (7)$$

The equilibrium is a symmetric Nash equilibrium: An equilibrium in which each agent's decision rules are best responses to the same decision rules when adopted by other agents. The equilibrium is a price of housing *p,* an expectation of the value of a house on the market *q,* an expectation of the outcome from the search process *s*, a reservation service flow λ*, and a belief about the probability that a buyer will purchase a house μ when the price is *p.* [52] All these variables must satisfy equations (1), (2), (5), (6), and (7). These equations can be solved numerically.

In this model, optimal pricing implies that a house sells with probability less than one each time period. The expected TOM is

$$TOM = \frac{1 - \mu}{\mu} \ . \quad (8)$$

To evaluate what happens when the houses in the market have different amenity levels such as school quality attached to them, we redefine the housing service flow to consist of an idiosyncratic component λ and an aggregate component *x*,

$$d = \lambda + x \, . \quad (9)$$

The idiosyncratic component λ has the same interpretation as before. The state variable *x* is aggregate in that all agents who live in houses receive exactly the same *x*. The variable *x* can

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[52] The proof for the existence of equilibrium can be found in Krainer and LeRoy (2002).

reflect the aggregate state of the economy such as employment growth and interest rates. Under this interpretation, shocks to the productivity of the land or to job growth filter their way into house prices through *x*. A more concrete interpretation of *x* could include amenity levels such as school quality or the level of crime in the area. Under this interpretation, changes to a location-specific component in the housing service that reflects the value of land filters into house price through *x*. By adding a random variable *x* to the housing service flow, the equations above that define equilibrium become functions of *x.* The main result of this model is the joint derivation of a probability of sale function $\mu(x)$ and a pricing function $p(x)$. The main proposition of the model is that the probability of sale, $\mu(p)$, differs across states of *x.* Krainer (1999) shows that the probability of sale is higher in the "high" state than it is in the "low" state.[53] A second observation is that housing prices are also higher in the "high" state.

Thus, we expect that houses located in higher quality school attendance areas show capitalization of school quality both in terms of prices and liquidity, where better schools lead to shorter selling times as well as higher house values.[54]

Empirical Methodology

Many empirical studies have used log-linear regression models to estimate determinates of TOM (Belkin et al., 1976; Miller, 1978; Sirmans et al., 1991). To capture the possibility that selling price and TOM are interactive variables, some studies have estimated simultaneous or two-stage models. The complexity in this process arises

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[53] Krainer (1999) proves this proposition by assuming that the probability of sale is constant over x, and then derives a contradiction. This proof is presented in the Appendix D.

[54] For simplicity, assume that *x* is a random variable that can take on just two values, low and high. In terms of school quality, high state can be viewed as school that receives an improved categorical ranking based on a student performance score.

because the specifications of both price and the TOM model are very similar, making it hard to identify separate equations.

In a typical empirical study of housing market liquidity, the listing or selling prices along with the physical and location attributes of the house are on the right-hand side, and TOM is on the left hand side. The methodology of this study is a simultaneous system of a hedonic price model and a TOM model. We use an approach developed in Turnbull and Dombrow (2006). This approach allows us to extend the hedonic price model used in Chapter III by controlling for localized neighborhood market conditions, thereby eliminating the need to deal with the consequences of spatial correlation. In our models, the log of sales price is explained by the marketing time, house characteristics, school characteristics, location, and housing market condition. TOM is a function of the sales price, house characteristics, school characteristics, location, and housing market condition. The different variables used to describe local housing market conditions ensure that both regression equations are identified in the 2SLS estimation.

We modify the hedonic price function from the previous chapter to capture the simultaneity in price time relationship as follows:

$$ln(P_{inkt}) = \alpha + \beta_1 TOM + \delta Z_{kt} + \Gamma_{ink} + \omega_t + \Phi_{ijk} + \varepsilon_{inkt}$$

$$TOM = \alpha + \beta_2 ln(P_{inkt}) + \delta Z_{kt} + \Gamma_{ink} + \omega_t + \Phi_{ijk}' + \varepsilon_{inkt} \quad (1)$$

where P_{inkt} is the price of house *i* in neighborhood *n* in school *k* at time *t*. Z_{kt} are the year-specific school level attributes, which include school district performance as measured by standard test scores and the socioeconomic and demographic composition of the students. Γ_{ink} is a term that captures non-school time-invariant observable attributes of the unit including the neighborhood.

Φ_{ijk} and Φ_{ijk}' are terms that capture neighborhood housing market conditions. ε_{inkt} is a time-variant unobservable that is assumed to be randomly distributed and uncorrelated with Z_{kt} and Γ_{ink}. ω_t's are the time fixed effects such as year, month and season that capture market conditions.

We define the time-invariant unit attributes as a function of observed housing unit attributes (X_i) and neighborhood attributes (W_n).

$$\Gamma_{ink} = \beta X_i + \mu W_n \qquad (2)$$

Equation (2) assumes that unobserved unit and neighborhood attributes are uncorrelated with X_i as well as W_n. This specification uses neighborhood controls based on the decennial census. The estimating system of equations now becomes

$$ln(P_{inkt}) = \alpha + \beta_1 TOM + \delta Z_{kt} + \beta X_i + \mu W_n + \omega_t + \Phi_{ijk} + \varepsilon_{inkt}$$

$$TOM = \alpha + \beta_2 \, ln(P_{inkt}) + \delta Z_{kt} + \beta X_i + \mu W_n + \omega_t + \Phi_{ijk}' + \varepsilon_{inkt} \qquad (3)$$

We also re-estimate our results by considering only those houses that are geographically close to the school attendance boundary. We do this by rewriting equation (2) as

$$\Gamma_{ink} = \beta X_i + \phi K_b, \qquad (4)$$

where K_b is the vector of boundary dummies that represent the unique boundary that house *i* is associated with, the nearest school attendance boundary. After incorporating this adjustment, the estimating system of equations becomes:

$$ln(P_{inkt}) = \alpha + \beta_1 TOM + \delta Z_{kt} + \beta X_i + \phi K_b + \omega_t + \Phi_{ijk} + \varepsilon_{inkt}$$

$$TOM = \alpha + \beta_2 \, ln(P_{inkt}) + \delta Z_{kt} + \beta X_i + \phi K_b + \omega_t + \Phi_{ijk}' + \varepsilon_{inkt} \qquad (5)$$

The system of equations in (3) and (5) can be estimated using various methods including the instrumental variable approach (e.g., two- and three-stage least squares). The different

elements in the neighborhood housing market conditions, vectors Φ_{ijk} and Φ_{ijk}', ensure that both regression equations are identified in the 2SLS estimation. The 2SLS estimates we report take into account the endogeneity of price and marketing time. Turnbull and Dombrow (2006) present how spatial competition and externality effects can be applied to the housing market and therefore controls for the local housing market conditions are required in estimating price and TOM equations. The basic idea is that the number of houses for sale in a small neighborhood surrounding a particular house can have localized effects on the distribution of prospective buyers and sellers. A greater number of houses for sale increases the competition among sellers for buyers considering houses in the neighborhood. Similarly, a greater number of houses for sale may draw more prospective buyers to the neighborhood, potentially increasing the chance of matching a particular house with a buyer.[55]

Therefore, the sales price is explained in part by the concentration of competing listings in the neighborhood, listing density, LD, which is captured in vector Φ_{ijk}. The TOM equation uses a modified measure of localized competition, C, which is captured in vector Φ_{ijk}'. These measures for each house *i* are as follows:

$$LD = \sum \frac{(1 - D(i,j))^2 O(i,j)}{s(i) - l(i) + 1} \qquad (4)$$

$$C = \sum (1 - D(i,j))^2 O(i,j) \qquad (5)$$

Here, *l(i)* and *s(i)* are the listing date and sales date for house *i*, respectively, so that TOM is now, *s(i)-l(i)+1. C*orrespondingly, *l(j)* and *s(j)* are the listing date and sales date for house *j. O(i,j)* represents the overlapping TOM for contemporaneously listed houses *i* and *j,* and is defined as

[55] For detailed discussion of spatial competition and shopping externalities in the housing market and the construction of the variables to capture those, see Turnbull and Dombrow (2006).

$O(i,j) = min[s(i),s(j)] - max[l(i),l(j)] + 1$. $D(i,j)$ is the distance in miles between houses *i* and *j* and it is calculated using the geocoded data.

The calculations for these variables include all applicable competing house sales; that is, houses *j* within one mile of the house *i*. These calculations are constructed to account for the number of days that competing houses actually overlap, weighted by the distance between them. The distance weighting is necessary to capture the belief that competing houses that are close by have stronger effects than houses that are farther away. The calculations also include houses listed before and after our sample period that overlap with our sample period. Following Turnbull and Dombrow (2006), a competing house is defined as one that is 20 percent larger or smaller in living area than the house for sale.

In summary, we use the 2SLS to re-estimate the hedonic price models from Chapter III that examine the original establishment of the community sensitive attendance boundaries: the standard hedonic, system of equations (3); the attendance boundary fixed effects, system of equations (5); and one model that examines redistricting: the standard hedonic, system of equations (3). To analyze the effect of redistricting on housing values, we use the full sample of housing transactions from 1999 to 2002. This specification is similar to using the system of equations (2) except that a new measure of school quality is added: change in school's categorical ranking that is based on the school performance score. Our simultaneous model of sales price and marketing time specifically controls for the effects of competition among nearby houses for sale.

Data

In addition to variables described in Chapter III, we create six new variables that describe the neighborhood housing market.[56] These are: listing density that measures the average intensity of competition (*LD*); competition measures the cumulative competition from other houses over the entire marketing time for a given house (*competition);* new listing density/new competition is similar to the listing density/competition but only includes newly listed houses in its calculation (*newLD/newCompetition)*; vacant listing density/vacant competition is similar to the listing density/competition but only includes competing vacant houses in its calculation (*vacLD/ vacCompetition).* [57]

Table 11 and Table 12 give the summary statistics over two time periods, 1994-1998 and 1999-2002, of the variables that enter into the regression analysis. The variables used to describe neighborhood housing market are under Neighborhood Market Conditions. These are indexes that measure concentration and competition of other listings in the neighborhood.

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[56] Turnbull and Dombrow (2006) suggest that these variables capture the effects of neighborhood market conditions because the number of houses for sale in a small neighborhood surrounding a particular house can have localized effects on potential buyers and sellers. A greater number of houses increases the competition among sellers for buyers who are searching in a particular neighborhood. Similarly, a greater number of houses for sale in a particular neighborhood may draw more potential buyers increasing the likelihood of a match between a house and a buyer.
[57] Newly listed house is defined to be any house that has been listed for 14 days or less.

Table 11. *Summary Statistics: 1994-1998*

Variable (Description)	***Number of Obs.***	***Mean***	***Std. Dev.***	***Min***	***Max***
Dependent Variable					
soldprR (sold price in '99$)	*10640*	*124812.2*	*57246.1*	*40000*	*358146.5*
TOM (time-on-market)	10640	78.58111	63.20812	14	365
School Attributes					
test (percent passing CRCT)	7533	90.055	6.272	60.750	99.750
black_school (percent black in school)	7533	0.505	0.240	0.067	1.000
lunch_school sq (percent on free lunch square)	7533	0.479	0.211	0.066	0.944
House Attributes					
num_beds (number of bedrooms)	10640	3.277	0.632	1.000	6.000
fullbath (number of fullbath)	10640	2.041	0.484	1.000	4.000
livarea (living area in thousand sq. feet)	10640	1.912	0.569	0.555	4.460
netarea (total area-living area)	10640	0.688	0.287	0.100	1.995
Tract Attributes					
ownerP (percent of owner occupied housing)	10640	0.667	0.188	0.051	0.909
blackP (percent black in tract)	10640	0.225	0.238	0.010	0.984
kidsP1 (percent kids under 5)	10640	0.070	0.018	0.018	0.126
kidsP2 (percent kids 5-17)	10640	0.185	0.042	0.032	0.326
medHH99 (median household income in thousand '99$)	10640	50.016	15.323	11.397	78.509
enrollP (percent enrolled in private schools)	10640	0.052	0.083	0	0.373

Table 11(continued).

Variable (Description)	*Number of Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
Neighborhood Market Conditions					
LD (Listing Density)	10640	3.654	2.666	0	18.797
newLD (New Listing Density)	10640	1.866	1.610	0	14.193
vacLD (Vacant Listing Density)	10640	0.565	1.145	0	10.481
competition (Competition)	10640	291.855	364.480	0	5206.805
newCompetition (New Competition)	10640	180.019	280.892	0	4868.132
vacCompetition (Vacant Competition)	10640	47.6146	131.4766	0	2364.172

[a] School averages are calculated using only houses sold after the publication of the Consent Decree document containing school attendance zones. These cover sales made after June, 1996.

Table 12. *Summary Statistics: 1999-2002*

Variable (Description)	*Number of Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
Dependent Variable					
soldprR (sold price in '99$)	6414	129283.6	54784.23	40000	320000
tom (time-on-market)	6414	68.608	44.559	14.000	180
School Attributes					
sps Improve (school improved rating)	6414	0.188	0.390	0	1.000
sps Worse (school lowered rating)	6414	0.061	0.240	0	1.000
reassign (reassignment dummy)	6414	0.126	0.332	0	1.000
blackChange (change in percent black in school)	6414	0.051	0.082	-0.183	0.666
freelunchChange (change in percent on free lunch)	6414	0.060	0.067	-0.216	0.381
House Attributes					
num_beds (number of bedrooms)	6414	3.232	0.626	1.000	5.000
fullbath (number of fullbath)	6414	2.024	0.503	1.000	5.000
livarea (living area in thousand sq. feet)	6414	1.870	0.545	0.703	4.435
netarea (total area-living area)	6414	0.675	0.282	0.110	1.995
Tract Attributes					
blackP (percent black in tract)	6414	0.208	0.231	0.010	0.984
kidsP1 (percent kids under 5)	6414	0.069	0.018	0.018	0.126
kidsP2 (percent kids 5-17)	6414	0.184	0.042	0.032	0.326
medHH99 (median household income in thousand '99$)	6414	50.331	14.774	11.397	78.509
enrollP (percent enrolled in private schools)	6414	0.054	0.084	0	0.373
Neighborhood Market Conditions					
LD (Listing Density)	6414	3.798	2.494	0	18.302
newLD (New Listing Density)	6414	1.739	1.446	0	11.306
vacLD (Vacant Listing Density)	6414	1.875	1.724	0	13.600
competition (Competition)	6414	263.677	277.029	0	2727.606
newCompetition (New Competition)	6414	141.995	187.771	0	1724.786
vacCompetition (Vacant Competition)	6414	133.419	182.757	0	1985.733

Results

This section reviews some of the key results from different sample areas and is based on the previously described empirical models. Our findings based on original school assignments are reported in Table 13, while Table 14 reports our findings based on school reassignments. These results combine to suggest that there is a statistical link between marketing time and school quality variables. More comprehensive results are presented below.

Table 13 presents the key results of the school quality parameter estimates for the pooled sample (1994-1998) and the boundary sample. The first two columns, labeled specification (1), show the price equation and the TOM equation estimates from 2SLS analysis and neighborhood controls drawn from census tract variables when we consider only the impact of test scores, *test*. We then expand the model by adding other variables that describe student bodies' socioeconomic characteristics. The final two columns, labeled specification (4) in Table 13, show 2SLS results using boundary fixed effects in the price equation. For this analysis, we determine the attendance boundaries for 60 elementary schools in East Baton Rouge Parish. We follow Black (1999) and select only houses within a 0.35 mile buffer of the attendance boundary. In this restricted sample there are 6,801 single family residences. The discussion that follows refers to the results under specification (3) for the full sample and specification (4) for our boundary sample.

The variables under *School Attributes* are the main variables of interest here. The coefficient on the test scores in the price equation appears statistically insignificant across both samples. However, in both models, we find that increasing test scores in a neighborhood school results in shorter marketing time for houses in those attendance zones. Furthermore, the test score coefficient in the TOM equation in our full sample, specification (3), suggests that

increasing the test scores by one standard deviation, for the given selling price, above the mean reduces marketing time by about two days, or just over 2.5 percent of average marketing time.[58] No other school variable appears significant in the TOM equation in our full sample.

Looking at the boundary sample, specification (4) in the Table 13, all three of the school variables in the TOM equation are significant. The level of significance varies from 1 percent for students receiving free lunch to 10 percent for school racial composition. The coefficients on these variables imply that higher test scores are associated with a shorter marketing time of a little over three days for an increase in one standard deviation at the mean; higher percent black in school is associated with a longer marketing time of about four days for an increase in one standard deviation at the mean; and higher percent on free lunch is associated with a shorter marketing time of about seven days for an increase in one standard deviation at the mean. In addition, our boundary sample results using the simultaneous system indicate that the representation of blacks in local public schools has no effect on property values after controlling directly for test scores.[59]

Another interesting result concerns the percent of school-age children enrolled in private schools. Recall, that in the hedonic price equation of Chapter III, we see that the coefficient on this variable is negative, indicating a negative effect on property values, possibly because some houses must be sold at discounted prices to capture the cost of private education. This result is consistent across both full and boundary samples, price equation in specifications (3) and (4) in Table 13, and it shows that one standard deviation increase in the percent enrollment in private schools is associated with about a 0.64 percent decrease in housing prices. When looking at the

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[58] Seven percent of our sample has percent passing CRCT of 96.33 or higher.
[59] Recall that the coefficient on the representation of blacks in local public schools was positive and significant at 10 percent in our hedonic price equation from the Chapter III.

Table 13. 2SLS Regression Results 1994-1998 full sample:

Endogenous Variables: ln(sold price in '99$)

TOM (time-on-market in days)

	(1)		***(2)***	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
tom	-0.000293***		-0.000293***	
	(0.000040)		(0.000040)	
lnsoldprR		-15.59***		-15.27***
		(3.62)		(3.62)
School Attributes				
test	0.000296	-0.0831	0.000198	-0.284**
	(0.00037)	(0.10)	(0.00050)	(0.14)
black_school			-0.00426	-8.619**
			(0.014)	(3.90)
Lunch_school				
Observations	10640	10640	10640	10640
R-squared	0.87	0.55	0.87	0.55
Fixed Effects				

Standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: test, black_school, lunch_school, ownerP, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, fullbath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition.

Coefficients are not reported for the following variables: house age, mls area, year, season and month sold. Complete model estimates presented in the Appendix B.

Table 13 (continued).

	(3)		*(4)*	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
tom	-0.000293***		-0.000273***	
	(0.000040)		(0.000048)	
lnsoldprR		-15.87***		-12.92***
		(3.63)		(4.60)
School Attributes				
test	-0.000200	-0.358**	0.000671	-0.508**
	(0.00053)	(0.15)	(0.00074)	(0.20)
black_school	0.0362	-0.790	0.0400	17.84*
	(0.024)	(6.56)	(0.039)	(10.4)
Lunch_school	-0.0593**	-11.38	-0.0312	-33.56***
	(0.028)	(7.68)	(0.046)	(12.4)
Observations	10640	10640	6801	6801
R-squared	0.87	0.55	0.88	0.60
Fixed Effects			Boundary	Boundary

Standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: test, black_school, lunch_school, ownerP, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, fullbath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition.

Coefficients are not reported for the following variables: house age, mls area, year, season and month sold. Complete model estimates presented in the Appendix B.

boundary fixed effects regression, specification (4), the coefficient suggests even larger impact of private schools enrollment, about 1.85 percent. The TOM equation shows that the coefficient on this variable is again negative, indicative of shorter marketing time for those houses. This result is consistent across both specifications and it shows that for a given house selling price, one standard deviation increase in the enrollment in private schools in a census tract is associated with about 2 days shorter marketing time in our full sample, and about 3 days in our boundary sample. Increase in the private enrollment could be capturing additional options of private education. The availability of these options could make some locations more desirable increasing a probability of receiving an offer at any given time.

Our results show that housing comparables enter the house pricing equation with the expected sign. Increases in the living area, net area and the number of bathrooms increase the price of a house, on average. The coefficient on *TOM* variable that measures time-on-market is consistently negative and significant at a 1percent level in both samples. At the same time, the TOM equation estimates show that increases in the living area (*livarea*) and number of bathrooms (*fullbath*), while holding the size of the house constant, are associated with longer marketing time.

The results in Table 13 yield some interesting observations about *Neighborhood Market Conditions.* We show that vacant listing density, *vacLD*, enters the price equation with a negative sign and it is significant at a 1 percent level. Consistent with Turnbull and Dombrow (2006), this result suggests that a greater number of houses for sale in the neighborhood increases the competition for potential buyers and reduces the likelihood of a match between a given house and a potential buyer who is willing to offer more for that particular house. Looking at marketing time in our boundary sample, the TOM equation, specification (4), we note positive

and significant coefficients on all three competition variables indicating that having more houses for sale in the neighborhood surrounding a given house lengthens the time it takes to sell that house for a given price, other things equal.

Table 14 reports our findings based on school reassignments. The first two columns, labeled specification (1) in the Table 14, show the price equation and the TOM equation estimates from 2SLS analysis and neighborhood controls drawn from census tract variables when we consider only the impact of change in categorical ranking and reassignments. We, then, expend the model by adding other variables that capture student body's socioeconomic characteristics. As reported earlier, selling price is a function of days on the market, school attributes, house characteristics, location attributes, broad market conditions, and neighborhood housing market conditions. Similarly, the TOM equation is a function of selling price, school attributes, house characteristics, location attributes, broad market conditions, and competition that captures neighborhood housing market conditions. The reported 2SLS estimates take into account the endogeneity of price and marketing time. The base group consists of houses that are in the school attendance areas that have not changed their categorical ranking and have not been re-assigned.

We focus our attention to the coefficients of variables under *School Attributes.* Instead of test scores, we use a set of binary variables (*SPS Improve, SPS Worse*) that is equal to one if the house is in the school attendance zone that has a positive/negative change to its categorical performance measure. Many schools in the EBRSS have been low performing schools and we have a reason to believe that buyers might be interested in trends in school quality.

Table 14. *2SLS Regression Results 1999-2002: Endogenous Variables:*

ln(sold price in '99$)

TOM (time-on-market in days)

	(1)		*(2)*		*(3)*	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
TOM	-0.0000592		-0.0000494		-0.0000482	
	(0.000065)		(0.000065)		(0.000065)	
lnsoldprR		-1.706		-3.677		-4.022
		(3.39)		(3.41)		(3.42)
School Attributes						
Sps Improve	0.0419***	2.366**	0.0532***	4.536***	0.0528***	4.463***
	(0.0056)	(1.09)	(0.0060)	(1.19)	(0.0060)	(1.19)
Sps Worse	0.00798	11.59***	-0.00301	9.587***	0.000160	10.47***
	(0.0086)	(1.70)	(0.0089)	(1.76)	(0.0091)	(1.79)
BlackChange			0.165***	29.69***	0.242***	51.69***
			(0.033)	(6.58)	(0.056)	(11.1)
freelunchChange					-0.107*	-30.76**
					(0.062)	(12.4)
reassign	0.00854	-3.181***	0.00919	-2.998**	0.00825	-3.249***
	(0.0060)	(1.20)	(0.0060)	(1.19)	(0.0060)	(1.20)
Constant	10.82***	62.35*	10.82***	83.62**	10.82***	88.24**
	(0.024)	(35.8)	(0.024)	(36.0)	(0.024)	(36.1)
Observations	6414	6414	6414	6414	6414	6414
R-squared	**0.86**	**0.55**	**0.86**	**0.55**	**0.86**	**0.55**

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: sps Improve, sps Worse, blackChange, freelunchChange, reassign, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, f_bath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition.
Coefficients are not reported for the following variables: house age, mls area, year, season and month sold. Complete model estimates presented in the Appendix B.

Using these variables allows us to look into not just short-term fluctuations in test scores but also longer-term progress. We also use another binary variable that captures the change in reassignments, *reassign*, that it is equal to one if the house has been reassigned to a different school after the change in attendance boundaries in 2001. Recall that our results using the hedonic price function of Chapter III indicate that holding other factors fixed, an improvement in the categorical ranking of school performance is associated with a 5 percent increase in housing prices. On the other hand, we find no penalty for schools that see a decline in their categorical ranking. However, when we re-examine schools' categorical rankings on simultaneous determination of selling price and time-on-market, we note that houses located in the school attendance areas that have changed their categorical ranking are also sold after longer marketing time. Referring to the results reported in the specification (3) in the Table 14, a decline in categorical ranking is predicted to lengthen the marketing time by 10 days. Interestingly, the houses that are associated with schools that have an improved categorical ranking also see longer marketing times by about four days. Yet, at the given selling price, if the house is reassigned to a different school its marketing time is shorter by three days relative to a house that is not reassigned.

One possible explanation is that reassignments affected mostly houses that belonged to the attendance areas of previously overcrowded schools. Thus, the reassignment would indicate that children are now placed in less congested schools.

Our findings, once again, suggest that the representation of blacks in local public schools leads to an increase in property values after controlling directly for any changes in the school categorical rankings. An increase of one standard deviation in percentage point black in a school is associated with an increase of 1.9 percent in the house price, at the mean. At the same time,

for a given selling price, the TOM equation shows changes in percentage point blacks in a school by one standard deviation, or about 8 percent, are associated with longer marketing time, about 4 days, at the mean.

Consistent with the analysis based on the original school assignments, we again show that housing comparables enter the house pricing equation with the expected sign. Increases in the living area, net area and the number of bathrooms increase the price of a house, on average.

The results in Table 14 reinforce earlier conclusions about *Neighborhood Market Conditions.* Here, we show that vacant listing density, *vacLD*, and new listing density, *newLD*, enter the price equation with negative signs and the coefficients are significant at a 1 percent level. Consistent with Turnbull and Dombrow (2006), this result suggests that a greater number of newly listed and vacant houses for sale in the neighborhood increases the competition for potential buyers and reduces the likelihood of a match between a given house and a potential buyer who is willing to offer more for that particular house. Looking at marketing time, the TOM equation in the specification (3) in the Table 14, we note positive and significant coefficients on all but vacant competition variables, indicating that having more houses for sale in the neighborhood surrounding a given house lengthens the time it takes to sell that house for a given price, other things equal.

Conclusion

Hedonic value models have long been used in attempts to quantify the social benefits/costs of locational amenities/disamenities. Most early hedonic studies employ cross-sectional data, or at least data on a large number of housing transactions occurring over a relatively short period of time to evaluate how changes in local amenities are reflected in house

prices. The main assumption is that change in a local amenity reflects a change in a fundamental value of an asset and is transmitted to the market through prices. In most models of asset prices, time to sale is precisely zero. The real estate market does not appear to work this way. Krainer (1999)shows that when the fundamental value of housing services changes, this change is accompanied by a smaller change in a house price. Liquidity adjusts to make up the difference. In another words, when house values decline, sellers are slow to drop their prices. In turn, marketing time increases.[60]

We use a search model of the real estate market where prices and liquidity are determined endogenously to show that when the value of housing services flows, neighborhood school quality, is allowed to fluctuate, liquidity also fluctuates. For example, the model states that when school quality is low, sellers do not necessarily drop their prices. Rather, prices are sticky because sellers find it optimal to search for a buyer who attaches high value to the house based on other comparables.

Using the data from East Baton Rouge Parish, we investigate school quality variables' impact on the liquidity of the housing market through the housing service flow as recognized in the theoretical model. We establish a statistical link between TOM and many neighborhood market conditions.

For example, our analysis of original school assignment using the full sample shows no statistical significance of any school variable but test scores in the TOM equation. Once we focus on estimating differences in housing price effects near attendance zone boundaries we note

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[60] Fisher, Gatzlaff, Geltner and Haurin (2003) argue that slower relative reaction of sellers to changing market conditions explains the relationship between prices and liquidity. The traditional explanation (Case & Shiller, 2003; Genesove & Mayer, 1997) is that sellers "irrationally" refuse to recognize the decline in the value of their properties and continue to wait for higher than market values. Another explanation (Genesove and Mayer, 1997) is based on house sellers' equity constraints.

a stronger relationship between TOM and school variables. The results imply that higher test scores are associated with shorter marketing time; higher percent black in school is associated with longer marketing time; and higher percent on free lunch is associated with shorter marketing time.

In summary, we find statistical support to earlier research on a tradeoff between an acceptable price and the time a seller has a house on the market. Our empirical results show that selling price declines with longer marketing time. Furthermore, we find statistical evidence that the differences in transactions prices do not capture all of the differences in locational attributes.

Chapter 5: Conclusion

For many families with children, the most important factor they consider when buying a house is that of school quality. The value homebuyers place on the education of their children can be reveled by examining how much more people pay for houses in areas with better schools. Does the quest for high-quality schools have a significant effect on house prices? Which school characteristics do parents find most important when examining school quality? To answer these questions, this dissertation used a unique data set from East Baton Rouge Parish school system in Louisiana to provide the first empirical study that considers the impact of changes in school quality on simultaneous determination of selling price and time-on-market.

The end to EBRPSS's 47-year school desegregation case provided a rare opportunity to study how a sudden exogenous change in public policy impacts the housing market. The end of random school assignments and introduction of neighborhood schools followed by the redistricting implemented by EBRPSS are a natural experiment in education policy. The school district was operating under a court-imposed desegregation order. This desegregation order caused changes in the housing market locational amenities in the form of test scores and school demographic composition. Such exogenous change allowed us to use classical statistical theory that works only if variations in data occur randomly. The uniqueness of our data set and empirical methodology avoid common difficulties in housing market studies. While looking within one school district enabled us to eliminate variations in property tax rates, school spending, and other public services, two different sources of variation along boundaries of school attendance zones and following the change in school assignments provided for an ideal situation to study the effects of school quality measures and racial composition on housing prices. Similarly, controls for the localized housing market supply and demand conditions ensured that

price and time-on-market equations are identified in the 2SLS estimation, and removed a potential source of spatial correlation in housing data.

In the second chapter, we described EBRPSS's 88 schools and gave a brief history of the school system's battle with desegregation law suits from 1956 to 2003. In 1981, U.S. District Judge John Parker designed and ordered a desegregation plan that led quickly to a mass flight of 8,000 white students with many more to follow, which further complicated the desegregation plan. What was once a majority white school system, became a majority black school system. Due to these events, the school system changed dramatically as it operated under random school assignments. The 1996 Consent Decree eliminated random school assignments and created new "community sensitive" attendance zones. These events provided a rare opportunity to study the impact of changes in school assignments and school quality as measured by test scores, and racial composition on housing prices and time-on-market.

In the third chapter, we used the hedonic price model and conventional capitalization theory to measure the value of better schools. We followed Black's (1999) approach and used the boundary fixed effects technique to minimize the likelihood that omitted neighborhood characteristics are driving the results of the estimation. We also considered the impact of peers and included variables such as school racial composition and percent of students on free-lunch. The housing market reveals that the type of grading system used or the indicators of quality can have a large effect on property values. For example, our findings based on the initial school assignments show that the housing market does not seem to be sensitive to increases in test scores. On the other hand, our examination of school categorical rankings indicate that, holding other factors fixed, an improvement in categorical ranking of school performance is associated with a 5.61 percent increase in housing prices. At the same time, we observe no penalty for

schools that see a decline in their categorical ranking. Furthermore, our study indicates that in considering a neighborhood with a less elastic supply of housing, concentrated mostly in a central city, the improved categorical ranking of a school is associated with a 7.8 percent increase in the house price. At the mean, this is equivalent to $9,227 (the mean house price in this sub-sample is $118,300). Similarly, there is a penalty equivalent to a 5.5 percent of house price associated with houses in the schools that saw a decrease in their categorical ranking relative to those houses that saw no change in their school rankings. This result implies that central city house values are more elastic with respect to improvements in elementary school categorical rankings. Thus, improving elementary schools has a great potential for increasing house values, and, as a consequence, revenue from property taxes.

In the fourth chapter, we called attention to the problem of readjustment to the equilibrium following some environmental shock. In the short run, the supply of owner occupied housing is fixed and the market response to demand shocks should be symmetric: positive shocks result in price increases and negative shocks result in price decreases. However, housing markets typically respond to large negative demand shocks with long periods during which asset liquidity declines but house prices change relatively little. Thus, we accounted for the simultaneity of the time-price relationship by using the 2SLS to re-estimate the hedonic price models from the third chapter.

Using the data from East Baton Rouge Parish, we investigated how school quality impacts the liquidity of the housing market, through the housing service flow as established in the theoretical model. The empirical evidence produced by this study indicates that there is state dependant illiquidity. Of course, the empirical evidence offered here is relevant to only one

housing market. Future research could focus on the impact of school quality on simultaneous determination of selling price and time-on-market in the different metropolitan areas.

Two main areas for additional research concern school quality measures and time-on-market. Given the unique data, future research needs to incorporate the availability of intradistrict school choice. For example, the availability of choice programs contributes to underestimation of school quality capitalization since it gives parents living outside of their desired school attendance area the choice to send their child to any school within the school district. Similarly, when attendance boundaries were first determined, the district made every "reasonable good-faith effort" to desegregate the system while considering the size of the school, the distribution of students by grade level, natural boundaries, and, in some cases, family economics and neighborhoods. However, the original boundaries were not meeting the requirements spelled in the Consent Decree of 1996 and were redrawn in 2001. As a result of reassignments some students do not attend schools closest to their neighborhoods. Future research needs to investigate the impact of distance to the elementary school.[61]

It is possible to argue that the house and neighborhood characteristics collected in this dataset are not the most important characteristics. A different set of characteristics, such as nearby amenities, influence price and liquidity, but remain unobservable to the researcher. The same exercise can be repeated using a different amenity such as the level of crime in the area. In addition, study can be extended across time to determine if the results generated here are stable in different market conditions.

[61] Kane et al. (2003) find that an additional mile in distance from the elementary school was associated with a 1 to 5 percentage point decline in housing values. This outcome is equivalent to the effect associated with one standard deviation difference in test scores.

Finally, a critique of our empirical work is due to non-normality of the marketing time duration distribution, since duration is positive by construct. An empirical method that circumvents this problem is survival regression, or duration analysis. The significant difference between the OLS and survival regression is that a researcher is allowed to select a distribution for the error term in survival regression. The exponential or Weibull distributions are usually chosen for this application.

Appendix A: Attendance District Boundaries

The most important feature of attendance boundaries that make them useful for this estimation is that they are unchanging. The existence of this feature is what homeowners use when forming their expectations about the local school. It is plausible that, since the attendance boundaries were drawn in August of 1996, EBR homeowners do not have enough time to evaluate the information about local schools and include that information in their pricing decisions. Similarly, according to school district administrators, when attendance boundaries were first determined, the district made every "reasonable good-faith effort" to desegregate the system while considering the size of the school, the distribution of students by grade level, natural boundaries, and, in some cases, family economics and neighborhoods. Anecdotal evidence points that the boundaries, once drawn, were not meeting the requirements spelled in the Consent Decree and needed to be redrawn. For example, on September 27, 1996, shortly after the Decree was implemented, The Board sought permission to exceed the proposed enrollment in 17 schools. Similar motions were filed on September 24, 1997 and October 23, 1998. It became apparent that the Board will have to redraw the boundaries in order to comply with Consent Decree requirements. We use this implication of instability of the boundary sample and look at the school quality capitalization while excluding the boundary sample. There are 3,835 observations in this sample. The mean house value in this sample is $129,169. Table A1 reports parameter estimates on key variables. Even after such an exercise, we do not find any evidence of test score capitalization.

Table A1. *Regression Results Dependent Variable: ln(sold price in '99$)*

	(1)BASELINE HEDONIC	***(2)BASELINE HEDONIC***
Regressors	**Neighborhood Controls from Census Tracts**	**Neighborhood Controls from Local Market Conditions**
test	-0.00169	-0.00164
	(0.0010)	(0.0010)
black_school	-0.0309	-0.0358
	(0.046)	(0.047)
Lunch_school	-0.00713	-0.00329
	(0.054)	(0.056)
Observations	3835	3835
R-squared	0.88	0.88

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Coefficients are not reported for the following variables: House Attributes, Tract Attributes, house age, mls area, year and season sold.

Appendix B: Regression Results with Complete Estimates

Table B1. *Regression Results: Proxy for Land Supply Elasticity is New Construction in the Census Tract, 1994-1998*

Dependent Variable: ln(sold price in ’99 $)

	*(1)**FULL SAMPLE***	*(2) **NEW HOUSING <.25***	*(3) **NEW HOUSING >=.25***
Regressors	**lnsoldprR**	**lnsoldprR**	**lnsoldprR**
School Attributes			
Test	-0.000246	-0.00112	0.000250
	(0.00061)	(0.00069)	(0.0011)
black_school	0.0362	-0.0208	0.249***
	(0.025)	(0.030)	(0.040)
lunch_school	-0.0629**	-0.0541	-0.125**
	(0.030)	(0.037)	(0.051)
House Attributes			
TOM	-0.000253***	-0.000284***	-0.000194***
	(0.000027)	(0.000034)	(0.000040)
num_beds	0.00143	0.00485	0.00287
	(0.0041)	(0.0050)	(0.0068)
Fullbath	0.0194***	0.0280***	-0.00674
	(0.0051)	(0.0061)	(0.0084)
Livarea	0.472***	0.432***	0.548***
	(0.0065)	(0.0075)	(0.012)
Netarea	0.151***	0.142***	0.156***
	(0.0080)	(0.0090)	(0.016)
Tract Attributes			
ownerP	-0.0997***	-0.129***	-0.173***
	(0.017)	(0.030)	(0.049)
blackP	0.0135	0.0571***	-0.295***
	(0.017)	(0.021)	(0.054)
kidsP1	0.115	0.0184	-0.467
	(0.13)	(0.25)	(0.49)
kidsP2	-0.487***	-0.897***	0.939***
	(0.079)	(0.11)	(0.35)
medHH99	0.00502***	0.00640***	-0.000124
	(0.00033)	(0.00057)	(0.00073)
enrollP	-0.0741***	-0.133***	0.00532
	(0.027)	(0.030)	(0.073)
Constant	10.70***	10.78***	10.75***
	(0.019)	(0.030)	(0.041)
Observations	**10640**	**7171**	**3469**
R-squared	**0.87**	**0.85**	**0.91**

Table B2. *Regression Results: Proxy for Land Supply Elasticity is New Construction in the Census Tract, 1999-2002*

Dependent Variable: ln(sold price in '99 $)

	(1) ***FULL SAMPLE***	(2) ***NEW HOUSING <.25***	(3) ***NEW HOUSING >=.25***
Regressors	**lnsoldprR**	**lnsoldprR**	**lnsoldprR**
School Attributes			
sps Improve	0.0516***	0.0779***	0.0583***
	(0.0070)	(0.011)	(0.022)
sps Worse	-0.000666	-0.0548***	0.0126
	(0.0093)	(0.017)	(0.012)
blackChange	0.222***	0.474***	-0.488**
	(0.058)	(0.088)	(0.25)
freelunchChange	-0.0948	-0.193**	-0.337
	(0.061)	(0.077)	(0.54)
Reassign	0.00940*	0.0226***	0.144***
	(0.0056)	(0.0071)	(0.053)
Tract Attributes			
blackP	0.0136	0.0917***	-0.358***
	(0.023)	(0.026)	(0.063)
kidsP1	0.275	0.122	0.868
	(0.17)	(0.31)	(0.65)
kidsP2	-0.406***	-0.791***	0.0274
	(0.11)	(0.13)	(0.29)
medHH99	0.00398***	0.00548***	-0.00262***
	(0.00034)	(0.00045)	(0.00061)
enrollP	-0.00994	-0.0617	0.688***
	(0.034)	(0.038)	(0.11)
House Attributes			
TOM	-0.000163***	-0.000185***	-0.0000884
	(0.000045)	(0.000055)	(0.000065)
num_beds	0.00236	0.00289	0.00485
	(0.0050)	(0.0058)	(0.0100)
Fullbath	0.0274***	0.0318***	0.0145
	(0.0066)	(0.0076)	(0.012)
Livarea	0.426***	0.413***	0.432***
	(0.0084)	(0.0098)	(0.016)
Netarea	0.135***	0.128***	0.144***
	(0.0099)	(0.011)	(0.020)
Constant	10.82***	10.82***	11.12***
	(0.025)	(0.042)	(0.068)
Observations	**6414**	**4544**	**1870**
R-squared	**0.86**	**0.84**	**0.91**

Table B3. *2SLS Regression Results 1994-1998: Endogenous Variables:*

ln(sold price in '99$)

TOM (time-on-market in days)

	(1)		*(2)*	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
tom	-0.000293***		-0.000293***	
	(0.000040)		(0.000040)	
lnsoldprR		-15.59***		-15.27***
		(3.62)		(3.62)
School Attributes				
test	0.000296	-0.0831	0.000198	-0.284**
	(0.00037)	(0.10)	(0.00050)	(0.14)
black_school			-0.00426	-8.619**
			(0.014)	(3.90)
Lunch_school				
House Attributes				
num_beds	0.00170	-1.291	0.00168	-1.330
	(0.0035)	(0.95)	(0.0035)	(0.95)
fullbath	0.0192***	4.211***	0.0192***	4.174***
	(0.0042)	(1.15)	(0.0042)	(1.15)
livarea	0.471***	21.14***	0.471***	21.07***
	(0.0048)	(2.07)	(0.0048)	(2.07)
netarea	0.151***	-4.674**	0.151***	-4.800**
	(0.0065)	(1.88)	(0.0065)	(1.88)
Tract Attributes				
ownerP	-0.0968***	-10.98**	-0.0963***	-9.931**
	(0.017)	(4.63)	(0.017)	(4.65)
blackP	0.0186	-11.98***	0.0201	-8.810**
	(0.015)	(4.00)	(0.016)	(4.25)
kidsP1	0.128	-25.97	0.125	-31.36
	(0.13)	(34.9)	(0.13)	(35.0)
kidsP2	-0.506***	73.92***	-0.510***	65.84***
	(0.074)	(20.4)	(0.076)	(20.8)
medHH99	0.00513***	-0.250***	0.00513***	-0.238***
	(0.00030)	(0.084)	(0.00030)	(0.084)
enrollP	-0.0771***	-18.98***	-0.0766***	-18.04***
	(0.021)	(5.74)	(0.021)	(5.76)

Table B3 (continued).

	(1)		(2)	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
Neighborhood Market Conditions				
LD	-0.00162		-0.00162	
	(0.0013)		(0.0013)	
newLD	0.00261		0.00262	
	(0.0021)		(0.0021)	
vacLD	-0.00667***		-0.00664***	
	(0.0019)		(0.0019)	
competition		-0.00744*		-0.00724*
		(0.0042)		(0.0042)
newCompetition		0.169***		0.169***
		(0.0052)		(0.0052)
vacCompetition		0.0511***		0.0512***
		(0.0039)		(0.0039)
Constant	10.74***	199.6***	10.74***	195.9***
	(0.019)	(37.8)	(0.019)	(37.8)
Observations	10640	10640	10640	10640
R-squared	0.87	0.55	0.87	0.55

Standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: test, black_school, lunch_school, ownerP, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, fullbath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition.
Coefficients are not reported for the following variables: house age, mls area, year, season and month sold.

Table B4. *2SLS Regression Results 1994-1998: Endogenous Variables:*

ln(sold price in '99$)

TOM (time-on-market in days)

	(3)		***(4)***	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
Tom	-0.000293***		-0.000273***	
	(0.000040)		(0.000048)	
lnsoldprR		-15.87***		-12.92***
		(3.63)		(4.60)
School Attributes				
Test	-0.000200	-0.358**	0.000671	-0.508**
	(0.00053)	(0.15)	(0.00074)	(0.20)
black_school	0.0362	-0.790	0.0400	17.84*
	(0.024)	(6.56)	(0.039)	(10.4)
Lunch_school	-0.0593**	-11.38	-0.0312	-33.56***
	(0.028)	(7.68)	(0.046)	(12.4)
House Attributes				
num_beds	0.00160	-1.338	0.0198***	0.693
	(0.0035)	(0.95)	(0.0043)	(1.15)
Fullbath	0.0194***	4.231***	0.00634	3.455**
	(0.0042)	(1.15)	(0.0051)	(1.35)
Livarea	0.472***	21.36***	0.449***	17.09***
	(0.0048)	(2.07)	(0.0060)	(2.53)
Netarea	0.151***	-4.735**	0.149***	-3.865*
	(0.0065)	(1.88)	(0.0079)	(2.27)
Tract Attributes				
ownerP	-0.101***	-10.82**	-0.260***	5.919
	(0.017)	(4.69)	(0.026)	(6.98)
blackP	0.0120	-10.30**	0.00443	5.728
	(0.016)	(4.36)	(0.029)	(7.81)
kidsP1	0.141	-27.64	-0.232	56.89
	(0.13)	(35.0)	(0.23)	(61.0)
kidsP2	-0.502***	66.64***	-0.0135	5.280
	(0.076)	(20.8)	(0.13)	(34.5)
medHH99	0.00507***	-0.247***	0.00616***	-0.138
	(0.00030)	(0.084)	(0.00042)	(0.12)
enrollP	-0.0765***	-18.06***	-0.127***	-33.01***
	(0.021)	(5.76)	(0.029)	(7.74)

Table B4 (continued).

	(3)		(4)	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
Neighborhood Market Conditions				
LD	-0.00146		0.000227	
	(0.0013)		(0.0016)	
newLD	0.00258		0.00121	
	(0.0021)		(0.0026)	
vacLD	-0.00665***		-0.0131***	
	(0.0019)		(0.0025)	
Competition		-0.00695*		0.0211***
		(0.0042)		(0.0052)
newCompetition		0.168***		0.142***
		(0.0052)		(0.0064)
vacCompetition		0.0512***		0.0553***
		(0.0039)		(0.0051)
Constant	10.74***	203.1***	10.78***	118.9*
	(0.019)	(37.9)	(0.16)	(64.7)
Observations	10640	10640	6801	6801
R-squared	0.87	0.55	0.88	0.60
Fixed Effects			Boundary	Boundary

Standard errors in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: test, black_school, lunch_school, ownerP, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, fullbath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition.
Coefficients are not reported for the following variables: house age, mls area, year, season and month sold.

Table B5. *2SLS Regression Results 1999-2002: Endogenous Variables:*

ln(sold price in '99$)

TOM (time-on-market in days)

	(1)		*(2)*		*(3)*	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
TOM	-0.0000592		-0.0000494		-0.0000482	
	(0.000065)		(0.000065)		(0.000065)	
lnsoldprR		-1.706		-3.677		-4.022
		(3.39)		(3.41)		(3.42)
School Attributes						
Sps Improve	0.0419***	2.366**	0.0532***	4.536***	0.0528***	4.463***
	(0.0056)	(1.09)	(0.0060)	(1.19)	(0.0060)	(1.19)
Sps Worse	0.00798	11.59***	-0.00301	9.587***	0.000160	10.47***
	(0.0086)	(1.70)	(0.0089)	(1.76)	(0.0091)	(1.79)
BlackChange			0.165***	29.69***	0.242***	51.69***
			(0.033)	(6.58)	(0.056)	(11.1)
freelunchChange					-0.107*	-30.76**
					(0.062)	(12.4)
reassign	0.00854	-3.181***	0.00919	-2.998**	0.00825	-3.249***
	(0.0060)	(1.20)	(0.0060)	(1.19)	(0.0060)	(1.20)
House Attributes						
num_beds	0.00320	-1.358	0.00263	-1.439*	0.00211	-1.584*
	(0.0043)	(0.86)	(0.0043)	(0.86)	(0.0044)	(0.86)
f_bath	0.0274***	-1.430	0.0274***	-1.368	0.0277***	-1.264
	(0.0052)	(1.04)	(0.0051)	(1.04)	(0.0051)	(1.04)
livarea	0.424***	9.111***	0.425***	9.991***	0.425***	10.23***
	(0.0062)	(1.79)	(0.0061)	(1.80)	(0.0061)	(1.80)
netarea	0.137***	-1.898	0.136***	-1.766	0.136***	-1.734
	(0.0081)	(1.70)	(0.0081)	(1.70)	(0.0081)	(1.70)

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: sps Improve, sps Worse, blackChange, freelunchChange, reassign, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, f_bath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition. Coefficients are not reported for the following variables: house age, mls area, year, season and month sold.

Table B5 (continued).

	(1)		*(2)*		*(3)*	
Regressors	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**	**lnsoldprR**	**tom**
Tract Attributes						
blackP	0.0115	-6.030	0.00806	-6.475*	0.0153	-4.346
	(0.019)	(3.79)	(0.019)	(3.79)	(0.020)	(3.88)
kidsP1	0.510***	-55.78*	0.254	-100.2***	0.286*	-90.27***
	(0.15)	(30.9)	(0.16)	(32.3)	(0.16)	(32.6)
kidsP2	-0.446***	-13.20	-0.364***	0.328	-0.428***	-18.66
	(0.094)	(18.9)	(0.096)	(19.1)	(0.10)	(20.6)
medHH99	0.00407***	-0.188***	0.00386***	-0.214***	0.00398***	-0.175***
	(0.00030)	(0.061)	(0.00030)	(0.061)	(0.00031)	(0.063)
enrollP	-0.0232	-4.045	-0.0205	-3.637	-0.0151	-2.063
	(0.026)	(5.27)	(0.026)	(5.26)	(0.026)	(5.29)
Neighborhood Market Conditions						
LD	0.00571***		0.00698***		0.00721***	
	(0.0020)		(0.0021)		(0.0021)	
newLD	-0.00650**		-0.0069***		-0.0069***	
	(0.0026)		(0.0026)		(0.0026)	
vacLD	-0.00506**		-0.00624**		-0.0065***	
	(0.0024)		(0.0024)		(0.0024)	
competition		0.103***		0.105***		0.106***
		(0.0050)		(0.0050)		(0.0050)
newCompetition		0.118***		0.117***		0.117***
		(0.0056)		(0.0056)		(0.0056)
vacCompetition		-0.102***		-0.104***		-0.105***
		(0.0053)		(0.0053)		(0.0053)
Constant	10.82***	62.35*	10.82***	83.62**	10.82***	88.24**
	(0.024)	(35.8)	(0.024)	(36.0)	(0.024)	(36.1)
Observations	6414	6414	6414	6414	6414	6414
R-squared	**0.86**	**0.55**	**0.86**	**0.55**	**0.86**	**0.55**

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Exogenous variables: sps Improve, sps Worse, blackChange, freelunchChange, reassign, blackP, kidsP1, kidsP2, medHH99, enrollP, num_beds, f_bath, livarea, netarea, LD, newLD, vacLD, competition, newCompetition, vacCompetition. Coefficients are not reported for the following variables: house age, mls area, year, season and month sold.

Appendix C: Regression Results with School Performance Score as Independent Variable

The empirical hedonic price function defined in Chapter III is as follows:

$$ln(P_{inkt}) = \alpha + \delta Z_{kt} + \Gamma_{ink} + \omega_t + \varepsilon_{inkt}$$

Here, we estimate our model specification where Z_{kt} elements are the year-specific school level attributes such as school performance score, percent black and percent receiving free lunch. Table 2C presents the coefficients on key variables.

We find no capitalization of performance scores. Again, we attribute this to many changes that EBRPSS has been through because of its battle with school desegregation law suits. As noted earlier, anecdotal evidence points to the fact that the boundaries, once drawn, were not meeting the requirements spelled in the Consent Decree and needed to be redrawn. These developments can impact homebuyers' expectations. It is not surprising that test scores are not capitalized, in part, because homebuyers are uncertain about future policy changes. In addition, there is a great deal of volatility in test scores and the way they are reported. For example, the Louisiana Department of Education reported *LEAP 21* and *The Iowa Tests* scores separately before the Louisiana School Accountability Program was established. As part of the accountability system, each school annually receives a School Performance Score (SPS), which indicates how well its students perform. Specifically, each school's effectiveness and progress are measured as a weighted composite index using results from state wide testing programs: 60 percent weight for the *LEAP 21* tests, 30 percent weight for the *Iowa Tests,* and 10 percent weight for the attendance and dropout index. School Performance Labels are assigned based on this score. Table C1 lists six performance categories.

Table C1. *2000-2001 School Performance Label Assignment*

School Performance Label	*SPS Range*
School of Academic Excellence	150.0 or above
School of Academic Distinction	125.0 – 149.9
School of Academic Achievement	100.0 – 124.9
Academically Above the State Average	79.9 – 99.9
Academically Below the State Average	30.1 – 99.9
Academically Unacceptable School	30 or Below

The distribution of the school performance labels gives an indication of a low performing school district. For example, there are no schools of academic excellence in the district and only 1 percent of this district's elementary schools are Schools of Academic Distinction, while 57 percent of the district elementary schools are labeled Academically Below the State Average. These numbers are calculated based on elementary schools. Schools with grades 9-12 and 9-12 portions of K-12 schools (i.e., high school and combination schools) officially entered the Louisiana School Accountability System in the fall of 2001. Also, The Louisiana Department of Education uses a two-year accountability cycle. During each cycle, every school receives an SPS and a Growth SPS, which is calculated at the end of a cycle and is used to determine if a school has achieved its Growth Target. All schools also receive an annual growth target and are expected to reach a score of 120 by the 2013-14 school year. The Louisiana Department of Education reports that the performance of EBR schools has improved since the implementation of this plan. The average SPS for elementary schools in EBR increased five points from 1999 to 2004. As suggested by Kane et al. (2003), in such environment, a school that is improving has a difficult time signaling that improvement to the buyers in the housing market. Many schools in the EBRSS have been low performing schools, and we have reason to believe that buyers might be interested in trends in school quality.

Table C2. *Regression Results Dependent Variable: ln(sold price in '99$)*

	(1)Baseline Hedonic Level Values	***(2)Baseline Hedonic Level Values***	***(3) Baseline Hedonic Categorical Rankings***
Regressors	**Neighborhood Controls from Census Tracts**	**Neighborhood Controls from Local market Conditions**	**Neighborhood Controls from Local market Conditions**
School Attributes			
School Performance Score	0.000396	0.000340	0.000810***
	(0.00046)	(0.00047)	(0.00025)
black_school	0.116***	0.114***	
	(0.037)	(0.037)	
freelunch_school	-0.139**	-0.145***	
	(0.055)	(0.055)	
sps Improve			0.0553***
			(0.0072)
sps Worse			-0.00374
			(0.0094)
blackChange			0.153**
			(0.062)
freelunchChange			0.0182
			(0.073)
reassign	0.0115**	0.0110*	0.0111**
	(0.0057)	(0.0057)	(0.0057)
Constant	10.81***	10.83***	10.76***
	(0.066)	(0.067)	(0.034)
Observations	**6610**	**6610**	**6414**
R-squared	**0.86**	**0.86**	**0.86**

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Coefficients are not reported for the following variables: Tract Attributes, House Attributes, house age, mls area, year and season sold.

Appendix D: Theoretical Model and Calibration Exercise

To evaluate what happens when the houses in the market have different amenity levels such as school quality attached to them, we redefine the housing service flow to consist of an idiosyncratic component λ and an aggregate component *x*,

$$d = \lambda + x\,. \qquad (1)$$

The idiosyncratic component λ has the same interpretation as before. The state variable *x* is aggregate in that all agents who live in houses receive exactly the same *x*. The variable *x* can reflect the aggregate state of the economy such as employment growth and interest rates. Under this interpretation, shocks to the productivity of the land or to job growth filter their way into house prices through *x*. A more concrete interpretation of *x* could include amenity levels such as school quality or the level of crime in the area. Under this interpretation, changes to a location-specific component in the housing service that reflects the value of land filters into house price through *x*. By adding a random variable *x* to the housing service flow, the equations above that define equilibrium become functions of *x*.

For simplicity, assume that *x* can take on just two values, low and high (L,H). The evolution of *x* is described by a Markov chain with the transition matrix

$$M = \begin{bmatrix} \alpha & 1-\alpha \\ 1-\alpha & \alpha \end{bmatrix}$$

Additionally, let *q* be the expected value of having a house on the market and let μ(*p*) be the probability that a house will sell when the list price is *p*. The seller chooses a price to solve

$$q(x) = \max_p \{\mu(p)p + (1-\mu(p))\beta E q(x')\} \quad \text{for } x = x^L, x^H\,. \qquad (1)$$

The first part states that with probability μ the seller receives the asking price for the house. The second part relates to the possibility of re-listing the house in the next period. The seller puts the house back on the market and tries to sell it again in the next period. Here, the parameter β is a discount factor.

The first order condition that gives the optimal price *p* is

$$\frac{d\mu}{dp}(p(x) - \beta E q(x')) + \mu(p) = 0 \qquad \text{for } x = x^L, x^H. \qquad (2)$$

The selling price of housing, *p(x),* and the expected value of having a house on the market, *q(x),* are determined in equations (1)–(2) in terms of μ, the probability of sale function.

We now consider the optimal behavior for the agent in his role as buyer. We start first with an agent who currently has a "match" and will consume the housing service flow λ at the beginning of the next period. After this period, the homeowner will continue to consume λ if the match persists for another period, an event that happens with probability π. If, on the other hand, the match fails, the agent must put the house on the market and begin to search again, an event that happens with probability 1 – π. Define *v*(λ,x) to be the lifetime expected utility of owning a house yielding service flow λ, then

$$v(\lambda, x) = \beta E(x' + \lambda + \pi v(x', \lambda) + (1-\pi)(q(x') + s(x'))) \quad \text{for } x = x^L, x^H. \quad (3)$$

The first and the second part of the equation state that an agent will consume housing service flow with certainty for the first period and with the probability of π for the second period. The third part relates to the house selling process, which we saw above, yields *q* in expected value. The agent also has an option to search for a new house at this point. The value of this search option is represented by *s*.

Under the optimal buy rule the agent buys the house with service flow λ for price *p* only if the expected value of the house net of price is greater than the option to search again next period. That is,

$$v(x,\lambda) - p(x') \geq \beta E s(x') \qquad \text{for } x = x^L, x^H. \tag{4}$$

Since *v* is linear and strictly increasing in λ(x) there exists a λ*(x) such that a searching agent is indifferent between buying a house for the asking price *p* and searching again next period. That is, there exists an λ* (x) such that

$$v(x,\lambda^*) - p(x') = \beta E s(x'). \qquad \text{for } x = x^L, x^H. \tag{5}$$

A buyer keeps searching if she draws λ< λ* and buys if she draws λ>λ*. Therefore, we can write the expected value of search as

$$s(x) = F(\lambda^*(x))\beta s(x) + (1 - F(\lambda^*(x)))\left(\int_{\pi^*}^{1} v(x,\lambda)dF(\lambda) - p(x))\right) \qquad \text{for } x = x^L, x^H. \tag{6}$$

Here, the probability of sale is simply the probability of drawing λ>λ*. Given that *F* is the uniform distribution on [0,1] so that μ = 1 – *F*(λ*), or

$$\mu(x) = 1 - \lambda^*(x) \qquad \text{for } x = x^L, x^H. \tag{7}$$

The equilibrium is a symmetric Nash equilibrium: an equilibrium in which each agent's decision rules are best responses to the same decision rules when adopted by other agents. The equilibrium is a price of housing *p(x)*, an expectation of the value of a house on the market *q(x)*, an expectation of the outcome from the search process *s(x)*, a reservation service flow *λ*(x)*, and a belief about the probability that a buyer will purchase a house *μ(x)* when the price is *p* for $x = x^L, x^H$. All these variables must satisfy equations (1), (2), (5), (6), and (7). Given the

assumptions that there are two states of *x*, the model is solved by solving a system of 10 equations and 10 unknowns. These equations can be solved numerically.

Two most important parameters in this model are the match persistence parameter or π, and the state persistence parameter α. Given these parameters Krainer (2002) shows that when buyer valuations are high, sellers raise their prices in response to the increased valuations of buyers. It is also revealed that valuations of houses by potential buyers vary more across different states of the economy than do prices. Thus, changes in underlying value of property are not fully reflected in transaction prices. Rather, liquidity absorbs part of the capitalization of school quality.

Krainer (2002) performs a simple calibration exercise and looks at the differences across states between prices, valuations, and market liquidity. In his exercise, the match persistence parameter, π, and the state persistence parameter, α, are both equal to 0.9968. This value implies that expected time to match failure and expected time until a change in state variable *x* equal to six years. Using these parameter values, the model predicts that prices in the high dividend state are 4.7 percent higher than in the low dividend state. However, liquidity is shown to be affected much more than prices. In particular, the probability of sale in any given week in a high dividend state is about 18 percent higher than in the low dividend state.

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