Urban and Regional
Analysis Group

School Quality, House Prices and Liquidity

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Working Paper No. 07-03
February 2007

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Abstract

This paper develops an empirical framework for taking into account the effects of endogenous liquidity on price capitalization estimates. Changes in school attendance zones in the East Baton Rouge Parish public school district provide a natural experiment for studying how changes in school characteristics affect housing prices and liquidity. House price and selling time, or liquidity, are simultaneously determined in search markets. The empirical model exploits variation in the surrounding neighborhood market conditions pertinent to each house to identify the system of price and liquidity equations. The estimates are consistent with search-market theory in that liquidity absorbs part of the capitalization of school quality.

Keywords: capitalization, house price, liquidity, school quality, search market.

JEL Subject Codes: D40, D83, H52, I21, R21

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***Velma Zahirovic-Herbert acknowledges support from the Dan Sweat Fellowship and the Lincoln Institute of Land Policy. The authors are responsible for any errors.

1. Introduction

The quality of local public schools is often a major consideration for families buying houses. To attract potential buyers, real estate agents prominently feature school quality information along with other important house and neighborhood characteristics. Even when sellers are not inclined or required to offer information about school quality, this information is widely available to the public; it is becoming increasingly easy for buyers to include school quality measures when determining their value of a particular house. Following the standard approach taken in the government services and tax capitalization literature, studies of how school quality affects housing markets focus on buyers' valuations reflected in transaction prices.[1] The focus on prices likely reflects the influence of neoclassical capitalization theory based on static frictionless markets. It does, however, overlook a major difference between transactions conducted in frictionless static markets and transactions conducted in search markets; it is not only how school quality affects the expected selling price, but also how it affects the difficulty of selling the house for that price -- that is, liquidity.

This paper examines the impact of school quality on property values and liquidity. We develop an empirical framework drawing from classical capitalization analysis and search market theory to measure both price and selling time dimensions of market transactions. Extending the empirical approach developed in Turnbull and Dombrow (2006) and Turnbull, et al. (2006), our framework exploits the neighborhood market conditions surrounding each house to identify both the price and liquidity equations in the

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[1] For example, see Haurin and Brasington (1996), Hayes and Taylor (1996), and Black (1999). See Ross and Yinger (1999) and Fischel (2001) for reviews of the empirical literature on the capitalization of public service quality and property taxes into house prices.

system estimation. This approach has the added advantage of explicitly accounting for the factors sometimes argued to be the source of spatial correlation in housing transaction data (Brasington and Haurin, 2006).

The empirical framework represents a contribution to both the empirical housing market and capitalization literatures. But the empirical results themselves also contribute to the capitalization literature. The empirical application presents an unusual opportunity to isolate the capitalization of school quality. The school district is coterminus with a unified city-parish (county) government. This minimizes the effects of omitted variables that typically plague capitalization studies; looking within one school district and local government eliminates variations in tax rates and local public services across observations.

We examine the capitalization effects of changes in school attendance zones within the single unified school district. The policy change was designed and implemented on short notice. The changes in attendance zones produce direct and indirect exogenous changes in school quality, an important locational attribute of housing. The direct change in school quality occurs for houses assigned to new schools. In such circumstance, the assignment to a new school opens the opportunity for changes in both peer composition and measured school performance. The indirect change in school quality occurs for houses with unchanged school assignments. In these cases, the changes in attendance zones boundaries in other neighborhoods changes in the characteristics of the students assigned to their schools, thereby affecting peer composition and possibly measured school quality. We therefore eschew Black's (1999) boundary sample approach, instead using data from transactions over the entire school district in order to take into account both direct and indirect changes in school quality.

The paper is organized as follows. Section 2 summarizes the rationale underlying the simultaneous determination of prices and liquidity in housing market equilibrium. Section 3 explains the empirical model. Section 4 explains the data while sections 5 and 6 report the empirical results. Section 7 presents our conclusions.

2. House Prices and Liquidity in Search-Market Equilibrium

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; our measure of housing liquidity is the length of time it takes to sell a house.

Lippman and McCall (1986) is a seminal influence on search models of real estate markets. Haurin (1988) draws from search theory to motivate his analysis of house attributes and liquidity. One shortcoming of this type of analysis is that it is partial equilibrium; the representative house seller takes the behavior of potential buyers as given. Arnott (1989) introduces the buyer's problem into the model by assuming he or she purchases the house with the lowest price. Wheaton (1990) jointly models the buying and selling decision, although the analysis is exclusively steady state. Williams (1995) extends Wheaton's framework to a dynamic setting. One fundamental lesson from these and related studies is that price and liquidity are jointly determined. An additional insight from search models is that changes in underlying use value or buyers' valuations of property need not be fully reflected in transactions prices; they can also be reflected in changes in liquidity.

From a different perspective, Fisher, et al. (2003) argue that relatively slower seller reaction to changing market conditions explains the relationship between prices and liquidity. Another explanation for liquidity effects is that sellers' equity constraints can create downward reservation price rigidity, effectively forcing them to wait longer for the less-probable arrival of high-bidding buyers (Genesove and Mayer, 1997). An alternative explanation is that sellers, whether based on prospect theory or otherwise, irrationally refuse to recognize the decline in the value of their properties and continue to wait for higher-than-market values (Genesove and Mayer, 2001; Case and Shiller, 2003).[2]

Our empirical framework is based on Krainer's (2001) model of search market equilibrium. He develops a model that yields state-varying housing market liquidity without appealing to either financing constraints or irrational behaviour on the part of either buyers or sellers. The model shows that when the value of the housing service flow fluctuates, liquidity also fluctuates. In the context of our application, direct and indirect changes in expected school quality from attendance zone changes play the role of the change in housing service flow in Krainer's model.

In this model, agents form expectations about the kinds of transactions that are realistic in the economy and then meet prospective trading partners consecutively. Each seller bases his reservation price on his expectations about the distribution of buyers in the market and their willingness to pay for this particular house. The seller's trade-off

[2] The extra waiting time is required to increase the cumulative likelihood of a (low frequency) idiosyncratic buyer who values the house more than the average buyer in the market.

weighs the benefits of further search against the costs of delaying the sale. The benefit of further search is possibility that a buyer may arrive who attaches greater value to the house. The cost of waiting includes foregone consumption as well as the risk associated with the uncertain arrival of a better offer. At the same time, a buyer determines his willingness to pay by capitalizing the expected housing services the house provides and comparing this value to the seller's price, taking into consideration the opportunity to continue to search for another house.

Two main characteristics of the model show that prices and liquidity are determined endogenously and state-varying liquidity implies that prices do not absorb all of the gains (losses) in asset values from exogenous changes. The model predicts that the probability of sale depends on the aggregate state of the market. This implies a relationship between days-on-market and variables such as local employment growth as well as macro variables like interest rates.[3] The aggregate state of the market can include (dis)amenities such as crime in the area or, as in our application, school quality.

3. Empirical Methodology

Many empirical studies use log-linear regression models to estimate determinants of days-on-market or liquidity (Belkin et al., 1976; Miller, 1978; Kang and Gardner, 1989; Asabere et. al., 1993). Some, however, explicitly recognize that selling price and liquidity are simultaneously determined using simultaneous or two-stage models (Sirmans et al., 1991; Yavas and Yang, 1995; Forgey, et al. 1996; Huang and Palmquist, 2001; Rutherford, et al., 2001; Knight, 2002; Turnbull and Dombrow, 2006). Treating

[3] Krainer (2001) establishes an empirical link between days on the market and variables such as the interest rate, the slope of the term structure, and the job growth rate.

selling price and liquidity as simultaneously determined is complicated by the fact that both price and days-on-market are determined by similar, if not identical, factors. Simply put, two separate equations for price and liquidity cannot be identified. The literature nonetheless offers a variety of innovative ways of dealing with the endogeneity of selling time in price equations or price in selling time equations. In effect, most of these identification conditions reduce to the assumption that some property characteristics only affect selling price while others only affect selling time. Specifying these identifying factors is to some extent arbitrary in this literature, so it is not surprising that there is no widely accepted empirical framework for dealing with endogenous price and liquidity in a systems context. We offer an alternative approach that does not rely on ad hoc identification conditions.

Drawing from Krainer's (2001) search market model, expected house price, $E[P]$, and liquidity, $E[L]$ (measured as days on the market), are simultaneously determined. Thus, for a house with characteristics vector **X** and neighborhood market conditions summarized in the vector **C**, the relationship between expected price and liquidity is defined implicitly as

$$F(E[P],E[L],\mathbf{X},\mathbf{C}) = 0$$

In principle, the realized price and days-on-market can be expressed as separate functions, where ε_p and ε_l are the stochastic error terms for realized price and liquidity, respectively:

$$P = f(L,\mathbf{X},\mathbf{C}) + \varepsilon_p \quad (1)$$

$$L = g(P,\mathbf{X},\mathbf{C}) + \varepsilon_l \quad (2)$$

The neighborhood market conditions variables in the vector **C** play a key role in what follows, and so deserve closer attention.

The number of houses for sale in a small neighborhood surrounding a particular house will generally have localized competition and shopping externality effects (Turnbull and Dombrow, 2006). The localized competition effect arises when a greater number of houses for sale increases the competition among sellers for buyers considering houses in the neighborhood, thereby reducing the probability of a higher priced match within a given time window. The shopping externality effect arises when a greater number of houses for sale draws additional prospective buyers to the neighborhood, potentially increasing the chance of matching a particular house with a buyer. In this view, both price and time on the market transactions outcomes are affected by the number of competing listings in the neighborhood. The empirical measure of competition from neighboring houses for sale takes into account how long each competing house overlaps with the time this house is on the market, inversely weighted by the distance between the houses (Turnbull and Dombrow, 2006; Turnbull, et al., 2006).

To construct the appropriate variables, define $l(i)$ and $s(i)$ as the listing date and sales date for house i, respectively, so that days-on-market is $s(i)-l(i)+1$. Correspondingly, $l(j)$ and $s(j)$ are the listing date and sales date for house j. Contemporaneously listed houses i and j have overlapping times on the market of $O(i,j) = min[s(i),s(j)] - max[l(i),l(j)] + 1$. Let $D(i,j)$ denote the straight-line distance in miles between houses i and j. The measured competition for house i is

$$C = \sum (1 - D(i,j))^2 O(i,j) \qquad (3)$$

where the summation is taken over all competing houses j within one mile of i.

The vector of neighborhood market condition variables in (1) and (2) include the neighborhood competition variable (3). It turns out to be useful to also define another variable, listing density, as the measure of competing overlapping listings per day on the market, or

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

It is clear that (1) and (2) -- being codetermined in search equilibrium -- are functions of the same variables and so are not identified. Notice, however, that a regression of the price equation (1) will yield the estimated effect of competition C on price as the partial derivative $\partial P/\partial C$, holding days-on-market, or liquidity, constant. But a change in competition while holding liquidity constant is simply a change in listing density. Thus $\partial P/\partial C \equiv \partial P/\partial LD$, which implies that the hedonic price function (1) can be rewritten as a function of the listing density variables (4) instead of competition variables (3), or

$$P = h(L,\mathbf{X},\mathbf{LD}) + \varepsilon_p \tag{5}$$

The system of equations for price and liquidity is now (5) and (2). This approach provides a means of identifying both the price and liquidity equations in the estimation. It also introduces controls for localized market conditions, sometimes argued to be a source of spatial correlation.

The log of sales price is a function of the marketing time, house characteristics, school characteristics, location, and a set of listing density variables capturing neighborhood housing market conditions. Similarly, days-on-market is a function of the sales price, house characteristics, school characteristics, location, and a set of competition variables as a different measure of neighborhood housing market conditions.

The empirical model is

$$\ln(P_{inkt}) = \alpha + \beta_1 L + \delta Z_{kt} + \Gamma_{ink} + \omega_t + \Phi_{ijk} + \varepsilon_{inkt} \quad (6)$$

$$L = \alpha + \beta_2 \ln(P_{inkt}) + \delta Z_{kt} + \Gamma_{ink} + \omega_t + \Phi_{ijk}' + \varepsilon_{inkt} \quad (7)$$

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 supply and demand conditions using measures of listing densities and competition, respectively. 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).

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

This specification uses neighborhood controls based on the characteristics of census tracts (a formulation using census block groups is considered later). The estimating system of equations now becomes

$$\ln(P_{inkt}) = \alpha + \beta_1 L + \delta Z_{kt} + \beta X_i + \mu W_n + \omega_t + \Phi_{ijk} + \varepsilon_{inkt} \quad (8)$$

$$L = \alpha + \beta_2 \ln(P_{inkt}) + \delta Z_{kt} + \beta X_i + \mu W_n + \omega_t + \Phi_{ijk}' + \varepsilon_{inkt} \quad (9)$$

We estimate (8)-(9) using 2SLS to take into account the endogeneity of price and liquidity.

4. Data Description

This study uses single family housing transactions that occurred during 1998-2002. The data draws from the Multiple Listing Service (MLS) reports for Baton Rouge, Louisiana**.** Each house is geocoded to a specific elementary school and census tract. The house characteristics include common features such as *Bedrooms*, *Bathrooms*, *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, indicated by dummy variables for MLS areas or zones.[4]

The East Baton Rouge Parish School System provided maps of both the original school attendance areas as they were designed by the Consent Decree in 1996 and the new attendance zones implemented in the redistricting in 2001. We obtained school quality data from the State of Louisiana Progress Profiles for the years 1998 through 2002. Starting in the 1998-99 school year, Louisiana's School and District Accountability System reports a school performance score (SPS) for every public school.

[4] The subject area covers contiguous region and excludes houses in the separate small cities of Baker and Zachary, the only parts of East Baton Rouge Parish that are not within the unified City-Parish jurisdiction.

This score is calculated using index results from three parts: a state standardized test (LEAP 21), the *Iowa Test*, and an 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.[5] For each school we construct a set of dummy variables *SPS Improve* and *SPS Worse* that use the information about the change in school's performance category between two accountability cycles. In this case, *SPS Worse* equals one for a unit of observation if the school's performance category declines between two accountability cycles. For houses that are in the areas affected by the 2001 reassignments, we construct a dummy *Reassign*. In our sample, 18.8 percent see an improvement in their school's categorical ranking, while only a little over 6 percent see a decline in their school's standing. This improved ranking is due to reassignment in 9.3 percent of our sample. Over 75 percent of our sample does not see any change in their school's categorical ranking even though 12.9 percent of them are reassigned to different schools.

The neighborhood characteristics are defined based on 89 tracts in East Baton Rouge Parish during the 2000 Decennial Census. The variables include median household income, percent black in tract, percent of school age children enrolled in private schools, and percent of children of preschool and school age.

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

Finally, to capture market conditions of the entire urban area, the specification includes year, season, and month fixed effects based on the sales date in the transactions reports. We also include six variables to describe the neighborhood housing market condition. These variables are based on the competition and listing density variables (3) and (4) described in the model setup. *Listing density* measures the average intensity of competition; *Competition* measures the cumulative competition from other houses over the entire marketing time for a given house*; New listing density* and *New competition* are similar to the listing density/competition variables, except that they only include newly listed houses in their calculation (where "new" means within the first 14 days of listing); *Vacant listing density* and *Vacant competition* are constructed similarly except that they only include competing vacant houses.

The calculations for these variables include all applicable competing house sales. The calculations also include the relevant competing houses listed before and after our sample period that overlap with the sample period used in the estimation. Following Turnbull and Dombrow (2006), a competing house is defined as one that is within one mile and 20 percent larger or smaller in living area of the sold house.

Table 1 summarizes the means and standard deviations of the variables included in the data set. The dependent variable, house sale price, is adjusted for inflation, and the mean of $129,115 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 (1.868), and net area (.673). The variables used to describe neighborhood characteristics are under Tract Attributes and include: *Med Income*, median household income in thousands of '99 $ (mean of $50. 20); *Black*, percent black (mean of

20.95 percent); *Preschoolers*, percent preschoolers (mean of 7 percent); *School age*, percent school age children (mean of 18.34 percent). In addition, the average percent enrolled in private schools in the census tract, *Private school*, is 5.4 percent with standard deviation of 8.6 percent.[6]

The variables of central interest to this study are those measuring the school quality. The differences in school quality following the exogenous change in school assignments provide an ideal situation to study the effects of school quality measures and racial composition on housing prices. The average school SPS score is 80 and it varies between 42 and 124, average percent black in school is 61 and average change in percent black between two accountability cycles is five percent. We include dummy variables in the regression models to capture the change in school rankings while controlling for the school level test scores. These variables allow us to look into not just short-term fluctuations in test scores but also longer-term progress.[7] Another binary variable *Reassign* captures changes in re-assignments, so that it is equal to one if the house has been reassigned to a different school in the 2001 attendance zone boundary changes.

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

[7] These dummies capture the growth SPS or lack thereof over time in student achievement. These measures are consistent with the value added approach that education and labor economists argue is a better measure of school quality than just proficiency test results (Hanushek and Taylor, 1990; Meyer, 1997; Figlio, 1999). We assume that it is difficult for parents to notice a small change in the level values of test scores so that a school that is improving has a difficult time signaling that improvement to the buyers in the housing market. The Louisiana Department of Education started publishing for parents the School Report Card that presented the categorical ranking of a school and its growth target as well as its performance relative to other schools in the district. We believe that this information gives parents better understanding of how their local school performs.

5. Empirical Results

We begin by estimating the relationship between school performance and house prices and liquidity, model (1) in Table 2. There are reasons to believe that house values may not respond strongly to information in the annual school report cards. Students are tested twice a year, and these results are published separately from school performance scores. It is possible that parents find it confusing to differentiate between tests such as *Iowa* or LEAP 21. Many public schools in East Baton Rouge Parish have long been low performing schools, which provides a rationale for why buyers might be interested in trends in school quality more than current quality levels. To take this possibility into account, we use information released in the School Report Cards at the end of each accountability cycle that provides new information. By looking at the school rankings and, in particular, a change in rankings between two cycles, we can examine not just short-term fluctuations in test scores, but also the longer-term progress of schools and its impact on house prices and liquidity. These additional factors appear in models (2), (3), and (4) in Table 2.

Model (2) adds a dummy variable indicating a decline in a school's categorical ranking between two accountability cycles, *SPS Worse*. Model (3) adds a dummy variable indicating improvement in a school's categorical ranking between two accountability cycles, *SPS Improve*. The state focuses a large share of the financial rewards on the schools that meet or exceed growth targets. By including these measures, we test whether the housing market shares state policymakers' enthusiasm for these actions. Finally, model (4) includes the interaction *SPS Improve*Reassign.* This variable is introduced to distinguish between houses that are assigned to schools that are improving and houses that experience better schools simply because they are reassigned to them.

Table 2 summarizes the most important school quality parameter estimates from the four model specifications listed under School Attributes. The appendix reports the complete model estimates.

Focusing on the coefficients of variables listed under School Attributes, it appears that school quality can have a large effect on property values. The SPS quality variable is significantly positive in all equations. Increasing the SPS score by one standard deviation, about 18 points, increases the house price at the mean by $1,670 in model (1) or $2,160 in model (4). We do not, however, find a statistically significant relationship between marketing time and school performance scores in Table 2.

The *SPS Worse* and *SPS Improve* coefficients reveal that parents take into consideration additional information from school accountability reports about changes in performance ranking. The literature on school ranking is relatively new. Figlio and Lucas (2004) find some evidence that public exposure to school "report cards" affects house values . They use data from before and after the introduction of report cards in 1999 and conclude that an assigned letter grade is associated with an approximately 10 percent increase in a house price for each full grade increment in the months directly following the release of the grade. In contrast, Kane, et al. (2003) find that house prices did not decline in response to North Carolina "low performing" school ratings. They suggest that residents already had formed opinions that these schools were low performing so that the state reports yielded no new information. Our results resemble theirs. The *SPS Worse* coefficients are never significant in the price equation; declining schools' categorical rankings do not appear to affect price in our sample. However, when looking at the days-on-market equation, we note that declining schools' categorical rankings extend marketing time by 9.6 days at the mean, or 14 percent of the variation in marketing time. So, while there is no direct price effect, declining schools do make it more difficult to sell.

Looking at the *SPS Improve* variable, we see that improving schools' categorical ranking increases house price, as expected. At the mean, houses increase in value by about five percent or about $7,360. This amount is significantly reduced if the improvement in categorical ranking is due to reassignment rather than improvement in the school itself. As a result of reassignments, some students do not attend the schools that are closest to their neighborhoods. Kane, et al. (2003) find that an additional mile in distance from the elementary school was associated with a one to five percentage point decline in housing values, which they conclude is equivalent to the effect associated with one standard deviation difference in test scores or improvement in categorical rankings.

The *SPS Improve* effect on liquidity in model (3) is somewhat puzzling at first. The interactive coefficient in model (4), however, lends some insight into what is going on. The net effect of improvement from being assigned to a better school (rather than a given school improving) significantly improves liquidity. The market values reassignment to a better school as more valuable in this regard than being assigned to an improving school.

It is also interesting that the housing market appears to not directly discount schools based on student racial composition. This conclusion is similar to Norris (2002), which examines the school quality capitalization in six Louisiana parishes.[8] 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 do not move away from schools simply because they have a growing minority enrollment. We can conclude that property values are not adversely affected by a changing school racial balance. However, when looking at the liquidity dimension previously ignored in the literature, we also see that increasing the percentage of black students leads to longer selling times. An increase in one standard deviation, or about eight percent, is equivalent to additional 2.3 days of marketing time at the mean. While these houses may not sell for less on average, they are more difficult to sell.

6. Sensitivity Analysis

One of the challenges in the housing literature is separating the value of school test scores from other neighborhood amenities. This can be particularly problematic when considering school quality because better schools tend to be located in better neighborhoods. As a result, inadequate controls for neighborhood characteristics may inflate estimates of the value of school quality. 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.[9] 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.

[8] Norris (2002) data covers six parishes with large shares of ethnic minorities, blacks in particular, but does not include East Baton Rouge Parish.

[9] Recall that our focus on the impact of changes in school assignments (attendance zone boundaries) and changes in school categorical rankings on house prices requires that we use the full jurisdiction data, so we do not restrict our attention to boundary samples.

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 (Clapp et. al., 2004; Kane et. al., 2003). This implies that the areas being compared are not really the same neighborhoods.

We test the robustness of our results in several ways. First, we include more detailed neighborhood characteristics such as the population age distribution and educational attainment. We also repeat estimation using the more finely defined census block group data for neighborhood socioeconomic attributes. The coefficients on the school variables are not significantly affected by these changes; our choice of empirical neighborhood characteristics controls do not appear to be biasing the results.[10]

In a different vein, since families with children obtain the direct benefits of school improvements, we expect them to value school improvements more highly than households without children. Therefore, if families with children tend to live in houses with more bedrooms then houses with more bedrooms will exhibit stronger capitalization effects—whether or not they are currently occupied by a family with school-age children (Fischel, 2001).

In addition, we expect that the strength of the capitalization is determined in part by the elasticity of housing supply, a standard result in the frictionless market theory of capitalization.[11] For our empirical analysis, we define areas with limited availability of

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[10] These results are available from the authors.

[11] There are only few studies that take into account the effect of the housing stock adjustment (Edel and Sclar, 1974; Hilber and Mayer 2001, 2002; Brasington 2002). For example Brasington (2002) 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.

new housing as areas with inelastic housing supply; areas with active new construction are areas with more elastic housing supply.

Table 3 reports the coefficients of the key school quality variables for the models reestimated to take into account house size (column 2) and an inelastic house supply (column 3). The first column presents model (3) for the full sample in order to make comparisons easy. We find that capitalization rates are much stronger for the two sub-samples than for the full sample; price capitalization is stronger for larger houses and houses in areas with limited new construction. For example, increasing the SPS score by one standard deviation in the two sub-samples, about 18 and 20 points respectively, leads to a price increase of $2,230 or $2,930 at the mean (the mean in the first sub-sample is $131,654 and in the second sub-sample is $117,105).

Furthermore, 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 6.7 percent increase in the house price. At the mean, this is equivalent to $7,800 (the mean house price in this sub-sample is $117,105). Similarly, there is a 4.2 percent price penalty associated with schools reporting a decrease in their categorical ranking. This implies that central city house values are more responsive to improvements in elementary school categorical rankings than in neighborhoods with room for new housing. These results and the liquidity estimates in Table 3 illustrate that uniform school improvement across the school district will in general yield significant but different price and liquidity effects across neighborhoods.

7. Conclusion

A house is typically a family's largest single asset and the quality of local public schools is often a major consideration in housing decisions. 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 there are numerous studies that look at house buyers' valuations of school quality, there has been no attention given to its effect on liquidity. This paper presents the first empirical evidence for how school reform effort affects local housing markets in both price and liquidity dimensions.

This study presents a useful methodology, integrating and extending two divergent empirical approaches drawn from classical capitalization analysis and search markets. The results illustrate how the introduction of endogenous liquidity helps us to better understand outcomes found in the capitalization literature. As expected from a search market perspective, liquidity absorbs part of the capitalization of school quality, with changes in school quality not only affecting selling price, but also the difficulty of sale.

Table 1: Summary Statistics

Variable (description)	*Mean*	*Std. Dev.*	*Min*	*Max*
House Attributes				
Price (sold price in '99$)	129115.2	54703.93	40000	320000
DOM (days-on-market)	68.72684	44.6187	14	180
Bedroom (number of bedrooms)	3.228925	0.6272473	1	5
Bathroom (number of full bath)	2.0215	0.504008	1	5
Living area (living area in thousand sq. feet)	1.867937	0.5447554	0.703	4.435
Net area (total area under roof minus living area)	0.6733502	0.2831932	0.11	1.995
School Attributes				
SPS (School Performance Score)	0.08	0.018	0.042	0.1238
Black Change (change in percentage black)	0.0509717	0.0818793	-0.1830224	0.6657174
Reassign (school reassignment dummy)	0.12529	0.3310731	0	1
SPS Worse (school's ranking declined dummy)	0.0610982	0.2395289	0	1
SPS Improve (school's ranking improved dummy)	0.1880897	0.390814	0	1
Census Tract Attributes				
Black (percent black population)	0.2094725	0.2320738	0.0096137	0.9836207
Preschool (percent preschool age children)	0.0689008	0.0180333	0.0182637	0.1262475
School age (percent school age children)	0.1833684	0.0416955	0.0317789	0.3256724
Med income (median household income, thousand '99$)	50.20254	14.82492	11.397	78.509
Private enroll (percent of children enrolled in private schools)	0.0542176	0.0855807	0	0.3732262
Local Market Conditions (defined in the text)				
Listing Density	3.792902	2.490771	0	18.30214
New Listing Density	1.736714	1.443614	0	11.30623
Vacant Listing Density	1.869482	1.720032	0	13.59951
Competition	263.551	276.5766	0	2727.606
New Competition	141.9267	187.4681	0	1724.786
Vacant Competition	133.1796	182.3705	0	1985.733
Observations	6465			

Table 2: 2SLS selected parameter estimates
Endogenous variables: lnPrice and DOM

	(1) with	*(2)add*	*(3) add*	*(4) with*
	School Performance Score	**Change in School Ranking**	**Change in School Ranking**	**Dummy Interactions for Reassignments**
Price Equation				
School Attributes				
SPS	0.720***	0.720***	0.832***	0.931***
	(0.18)	(0.18)	(0.18)	(0.18)
Black Change	0.0472	0.0482	0.159***	0.133***
	(0.030)	(0.031)	(0.033)	(0.035)
SPS Worse		-0.00109	-0.000397	0.000616
		(0.0090)	(0.0089)	(0.0090)
SPS Improve			0.0540***	0.0578***
			(0.0060)	(0.0063)
SPS Improve*Reassign				-0.0400**
				(0.018)
DOM Equation				
School Attributes				
SPS	-37.96	-37.81	-28.13	17.66
	(34.9)	(34.8)	(34.9)	(35.9)
Black Change	28.82***	20.08***	30.17***	18.81***
	(5.81)	(6.02)	(6.58)	(6.92)
SPS Worse		9.472***	9.416***	9.696***
		(1.75)	(1.75)	(1.75)
SPS Improve			4.552***	6.229***
			(1.19)	(1.23)
SPS Improve*Reassign				-18.32***
				(3.52)
Observations	6465	6465	6465	6465

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Complete parameter estimates are reported in Appendix.

Table 3: 2SLS selected parameter estimates: Sensitivity analysis with respect to bedrooms and inelastic house supply. Endogenous variables: lnPrice and DOM

	Model (3)	***(3)for bigger houses: At least three bedrooms***	***(4) limited availability of new housing***
	Change in School Ranking	**Change in School Ranking**	**Change in School Ranking**
Price Equation			
School Attributes			
SPS	0.832***	0.948***	1.284***
	(0.18)	(0.18)	(0.21)
Black Change	0.159***	0.136***	0.248***
	(0.033)	(0.033)	(0.045)
SPS Worse	-0.000397	0.00240	-0.0421***
	(0.0089)	(0.0091)	(0.013)
SPS Improve	0.0540***	0.0625***	0.0666***
	(0.0060)	(0.0063)	(0.0084)
DOM Equation			
School Attributes			
SPS	-28.13	6.427	-100.8***
	(34.9)	(37.1)	(35.9)
Black Change	30.17***	31.25***	45.62***
	(6.58)	(6.82)	(7.74)
SPS Worse	9.416***	10.53***	9.564***
	(1.75)	(1.84)	(2.29)
SPS Improve	4.552***	5.859***	4.489***
	(1.19)	(1.27)	(1.42)
Observations	6465	6465	6465

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Complete parameter estimates available from authors.

Appendix

Table A1: Complete Parameter Estimates
Endogenous variables: lnPrice and DOM

	(1) with	*(2)add*	*(3) add*	*(4) with*
Price Equation	**School Performance Score**	**Change in School Ranking**	**Change in School Ranking**	**Dummy Interactions for Reassignments**
DOM	-0.0000589	-0.0000587	-0.0000529	-0.0000561
	(0.000066)	(0.000066)	(0.000066)	(0.000066)
School Attributes				
SPS	0.720***	0.720***	0.832***	0.931***
	(0.18)	(0.18)	(0.18)	(0.18)
Black Change	0.0472	0.0482	0.159***	0.133***
	(0.030)	(0.031)	(0.033)	(0.035)
SPS Worse		-0.00109	-0.000397	0.000616
		(0.0090)	(0.0089)	(0.0090)
SPS Improve			0.0540***	0.0578***
			(0.0060)	(0.0063)
SPS Improve*Reassign				-0.0400**
				(0.018)
House Attributes				
Bedrooms	-0.000178	-0.000193	0.00101	0.00113
	(0.0044)	(0.0044)	(0.0044)	(0.0044)
Bathrooms	0.0322***	0.0322***	0.0325***	0.0325***
	(0.0052)	(0.0052)	(0.0052)	(0.0052)
Living area	0.427***	0.427***	0.423***	0.422***
	(0.0062)	(0.0062)	(0.0062)	(0.0062)
Net area	0.135***	0.135***	0.135***	0.135***
	(0.0082)	(0.0082)	(0.0081)	(0.0081)
Tract Attributes				
Black	0.0236	0.0234	0.0218	0.0174
	(0.019)	(0.020)	(0.019)	(0.019)
Preschool	0.602***	0.600***	0.482***	0.508***
	(0.17)	(0.17)	(0.17)	(0.17)
School age	-0.633***	-0.631***	-0.588***	-0.568***

	(0.10)	(0.10)	(0.10)	(0.10)
Med income	0.00400***	0.00399***	0.00406***	0.00395***
	(0.00030)	(0.00031)	(0.00031)	(0.00031)
Private enroll	-0.00536	-0.00532	-0.00839	-0.0101
	(0.027)	(0.027)	(0.026)	(0.026)
Local Market Conditions				
Listing Density	0.00590***	0.00588***	0.00722***	0.00750***
	(0.0021)	(0.0021)	(0.0021)	(0.0021)
New Listing Density	-0.00645**	-0.00647**	-0.00705***	-0.00691***
	(0.0026)	(0.0026)	(0.0026)	(0.0026)
Vacant Listing Density	-0.00547**	-0.00546**	-0.00680***	-0.00699***
	(0.0025)	(0.0025)	(0.0025)	(0.0025)
Constant	10.78***	10.78***	10.75***	10.75***
	(0.028)	(0.028)	(0.028)	(0.028)
DOM Equation				
LnPrice	-4.461	-4.125	-4.536	-5.780*
	(3.45)	(3.45)	(3.42)	(3.42)
School Attributes				
SPS	-37.96	-37.81	-28.13	17.66
	(34.9)	(34.8)	(34.9)	(35.9)
Black change	28.82***	20.08***	30.17***	18.81***
	(5.81)	(6.02)	(6.58)	(6.92)
SPS Worse		9.472***	9.416***	9.696***
		(1.75)	(1.75)	(1.75)
SPS Improve			4.552***	6.229***
			(1.19)	(1.23)
SPS Improve*Reassign				-18.32***
				(3.52)
House Attributes				
Bedroom	-1.590*	-1.502*	-1.420*	-1.369
	(0.86)	(0.86)	(0.86)	(0.85)
Bathroom	-1.906*	-1.937*	-1.759*	-1.651
	(1.04)	(1.04)	(1.04)	(1.04)
Living area	11.21***	10.74***	10.49***	10.60***
	(1.80)	(1.80)	(1.79)	(1.79)
Net area	-2.042	-1.917	-1.815	-1.688

	(1.70)	(1.70)	(1.69)	(1.69)
Tract Attributes				
Black	-8.974**	-6.543*	-6.855*	-8.922**
	(3.80)	(3.82)	(3.81)	(3.83)
Preschool	-116.4***	-101.0***	-111.0***	-97.87***
	(33.0)	(33.1)	(33.1)	(33.1)
School age	18.45	0.0136	4.540	14.12
	(20.4)	(20.7)	(20.7)	(20.7)
Med income	-0.278***	-0.208***	-0.205***	-0.251***
	(0.061)	(0.062)	(0.062)	(0.062)
Private enroll	-5.305	-5.663	-5.985	-6.758
	(5.23)	(5.22)	(5.22)	(5.21)
Local Market Conditions				
Competition	0.102***	0.103***	0.104***	0.105***
	(0.0050)	(0.0050)	(0.0050)	(0.0050)
New Competition	0.119***	0.119***	0.118***	0.117***
	(0.0056)	(0.0056)	(0.0056)	(0.0056)
Vacant Competition	-0.101***	-0.101***	-0.102***	-0.103***
	(0.0053)	(0.0053)	(0.0053)	(0.0053)
Constant	99.71***	93.32**	95.37***	106.0***
	(36.4)	(36.4)	(36.0)	(36.0)
Observations	6465	6465	6465	6465
R-squared	0.55	0.55	0.55	0.55

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.

References

Arnott, R. (1989). Housing vacancies, thin markets, and idiosyncratic tastes. *Journal of Real Estate Finance and Economics, 2*(1), 5-30.

Asabere P. K., Huffman F. E., & Mehdian S. (1993) Mispricing and optimal time on the market. *Journal of Real Estate Research*, 8(1), 149-155.

Belkin, J., Hempel, D. J., & McLeavey, D. W. (1976). An empirical study of time on market using multidimensional segmentation of housing markets. *American Real Estate and Urban Economics Association Journal, 4*(2), 57-75.

Black, S. (1999). Do better schools matter? Parental valuation of elementary education. . *Quarterly Journal of Economics, 114*(2), 579-599.

Brasington, D. M., & Haurin D. R. (2006). Educational Outcomes and House Values: A Test of the value added Approach. *Journal of Regional Science* 46 (2), 245–268.

Brasington, D. M. (2002). Edge versus center: Finding common ground in the capitalization debate. *Journal of Urban Economics, 52*(3), 524-641.

Case, K. E., & Shiller, R. J. (2003). *Is there a bubble in the housing market?* : Brookings Panel on Economic Activity.

Edel, M., & Sclar, E. (1974). Taxes, spending, and property values: supply adjustment in a Tiebout-Oates Model. *Journal of Political Economy 82*(5), 941-954.

Figlio D.N. (1999). Functional form and the estimated effects of school resources

Economics of Education Review, 18(2), 241-252

Figlio, D. N., & Lucas, M. E. (2002). What's in a grade? School report cards and house prices: *American Economic Review*, 94(3) 591-604.

Fischel, W. A. (2001). *The Homevoter Hypothesis*. Cambridge, MA: Harvard University Press.

Fisher, J., D.Gatzlaff, D.Geltner, & D.Haurin. (2003). Controlling for the impact of variable liquidity in commercial real estate price indices. *Real Estate Economics, 31*(2), 269-303.

Forgey, F. A., Rutherford, R. C., & Springer, T. M. (1996). Search and liquidity in single-family housing. *Real Estate Economics, 24*(3), 273-292.

Genesove, D., & Mayer, C. J. (1997). Equity and time to sale in the real estate market. *American Economic Review, 87*(3), 255-269.

Genesove, D., & Mayer, C. J. (2001). Loss aversion and seller behaviour: evidence from the housing market. *Quarterly Journal of Economics*, 116(4), 1233-1260.

Hanushek E.A. & Taylor L.L (1990). Alternative assessments of the performance of schools: Measurement of state variations in achievement. *The Journal of Human Resources*, 25(2),179-201.

Haurin, D. R. (1988). The duration of marketing time of residential housing. *American Real Estate and Urban Economics Association Journal, 16*(4), 396-410.

Haurin, D. R., & Brasington, D. (1996). School quality and real house prices: inter- and intrametropolitan effects. *Journal of Housing Economics, 5*(4), 351-368.

Hayes, K. J., & Taylor, L. T. (1996). Neighborhood school characteristics: What signals quality to homebuyers? : *Federal Reserve Bank of Dallas Economic Review,* 3, 2-9

Hilber, C. A. L., & Mayer, C. J. (2001). *Land supply, house price capitalization, and local spending on schools* (Working paper #392): University of Pennsylvania.

Hilber, C. A. L., & Mayer, C. J. (2002). *Why do households without children support local public schools? Linking house price capitalization to school spending*: Federal Reserve Bank of Philadelphia.

Huang, J., & Palmquist, R. B. (2001). Environmental conditions, reservation prices, and time on the market for housing. *Journal of Real Estate Finance and Economics, 22*(2-3), 203-219.

Kane, T., Staiger, D. O., & Samms, G. (2003). *School Accountability Ratings and Housing Values*. Washington, D.C.: Brookings Institution Press.

Kang, H. B., & Gardner, M. J. (1989). Selling Price and Marketing Time in the Residential Real Estate Market. *Journal of Real Estate Research, 4*(1), 21-35.

Knight, J. R. (2002). Listing price, time on market, and ultimate selling price: causes and effects of listing price changes. *Real Estate Economics, 30*(2), 213-217.

Krainer, J. (2001). A theory of liquidity in residential real estate markets. *Journal of Urban Economics*, 49(1), 32-53.

Lippman, S. A., & McCall, J. J. (1986). An operational measure of liquidity. *American Economic Review, 76*(1), 43-55.

Meyer, R.H., (1997). Value added indicators of school performance: A primer. *Economics of Education Review,* 16(3), 283-301.

Miller, N. G. (1978). Time on the market and selling price. *Real Estate Economics, 6*(2), 164-174.

Norris, D. N., Jr. (2002). *Schools, race and housing values; the effect of school quality improvements on residential housing prices in Louisiana*. Paper presented at the Sothern Economic Association Conference.

Ross, S., & Yinger, J. (1999). *Sorting and voting: A review of the literature on urban public finance* (1 ed. Vol. 3). Amsterdam: Elsevier.

Rutherford, R. C., Springer, T. M., & Yavas, A. (2001). The impacts of contract type on broker performance. *Real Estate Economics, 29*(3), 389-409.

Sirmans, C. F., Turnbull, G. K., & Benjamin, J. D. (1991). The markets for housing and real estate broker services. *Journal of Housing Economics, 1*(3), 207-217.

Turnbull, G. K., & Dombrow, J. (2006). Spatial competition and shopping externalities: Evidence from the housing market. *Journal of Real Estate Finance and Economics, 32*(4), 391-408.

Turnbull G. K., Dombrow, J., & Sirmans, C.F., (2006). Big House, Little House: Relative Size and Value. *Real Estate Economics 34* (3), 439–456.

Wheaton, W. C. (1990). Vacancy, search, and prices in a housing market matching model. *Journal of Political Economy, 98*(6), 1270-1292.

Williams, J. T. (1995). Pricing real assets with costly search. *Review of Financial Studies, 8*(1), 55-90.

Yavas, A., & Yang, S. (1995). The strategic role of listing price in marketing real estate: Theory and evidence. *Real Estate Economics, 23*(3), 347-368.