

DO BETTER SCHOOLS MATTER? PARENTAL VALUATION OF
ELEMENTARY EDUCATION

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Do Better Schools Matter? Parental Valuation of Elementary Education

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Abstract: The evaluation of numerous school reforms requires an understanding of the value parents place on school quality. I use house prices to infer this value, where school quality is proxied by elementary school test scores. I do so by looking within school districts at houses located on attendance district boundaries; I am then comparing houses that differ along only one dimension: the elementary school the child attends. I thereby effectively remove the variation in neighborhood characteristics, property tax rates, and school spending. I find that parents are willing to pay 2.5% more for a 5% increase in test scores; this is approximately *half* the estimate one gets by running a typical hedonic housing price regression. This estimate is robust to a number of sensitivity checks.

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I. Introduction

The evaluation of a number of school policies requires an understanding of the value of better schools. Among these policies are busing programs, school choice, school voucher programs, and school finance laws. Of particular interest to policymakers is whether parents are informed enough as consumers of education to be sensitive to differences in performance of local schools and how they value these differences. This paper shows that parents are sensitive to apparently small differences in school performance and determines the dollar value parents associate with these differences.

There are a number of difficulties associated with determining how much people are willing to pay for better schools. We could survey parents on their willingness-to-pay for better schools, but we would have little faith in the precision of their answers. Instead, I look to the market and use house prices to infer the value parents place on public school quality.

However, we know that there are many differences between housing bundles that affect house prices, so the issue becomes how to isolate the particular effect of school quality. Ideally, we would look at similar quality houses on opposite sides of the same street, where the children on one side of the street attend one school and those on the other attend another school. There would be virtually no neighborhood variation, so differences in house prices would reflect only differences in school quality and school peers.¹ Using Massachusetts data on individual house

¹Separating out school effects from neighborhood effects is difficult and has not often been done successfully in the past. Even quasi-experimental programs (such as the Gautreaux housing relocation program described by Rosenbaum 1995) are unable to distinguish between the two: individuals who are randomly assigned to better neighborhoods do better, but it is unclear whether this is a result of living in better neighborhoods or attending better schools.

sales with exact geographic location information, I am able to observe something very close to this ideal, thereby minimizing the confounding effects of unmeasured neighborhood characteristics.

The approach I take is to look at attendance district boundaries, which are the geographic boundaries that determine which school a child attends *within* a school district. By looking within school districts, I eliminate all of the variation in property tax rates and much of the variation in financial inputs to schools. By looking at houses within a close proximity to each other but whose children attend different schools (on opposite sides of the attendance district boundary), I am able to control for neighborhood differences and get a credible estimate of the relative value of different schools, where better schools are those that have higher test scores. I find that, controlling for school financial inputs and neighborhoods, higher elementary school test scores are associated with higher house prices; a 5% increase in test scores (approximately one standard deviation) will lead to an increase in house prices of approximately 2.1%, or \$3,948 at the mean house price (\$188,000). From another perspective, a movement from the 25th percentile school (as ranked by test scores) to the 75th percentile school would result in a 2.9% increase in house prices, or \$5,452 at the mean house price. This estimate gives the value of the less observable components of school quality such as the school peers, more involved parents, and the quality of the teachers and administrators; because I am looking within school districts, I am holding constant financial inputs such as per pupil expenditures and teacher salaries.

Can these results be explained by other factors? I run a number of sensitivity checks and tests of omitted variable bias in order to check the robustness of the results. I run my regressions in both logs and levels using a variety of distances from the boundary and find the results to be

robust. However, one might argue that the boundaries of attendance districts represent clear neighborhood divisions, where houses on opposite sides of the boundary are in separate neighborhoods, so that the results are only picking up omitted neighborhood variation. I address this concern in a number of ways. First, I drop all boundaries that appear to be large streets or highways because they are more likely to represent a neighborhood boundary. Second, one might believe that there is a progression of neighborhoods from good to bad (with better schools associated with better neighborhoods) and argue that the results are merely picking up this progression. I test this with a pseudo-differences-in-differences technique using an artificially created control group. Third, I argue that the existence of smaller price effects for one- and two-bedroom houses relative to houses with three or more bedrooms is further evidence that the differences in housing prices I am measuring are truly due to differences in school quality. (Houses with three or more bedrooms are more likely to have children living in them.) Finally, one might worry that the results are picking up omitted house quality effects on opposite sides of the boundary (i.e. houses with the better schools are better cared for). By omitting observed house characteristics, such as number of bedrooms and bathrooms, I show that the results are virtually insensitive to observable housing characteristics, which suggests that unobserved characteristics are not driving the results. I conclude that the results are robust to the various sensitivity tests.

The main finding has a number of implications. These results provide information about how much parents value schools with higher test scores, which aids in the evaluation of school choice, school voucher programs, busing programs, and school finance laws. These estimates also provide the first step in a cost-benefit analysis of programs that seek to improve school

quality and school peers.

The structure of the paper is as follows. Section two presents the conceptual framework and basic methodology. Section three provides some institutional background on school districts in Massachusetts. Section four discusses my data. Section five presents my results and specification checks. Section six concludes.

II. Basic Methodology

When parents are choosing a house, they consider a number of factors. Among these are the house's structural characteristics (such as the year of construction, the number of bedrooms, the number of bathrooms, and the square footage), neighborhood characteristics (such as the types of individuals that will be living around them and the neighborhood amenities), and city characteristics (such as the distance from the central business district, the provision of public goods, property taxes, and school quality). This paper estimates the marginal valuation of better schools as measured by test scores, controlling for financial inputs to schools, property tax rates, and neighborhood characteristics.

When selecting a house, school quality is often cited as one of the most important considerations.² School quality can be divided into two components: the more observable component consisting primarily of school financial inputs, and the less observable component consisting of the quality of school peers, parents, teachers, and administrators. There is a large literature focusing on the first component (see Hanushek, 1996 and Card and Krueger, 1996).

²See *USA Today* (May 1996) and the *Boston Sunday Globe* (April 1996)

My work focuses primarily on the second component by looking within school districts and thereby effectively controlling for much of the school financial inputs.³

There has also been an extensive literature looking at the less observable components of school quality by focusing primarily on the effects of a child's peers on his own outcomes (see Mayer 1996 for a review), but much of this looks at outcomes much later in an individual's life. Because the focus is on an individual's outcomes, much of this work is plagued by omitted variable biases due to omitted family background characteristics. My work provides a more direct method of looking at the influence of school peer quality by looking not at individual outcome measures but at house prices; I am thereby measuring the parent's valuation *today* of better schools *today*. I do this by determining how much more parents are willing to pay for a house that is associated with a better school, *ceteris paribus*.

When looking at the valuation of better schools, the challenge is isolating the school effects from the neighborhood effects. This is difficult due to high correlations with neighborhood characteristics, both observed and unobserved. Typical hedonic housing price regressions (see Kain and Quigley, 1975, and Li and Brown, 1980) attempt to control for neighborhood characteristics, but one still worries that estimates of school quality coefficients are tainted by unobserved neighborhood characteristics that are also correlated with school

³Note that differences in property tax rates and per pupil expenditures are effectively eliminated by looking within school districts. The increased price that an individual is paying for a house associated with a better school is not going to affect the level of spending at that particular school. The fact that there may be some differences in spending at the school level is solely due to compositional differences of the student body (as special education students receive more money).

Even though differences in teacher salaries, for example, are removed, there still may be some indirect effects such as better students attracting better teachers, which would correctly be attributed to the better students.

quality. Work by Jud and Watts (1981) most closely resembles the work done in this paper. They look within one school district (Charlotte, N.C.) in 1977 and run hedonic housing price regressions within the district. By looking within the school district, their estimates are not affected by cross-district differences in property tax rates.⁴ However, since the authors are not limiting their comparison to houses within a close proximity of each other, their estimates may not be sufficiently controlling for unobserved neighborhood characteristics and hence may be biased.⁵

In order to credibly estimate the value of school quality, we must attempt to control for neighborhood characteristics, both observable and unobservable.⁶ If one looks at houses within school districts, one is effectively eliminating variation in property tax rates, school financial inputs, and the provision of other public goods that is generally determined at the city level, but not differences in neighborhoods. In order to remedy this problem, I focus on houses that are located on the boundary of attendance districts. Attendance districts are defined as the geographical boundaries that determine which school a child attends *within* a school district. By

⁴They use average grade-level performance on the state test of reading skills in the third grade as a control variable and find that an increase in test performance of 10% (approximately one standard deviation) leads to a 2.1 percentage increase in housing prices. In dollar terms, they state that an additional one-half year increase in the grade-level performance of students in the public school would be worth about \$675 to the average homeowner, or about \$48 million to the city of Charlotte as a whole.

⁵Other related work includes that by Bradbury, Case, and Mayer (1996), who look at the capitalization of school quality and taxes by estimating the relationship between changes in house prices and changes in school quality and taxes. My work eliminates the variation in tax rates by looking within school districts.

⁶Given the difficulty of representing neighborhoods using available neighborhood variables such as the median household income and the educational distribution of the neighborhood, the unobserved elements are of particular importance.

looking at houses very close to the boundary but on opposite sides and comparing house prices, I can determine the value of the better school as capitalized in house prices. (Children in the houses on opposite sides of the boundary attend different schools.) Because the houses are in close proximity to each other, variation in neighborhood characteristics will be small.

There are two advantages of my approach, which relies on the discontinuity of the attendance district boundary.⁷ One is that the omitted variable bias is substantially reduced because I am looking within neighborhoods and therefore unobserved neighborhood effects are unlikely to substantially affect my estimates. The other advantage is that I am getting a direct measure of value by estimating how much parents today are willing to spend for better schools.

III. Institutional Background

Attendance district boundaries provide a clean means of calculating the value of better schools as measured by test scores. One important feature of the attendance district is that its sole purpose is to determine school attendance. By looking across attendance district boundaries, the only variation comes from the elementary school a child attends. School finance in Massachusetts is determined almost entirely at the school district level (including basic aid, foundation aid (the Massachusetts form of equalization) and transportation), so looking within school districts removes variation in funding. Property tax rates are determined at the city level,

⁷Because geographic location and neighborhood affect housing prices in a smooth way, I am able to identify the effect of higher elementary school test scores on house prices by the difference between houses on opposite sides of the attendance district boundary (a discontinuity). For a more detailed discussion of the regression-discontinuity approach, see van der Klaauw (1997). Other work applying this approach includes Angrist and Krueger (1991) and Imbens and van der Klaauw (1995).

which in this sample is equivalent to the school district level, so once again looking within school districts removes this variation as well.⁸ Comparing houses on opposite sides of attendance district boundaries therefore provides an effective method for looking within neighborhoods at variations in school quality.

The fact that attendance district boundaries are relatively unchanging over time is another reason why they provide useful variation.⁹ School district administrators attest to this constancy. According to school district administrators, when attendance districts were first determined, the primary factors considered were the size of the school and the distribution of students by grade level. They also considered racial balance, natural boundaries (rivers or a highway), and in some cases family economics and neighborhoods.¹⁰ An administrator from the North Reading school district stated “this [family economics] is probably the least of the factors, but in some instances, it is a consideration. We try not to have one school with all the advantaged or disadvantaged children.”

When asked how often attendance district boundaries are changed, the overwhelming consensus among administrators was that they hardly ever change. One administrator replied,

⁸One school district, Groton Dunstable, consisted of more than one city; in this case, the property taxes, along with other public goods provided at the city level, would vary within the school district. As a result, the district was excluded from the sample.

⁹Note that the fact that attendance district boundaries are unchanging is not an assumption of the work. Were it the case that these boundaries changed often, we would not expect to see significant differences in house prices on opposite sides of the boundaries. The fact that some districts may have boundaries that change more often will lead me to underestimate the true value of better schools as measured by test scores.

¹⁰Boundaries that are considered natural boundaries (such as rivers and parks) are excluded from my sample. See the data section for a more detailed discussion.

“Boundaries are not changed very often, and when they are it is for some large reason such as the closing or opening of a school. Sometimes new [housing] developments may cause this to happen. Changing boundaries is a sensitive issue to everyone.” The process typically involves identifying where all the children are by grade level and street, and then identifying a variety of options for boundaries. The district then holds public hearings and tries to respond to the concerns of parents. Finally, the school district makes the decision. Administrators emphasize that this is a very sensitive issue to homeowners and requires many discussions with parents.¹¹

While the attendance district boundaries are unchanging in most school districts, the structure of some of the Massachusetts school districts has undergone significant changes over the past 10 years. Most notable is the availability of intra- and/or inter-district school choice in some school districts. Inter-district choice gives parents living outside of a choice district the opportunity to send their child to a school within that district, thereby enabling the child to attend a school outside of his own district. Intra-district choice gives parents the opportunity to choose which school *within* the school district they send their child to.

The availability of inter-district school choice began with the 1991-1992 school year in Massachusetts and now exists in 87 districts across the state. This allows parents more choice regarding which school their child will attend (because they now have not only their geographically determined school within the district, but also the option to send their child

¹¹Anecdotal evidence also corroborates the idea that the boundaries, once drawn, are not readily changed. According to an article from *USA Today* (May 1996), “Jay Broder, vice president of a manufacturing company in Louisville, helped defeat a school board plan in February that would have shifted his second-grade daughter out of the popular Centerfield Elementary School where 63% of fourth-graders tested proficient in reading versus 32% at nearby Crestwood Elementary. A change also would have jeopardized the \$60,000 appreciation he’s enjoyed over nine years of [home] ownership, he says.”

outside the district if the outside district has a school choice program.) As a result, my results may underestimate the true value of schools and school peers because parents may not be willing to pay as much for their within-district school if they also have the option of outside-district schools.

There are also a few school districts with intra-district school choice. In this case, a parent has a choice of all (or some subset) of the schools within the district, and school determination is not based solely on geography. (In fact, geographical location is one of many considerations when determining a child's school, but it is not the only, nor necessarily the primary, consideration.) Because of this, I have excluded districts with intra-district choice from my sample. There are, however, school districts that have a system of limited choice, where geography is the primary determinant of school attendance but parents may choose to put their child on a waiting list for another school. Admittance to the other school is based on space availability, and often these children will not be provided with transportation by the school district.¹² Because this is not a formal intra-district choice program, the school districts are not omitted from the sample. Their inclusion may lead to a downward bias of my estimate. Also, if one believes that the implementation of school choice within a district is positively correlated with parental concern and parental valuation of school quality and peer effects, by excluding districts with school choice I will once again be underestimating the value of school quality.

¹²Note that admittance is almost always at the discretion of district administrators, and children are most frequently allowed to move for a pedagogical reason or to improve the racial balance. These transfers are therefore not generally available but person-specific.

IV. Data

Housing price data on sales and purchases were obtained from Bankers and Tradesman, a data products group. The data cover all purchases and sales from 1993 through 1995 for Middlesex, Essex, and Norfolk counties in Massachusetts.¹³ (See Figure 1.) Massachusetts proves to be a good area to study because the school districts are small, which leads to a relative homogeneity of populations within school districts, as opposed to areas with much larger school districts. Because Massachusetts is characterized by a large number of small school districts (in general, a city is equivalent to a school district), and because I am looking across schools within school districts, I was limited in my ability to investigate middle and high school boundaries. (Most of the districts had only one high school and a majority had only one middle school.) I therefore focus exclusively on elementary schools. I obtained attendance district boundaries from the individual school districts themselves.

Once I determined the boundaries of the attendance districts, I was then able to map the houses into the attendance districts using ARCview software and the TIGER (Topologically Integrated Geographic Encoding and Referencing) System files from the Census Bureau. Houses were mapped based on longitude and latitude and geographic matching through addresses. Figure 2 presents an example of a city in my sample; the thick black lines represent the attendance district boundaries, while the thin black lines represent streets within the city. Houses were assigned to attendance district boundaries based on proximity; a house was assigned to the

¹³These three counties account for 43.4% of total school enrollments in Massachusetts in the 1995-96 school year, with the following breakdown: Middlesex 21.4%, Essex 11.9%, and Norfolk 10.1%. There are a total of 14 counties in Massachusetts. (Market Data Retrieval, 1996).

nearest boundary, regardless of distance. Each house is associated with only one boundary. Houses were also matched to census block groups, the smallest geographic unit for which STF3 census data is collected (each block group has an average of 1,400 people). Figure 3 shows the attendance districts (thick black lines) and the census block groups (thin black lines) for this city. Based on census block group identification, I was then able to match the houses to the 1990 census data. In addition to census data, houses were matched to school district-level data such as per pupil expenditures, pupil/teacher ratios, and property taxes.

This study was limited to single-family residences for reasons of comparability.¹⁴ In order for a school district to be included in the sample, it must have at least two elementary schools that overlap grades.¹⁵ There were also 4 school districts with intra-district choice programs, which allow parents to choose which school within the district their child attends.¹⁶ Because school assignment is not based on geographic location, housing prices will not pick up differences in school quality; therefore, as previously mentioned, these school districts were excluded from the sample. In addition, there were 24 school districts whose attendance district boundaries were either poorly defined or not available. The resulting sample covers 39 school districts.

Because of concerns about neighborhood differences on opposite sides of an attendance

¹⁴Some transactions have missing “type of residence” data, which leaves me unable to distinguish single-family residences. I have excluded these observations from the sample. In some cases, entire city-year cells are excluded.

¹⁵There are a number of school districts with two elementary schools but whose grade levels are disjoint sets, i.e. one school covers grades K-2 and the other grades 3-5.

¹⁶These districts are Cambridge, Somerville, Lowell, and Lawrence.

district boundary, I was careful to exclude boundaries from my sample if the two attendance districts were divided in ways that seemed to clearly divide neighborhoods; attendance districts divided by large rivers, parks, golf courses, or any large stretch of land were not included in the sample.

Summary Statistics

The full sample consists of 22,679 single-family residences within 39 school districts that have at least two elementary schools that overlap grades and no system of intra-district school choice. There are 181 attendance district boundaries in the sample. Tables 1 and 2 summarize the data.

In regressions where the house price in dollars is the dependent variable, prices are deflated to 1993 dollars using the median house price in Boston for the quarter¹⁷. While in principle this deflator is limited by the fact that increases in the median house price could reflect changes in the structures themselves and not appreciation, because the sample is only three years long this is not likely to be a problem. (See Case and Shiller, 1987). In addition, all house prices are adjusted to incorporate the future stream of property tax payments, assuming that property taxes remain constant and a discount rate of 6% for an infinite lifetime. Results are entirely insensitive to this adjustment. The mean house price in my sample is \$188,076 with a standard deviation of \$113,923. The median house price is \$157,931.

My proxy for school quality is the 4th grade Massachusetts Educational Assessment

¹⁷Source: National Association of Realtors *Home Sales*, various years.

Program (MEAP), a statewide assessment performed every two years on students in grades 4, 8, and 12. Its purpose is to both furnish information to improve curriculum and instruction in Massachusetts schools and to provide reliable results for comparison at the school, district, and state levels.¹⁸ While there is little evidence that relates elementary school test scores to outcomes later in life such as wages and employment, the popular literature suggests that parents do use test scores as a primary measure of school quality.¹⁹ Additionally, if parents are not considering test scores specifically when evaluating a school but are looking at characteristics that are correlated with test scores, test scores will still be an appropriate measure.²⁰

The MEAP test consists of five parts: reading, science, social studies, mathematics, and writing. I use test scores for 1988, 1990, and 1992. I focus primarily on the sum of the math and reading scores, averaged over the three years.²¹ Each section is scored out of 16.00, and the scoring is a relative scoring on the state level, with the best school receiving a 16.00. The means of the math, reading, science, and social studies scores averaged over the three years are 13.8, 13.8, 13.7 and 13.7, with standard deviations of .77, .68, .63, and .65 respectively. The mean value of the average of the sum of the reading and math over the three years, is 27.59. (See Table 2 for a more detailed breakdown of the distributions.) I also test the sensitivity of the

¹⁸Additionally, the total number of test questions is divided into several forms per grade, with each student completing one form. In any school, all forms of the test are taken several times each, thereby producing valid and reliable test scores for the school and district as a whole. The entire test lasts approximately 2 hours. Massachusetts Department of Education, 1994.

¹⁹See The Elementary School Handbook, p.21.

²⁰See Hoxby (1996) for more discussion of what parents consider when choosing a school.

²¹Other work uses either the math, the reading, or the sum of the two as indicators of school quality. See Bradbury, Case, and Mayer (1995) and Peterson (1996).

results to my choice of the sum of the reading and math scores averaged over the three years as the indicator of school quality. In some cases, school scores are unreported due to small school and class size (a school with fewer than 20 students in the 4th grade does not report its scores) or because the school opened recently (and hence has no previous test scores). In the case of new schools, excluding these boundaries because of omitted test scores is not problematic, as the recent opening of a new school undoubtedly resulted in a change in the attendance districts of the school district and some uncertainty as to the expected quality of that school that may be reflected in house prices. It is unclear how the exclusion of small schools will affect the results.

I use a number of census block group variables to attempt to control for neighborhood characteristics. (See Table 1.) Within the full sample, the mean age distribution is 12% children aged less than 10 years, 45% adults between 22 and 44 years old, 28% adults between 45 and 64, and 14% adults 65 years or older. There are an average of 1.5% of households that are female headed with children, while approximately 1.5% are Hispanic and fewer than 1% are non-Hispanic black. There are fewer than 1% of households, on average, below the poverty level and under 65. 15% of adults over the age of 25 have a bachelors degree, 10% have a graduate degree, and 8% have less than a high school diploma. All of these are measured at the census block group level and not at the individual house level.

I also add a number of school district characteristics measured for all schools in the district. The average pupil/teacher ratio is 15.02, which is approximately the state average. About half of the districts have a free- or reduced cost-preschool program. The average per-pupil expenditure in 1993 was \$4,440. Also measured at the school district level are property tax rates (in my sample, the city and school district are synonymous). The average property tax is \$13.60

per \$1000 of assessed house value. I use these measures to proxy for financial inputs into schools, most of which occurs at the school district level.

In addition, there are a few boundaries that also represent the boundaries which determine middle school attendance. In this case, I am estimating the value of both the elementary and the middle school. This is only the case in a limited number of districts. In general, there is only one middle school or the boundaries are different for the middle schools, so this is not a concern.

V. Empirical Specifications and Results

When estimating the marginal valuation of better schools as measured by test scores, there are a number of concerns one must address. Among these are the fact that neighborhoods and school quality are highly correlated and any omitted variables may upwardly bias estimates of school quality valuation. Another concern is that property tax rates vary, and it is difficult to disentangle property taxes from school spending and school quality. Previous work has used typical hedonic housing price regressions to determine the value of better schools.²² This work is tainted by omitted variable biases. As a comparison, I first use my data to run a typical hedonic housing price regression. These results are then used as a comparison for my boundary fixed effects approach which controls for differences in property tax rates and neighborhoods.

A. Aggregate Regression

I first run a hedonic housing price across all school districts in my sample in order to

²²See Kain and Quigley (1975) and Li and Brown (1980) for examples of hedonic housing prices regressions.

contrast with my own approach. Some key problems with this approach include the problem of omitted neighborhood characteristics that may be correlated with the measure of school quality and the fact that I am not necessarily comparing similar houses. One might imagine that neighborhoods with more conscientious neighbors also have better schools, and people are paying for the opportunity to live among more conscientious people. By not including “conscientious neighbors” in my regression, I will upwardly bias my estimate of the coefficient on school test scores. Additionally, the cross-school district regression does not necessarily provide the proper comparison. I want to be comparing two houses that are virtually identical except for the school the children attend. By looking across school districts, there are so many differences it is hard to believe that by putting in controls for neighborhoods and school inputs, I am correcting the problem of comparability.

In order to provide a point of comparison, I regress the log of the house price on various neighborhood, school quality, and house characteristics, along with year of sale by quarter dummies.

The equation I estimate is as follows:

$$\log(\text{price}_{iajk}) = \alpha + X'_{iajk} \beta + Z_j \delta + S_k \theta + \gamma \text{test}_a + \epsilon_{iajk}$$

where price_{iajk} represents the selling price of house i in neighborhood j in attendance district a in school district k . X_{iajk} is a vector of house level characteristics, including the number of bedrooms, bathrooms, lot size, internal square footage, and age of the building. Z_j is a vector of neighborhood characteristics, proxied by block level data from the 1990 census that includes the percentage of Hispanics, the percentage of non-Hispanic blacks, the percentage of female headed

households with related children, the percentage of people below poverty and under 65 years of age, the percentage of people 25 or over with a bachelors degree, a graduate degree, and who never finished high school, and the age distribution (divided into the following categories: 0-9 years, 10-21, 22-44, 45-64, and 65 and older).²³ I also include the distance of the house from Boston and the distance squared to proxy commuting time.²⁴ S_k represents school quality characteristics such as per pupil expenditures in 1993, the pupil/teacher ratio, and the existence of free or reduced cost preschool programs, all measured at the school district level, along with property tax rates (also at the district level), and $test_a$ represents the sum of the reading and math MEAP test scores for the elementary school averaged over 1988, 1990, and 1992.²⁵

The results (presented in Column 1 of Table 3 and Column 1 of Appendix Table 2) are consistent with previous work done on housing prices.²⁶ Bedrooms and bathrooms are positively correlated with higher house prices, as is lot size and the square footage of the house. The number of bathrooms comes in non-linearly. The age of the building and the distance from the center city are both negatively related to the house price, also in non-linear fashions.

School characteristics also enter the equation in the manner one would expect. Per pupil

²³I was unable to obtain crime data to include in the regression. While this is a notable omission, the focus of the paper is not this aggregate hedonic regression but the across-boundary comparisons, which, due to the small area being studied, removes variation in crime.

²⁴The coordinates used to represent Boston were obtained from the National Gazetteer of the U.S.A. 1990, and are the coordinates for official use on Federal Government maps and publications. Distance to the city is measured as linear distance and not the distance one actually must travel by car or other forms of transportation.

²⁵All regressions with $\log(\text{price})$ as the dependent variable also include year of sale by quarter dummies.

²⁶Standard errors are adjusted for clustering at the census block group level.

spending is positively correlated with house prices, and the coefficient suggests that a \$500 increase in per pupil expenditures would lead to a 2.7% increase in the house price (\$5,076 at the mean of \$188,000). A higher pupil/teacher ratio is associated with a lower house price, while higher test scores are associated with a higher house price. The magnitude of the test scores coefficient indicates that a 5% increase in the average test score is associated with a 4.5% increase in the house price, an increase that is equivalent to \$8,460 at the mean.

These results are not surprising. But the serious problem of unobserved or unmeasured neighborhood characteristics remains. While I am controlling for some neighborhood characteristics, one might worry that I am not completely characterizing the neighborhood by this limited number of variables. As a result, one could persuasively argue that the coefficient on test scores is biased because of correlations with unobserved or unmeasured neighborhood characteristics.

Additionally, by running a basic regression of this type we are not ensuring that the proper comparison is being made. We may be comparing houses across school districts that are very different, when in reality we want to compare similar houses within similar neighborhoods with similar tax regimes; we would then be focusing on differences in school quality while ensuring that the houses are comparable in other respects (neighborhood, house quality, etc.).

B. Boundary Fixed Effects

Because of the problems associated with the more typical aggregate hedonic regression, I focus my attention on within-school district, within-neighborhood estimation, where I am looking at houses that are located in close proximity to each other and that vary along only one

characteristic: the elementary school the child attends. I do so by mapping out the boundaries that determine which elementary school a child attends and then looking at houses along opposite sides of these boundaries. By including dummy variables for each boundary in the regression, I am essentially removing all the variation that is common to both sides of the boundary. This includes all city, school district, and neighborhood differences. I then argue that the houses on opposite sides of the boundary are different only in the elementary school the children attend. This represents my boundary fixed effects.

When I estimate the equations using boundary fixed effects, I systematically restrict my sample to smaller and smaller distances from the boundary. I do so under the assumption that the closer one is looking to the boundary, the less likely it is that there are differences other than the elementary school quality for houses on opposite sides of the boundary.

I estimate the following equation:

$$\log(\text{price}_{iab}) = \alpha + X'_{iab}\beta + K'_b\phi + \gamma \text{test}_a + \epsilon_{iab}$$

where price_{iab} is the selling price of house i in attendance district a near boundary b . X_{iab} is a vector of house characteristics that includes number of bedrooms, bathrooms, lot size, internal square footage, and age of the building, and K_b is a vector of boundary dummies. The test score (test_a) is the sum of the reading and math elementary school test scores averaged over 1988, 1990, and 1992 for the attendance district.

I initially estimate this equation for the sample of houses that are located within .35 miles from the nearest boundary, arguing that the houses on opposite sides of the boundary but within 1/3 mile are more similar than the full sample in all respects except the elementary school the

child attends. These results are presented in Table 3 Column 2. One can see that the coefficient on elementary school test scores is approximately *half* of the coefficient initially estimated using the more typical hedonic housing price regression.²⁷ As a check of the assumption that there are no significant neighborhood differences being picked up in my test scores coefficient, I restrict my sample even further. Columns 3 and 4 show the estimates as the sample is restricted to only houses very close to the boundary, with the distances at .20 of a mile and .15 of a mile from the boundary.²⁸ In both cases, the coefficients on house characteristics and test scores do not change significantly.

Table 4 shows how the houses on opposite sides of the boundary become more similar as the sample is reduced to houses that are closer and closer to the boundary. The ratios represent the difference in means of houses on opposite sides of the boundary for the restricted sample over the difference in means for the whole sample. As expected, the number is generally decreasing, indicating that, by looking closer to the boundary, we are comparing houses that are more similar in both physical attributes and neighborhood characteristics.

Table 5 presents a comparison of the results and the magnitude of the effect in the various specifications. The variable of interest is the elementary school test scores. We can see that the coefficient on the elementary school test scores is significantly positive in all cases. When looking at the regression where the houses are only .15 miles from the boundary (Column 4), the

²⁷One might worry that the decline in the coefficient on test scores is due to the decreased sample size alone. Appendix Table 1 Columns 1 and 2 show that when the more typical aggregate hedonic housing price regression is run on the subsample of houses that are located within .15 miles from the boundary, the coefficient on the elementary school test score is unchanging.

²⁸Houses located exactly on the boundary were dropped due to the imprecision of the mapping software. Results are not sensitive to this exclusion.

better schools are associated with the better neighborhoods). I test this hypothesis by creating an artificial control group that is entirely within each elementary school attendance district but that spans the same distance. If it is not differences in schools that the results are picking up, but instead the progression of neighborhoods, one would expect the same results for houses that do not cross the boundaries of attendance districts. As a control group, I take houses that are between .4 and .8 miles from the boundary within the same attendance district. I assume that better schools are associated with better neighborhoods, so for the houses in the attendance district of the “better” school³¹, the houses further from the boundary (between .6 and .8 miles from the boundary) are deemed the “better” control group. For the houses in the attendance district of the “worse” school (with the lower test scores), the houses closer to the boundary are deemed the “better” group (because I assume that this “bad” relative neighborhood is only getting worse, just as the “good” relative neighborhood is only getting better), so any house between .4 and .6 miles from the boundary was the “better” control group. I then ran two regressions. The first was the true treatment estimation. Using houses within .20 mile of the boundary, I regress the log house price on boundary dummies, house characteristics, and a “hi” dummy indicating if the house is on the “better” side of the boundary (as determined by the average test scores). The second regression uses the artificial “control” group (the sample that was contained entirely within the attendance district and did not cross any boundaries) and regresses the log house price on the same controls, the only difference being that the “control” regression had the artificial dummy for being on the “better” side. The results of these

³¹ as determined by the average of the reading and math MEAP scores for 1988, 1990, and 1992.

1. Neighborhood Boundaries

A primary concern might be that the boundaries actually do represent the dividing lines of neighborhoods, so that even looking at houses right near the boundary but on opposite sides still represents two distinct neighborhoods.³⁰ This seems most likely if the boundary is represented by a highway, a busy street, a river, or railroad tracks. When initially creating the data set, I was careful to exclude boundaries that appeared to be obvious neighborhood dividers such as major rivers, golf courses, and parks. As a sensitivity check, I later went back and noted all the boundaries that were railroad tracks, highways, or even major streets. In order to be sure that my results represented the difference in the schools alone, I was careful to err on the side of caution and threw out every boundary if there was even a suspicion that it may be dividing a neighborhood. The results of this regression is presented in Column 1 of Table 6. It is clear that there is only a slight decrease in the coefficient from .016 to .013 with the new estimate being statistically that same. This supports the theory that the results represent true differences in the value of schools and not neighborhood divisions.

2. Neighborhood Progression

By restricting my sample to a narrow band around the boundary, I argue that the neighborhoods on either side are the same. One could be concerned that the band is too wide and worry that I am picking up progressions in neighborhoods from worse to better (assuming the

³⁰I did, however, visit a subsample of neighborhoods to see the boundaries for myself. I looked for distinctions in neighborhoods or in general upkeep of the houses and yards and found no differences across boundaries. Personal observation has led me to believe that the boundaries do not, in fact, represent neighborhood divisions. I do, however, try to test this with my data.

coefficient suggests that a 5% increase in test scores (approximately one standard deviation) is associated with a 2.1% increase in housing prices, or an increase of approximately \$3,948 at the mean (the mean house price is \$188,000). This is roughly *half* the estimated effect if one runs a simple hedonic housing price regression, which is presented in Column 1. This suggests that, if one does not carefully control for neighborhood characteristics, one will greatly overestimate the value of the additional school quality as measured by test scores. Another view of the results from the boundary fixed effects regression is presented in Table 5a. This shows the percentage change in house prices and the dollar value (evaluated at the mean house price) as one moves along the distribution of elementary school test scores.

Because there is no substantive difference in the results between the .35 mile restricted sample, the .20 mile restricted sample, and the .15 mile restricted sample, I use the .35 mile sample in future regressions in order to increase precision (without imposing any more significant identifying restrictions). Appendix Table 1 presents the results when the regressions are run with the house price in levels as the dependent variable; the results are substantively the same. I also test the sensitivity of my results to the choice of test score and find them to be completely insensitive.²⁹

C. Sensitivity Tests

In order to test the sensitivity of the results, I try a number of specification tests.

²⁹When I used the average of the sum of the science and social studies test scores for the three years instead of reading and math, the results did not change. The coefficient on the test score (at .15 miles from the boundary) is .016 with a standard error of .007, compared to .015 with a standard error of .007 for the sum of the reading and math.

regressions are presented in Table 6, Columns 2 and 3. As expected, I find that the “hi” dummy in the true regression, Column 2 (where houses were on opposite sides of the boundary) has a significant positive coefficient (.024 with a standard error of .009), while the control “hi” was zero and insignificant, see Column 3 (-.001 with a standard error of .009).

As another check, I include neighborhood characteristics such as the racial and age distribution at the census block group level in the regression. As one can see in Column 4 of Table 6, the coefficient on test scores does not change significantly. This provides strong evidence that my results are not just picking up a natural progression in neighborhoods.³²

3. House Quality

Finally, one might be concerned that I am picking up unobservable differences in house quality. If one argues that people more concerned about schools also take better care of their houses, then my results might in fact be picking up in part the value of the “better cared for” houses. (One could, however, make the equally likely argument that people who care a lot about schools given a particular budget constraint are willing to settle with “less cared for” homes in order to get the better schools, which would work in the opposite direction.) I test this in a number of ways. I first look at how observable characteristics differ across boundary lines. A subsample of these results are presented in Table 6, Columns 5 and 6, where I regress house

³²It is interesting to note, however, that the coefficient on the test score variable does become less precisely estimated, which may suggest that what the test score variable is picking up is in part the value of having better students and parents at the school. However, it is not clear that one would want to include neighborhood controls. For example, if the benefit of having better educated neighbors comes through having better children at the school, then including the education level of one’s neighborhoods would pick up some of the valuation that should be attributed to having a better school.

different tests of specification and omitted variable biases.

What does this number tell us? If a family is deciding between two houses within a school district, one which is associated with an elementary school with a test score that is 5% or one standard deviation higher than the other (1.4 points), that family can expect to pay about \$3,948 (at the mean house price) more to send its children to the better elementary school. This can also be thought of as a flow of money over a period of time; if we spread this out forever (and we assume an interest rate of 6%), that is equal to \$237 each year.

It is important to consider what it is that we are actually measuring when we say “school quality.” Is it the better peers, the better teachers or administrators, or is it the more involved parents at the school? My results do not distinguish between these explanations. In addition, this sample does not necessarily reflect the preferences of the people we are considering when we make educational policies. These data represent a variety of suburban areas outside of Boston, and the preferences of these people may not be the same as those of individuals living in the inner cities who might be most affected by busing or school choice policies.³³

These results do, however, have a number of important implications. Most importantly, better schools do matter to parents; they are willing to pay more for their children to go to schools where children have higher test scores. From a policy perspective, if we consider a program like Metco³⁴ in Massachusetts that involves sending a few inner-city children to schools

³³When considering educational policies for improving the inner city, differing costs to obtain similar outcomes must also be considered. See Duncombe and Yinger (1997). Additionally, my estimates are generated based on small differences in test scores, so any projections about the value of large differences should be done with caution.

³⁴The purpose of the Metco Program is to promote desegregation and to provide urban students with opportunities to achieve academically by enrolling minority children from Boston in participating

These results are presented in Table 6 Column 7. We can see that the coefficient on test scores interacted with the three or more bedroom dummy is still statistically significant and is a bit higher, (.017) while the coefficient on the interaction of one- and two-bedroom houses and test scores is much smaller (.006) and statistically insignificant. This reinforces the idea that the effect I am picking up really is due to the differences in elementary schools and not just unobserved differences in the quality of the houses.

VI. Conclusion

Anecdotal evidence suggests that parents care about school quality. *USA Today* (May 1996) recently published an article discussing the willingness of parents to pay more to live in areas with better schools, *ceteris paribus*; the article notes that "...Real estate agents, appraisers, home builders and tax authorities overwhelmingly agree that proximity to high-quality schools is now the No. 1 factor in determining what a home is worth in any given market." But anecdotal evidence does not distinguish whether people are paying for higher school spending, better paid teachers, better neighborhoods that are associated with better schools, or better school peers and other unmeasured elements of school quality. Different policies affect different margins, and as a result it is important to determine the value of the components individually. I have developed an approach that, by looking within school districts and neighborhoods, allows me to isolate the value of better school peers and other unmeasured elements of school quality such as teachers and parents. I find that parents do care about school peers and other unmeasured components of school quality and are willing to pay about 2.1% more for houses associated with 5% higher test scores at the mean; this is \$3,948 at the mean house price. These results are very robust to

square footage and lot size on the elementary school test score and the boundary dummies. The results show no significant difference between houses on opposite sides of the boundary with respect to these observable characteristics. I also regress the $\log(\text{price})$ on the test score without including any controls for house characteristics. (Boundary and quarter year dummies were still included.) The coefficient on the test score variable is relatively unchanging, which suggests that observable characteristics are not varying much on opposite sides of the boundaries. If observable characteristics (such as the number of bedrooms, bathrooms, lot size, and internal square footage) do not vary significantly on opposite sides of the boundary, this may suggest that unobservables are also relatively unchanging.

4. One- and Two-Bedroom Houses

Another check involves comparing the results for one- and two-bedroom houses to the results for 3 or more bedroom houses. If there were perfect product differentiation, with all families living in houses with three or more bedrooms and all individuals without children living in one- and two-bedroom houses, and if the stock of houses were fixed, we would expect there to be no price effect for one- and two-bedroom homes. We do not believe that there is perfect segregation, but we do suspect that people who live in houses with more bedrooms are more likely to have children. We would therefore expect to see people in houses with three or more bedrooms to be willing to pay more for better schools than people in one- and two-bedroom houses. I estimate equation (2) but instead of the using the test score, I include the interaction of the test score and a dummy indicating if it is either a one- or two-bedroom house and the interaction of the test score and a dummy indicating if it is a three or more bedroom house.

in suburban Boston areas, this could provide an estimate of the benefit to the parents of the child. Since the program moves only a few children to each suburban school, the partial equilibrium estimate of marginal valuation may be appropriate.³⁵ If the difference in test scores between the two schools is 9.4 points, then this change in school attendance would increase the value of the house in Boston by 14%, or \$1,579 per year at the mean house price in my sample (calculated as a perpetual flow with an interest rate of 6% per year; the present discounted value is \$26,320). We could then determine the difference in per-pupil expenditures between the two districts (to calculate the cost of moving the student) and determine the net benefit of the program.³⁶

Parents are willing to pay more for better schools as measured by test scores, and these preferences are capitalized in house prices. We now have a precise estimate of this valuation. As a result, we are one step closer to estimating the benefits of a variety of educational policies.

suburban school districts. Source: Massachusetts Department of Education.

³⁵This example assumes that the treatment is non-linear in that the urban student will benefit from suburban school but that the addition of one urban student does not have a negative effect on the other students in the suburban school.

³⁶This difference is derived from the arbitrary selection of an inner-city Boston school, Blackstone Community, with an average test score of 21.2, and a suburban Belmont school, Burbank Elementary, with an average test score of 30.67. Note again that this exercise involves strong out-of-sample assumptions.

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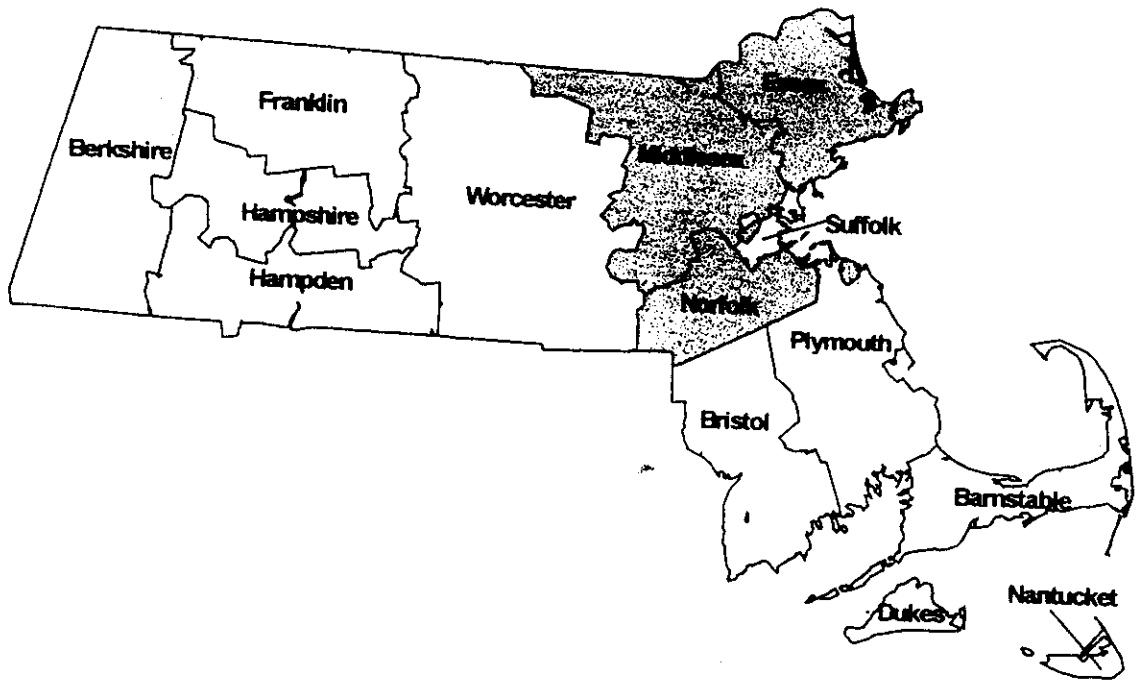
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Figure 1: The Counties of Massachusetts



Example of Data Collection for One City: Melrose

Figure 2 : Streets, Water, and Attendance District Boundaries

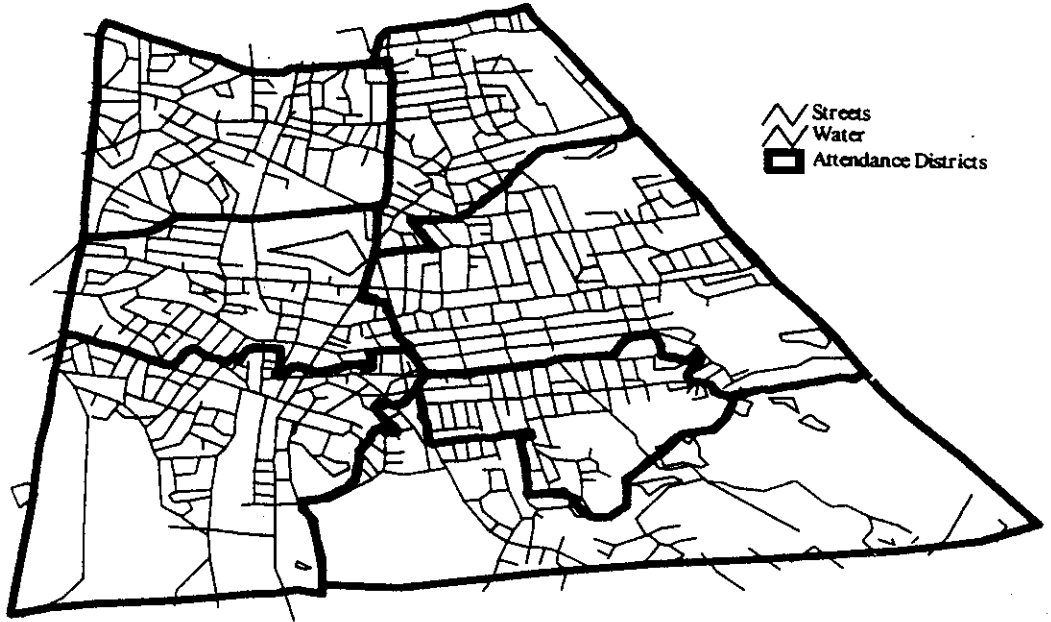


Figure 3 : Census Block Groups and Attendance District Boundaries

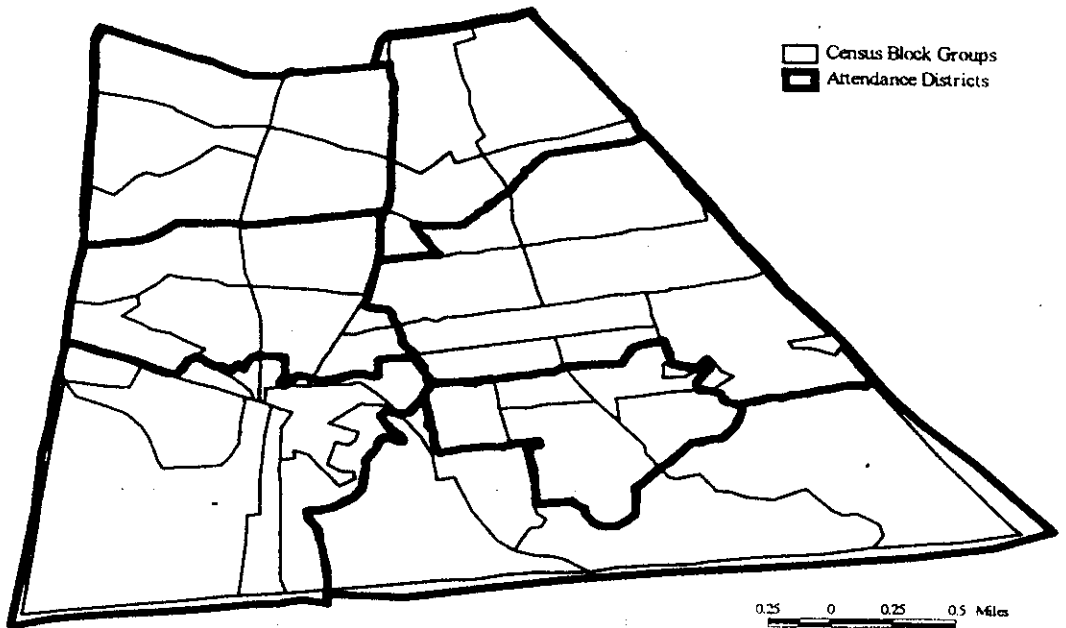


Table 1
Summary Statistics

Distance from Boundary: Variable	Full Sample		.35 Mile		.20 Mile		.15 Mile	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
house price (\$1993), tax adjusted ¹	188,076	113,923	185,799	108,081	184,955	108,111	186,387	114,001
log(house price)	12.1	0.5	12.1	0.5	12.1	0.5	12.1	0.5
bedrooms	3.2	0.9	3.2	0.9	3.2	0.9	3.2	0.9
bathrooms	1.5	0.7	1.5	0.7	1.5	0.7	1.5	0.7
age of building	53	36	57	35	59	35	59	35
lot size (1,000s)	17.3	15.0	14.3	12.5	14.0	12.4	14.1	12.6
internal square footage (1,000s)	1.8	0.8	1.8	0.8	1.8	0.8	1.8	0.8
School Characteristics²								
test scores (grade 4) ³	27.6	1.4	27.5	1.4	27.5	1.4	27.5	1.5
per pupil spending 1993 (\$1000)	4.4	7.2						
pupil/teacher ratio	15.0	1.7						
preschool program ⁴	0.5	0.5						
property taxes ⁵	13.6	1.7						
Neighborhood Characteristics⁶								
distance to Boston ⁷	17.4	7.8						
% Hispanic	0.015	0.023						
% non-Hispanic black	0.009	0.012						
% 0-9 years old	0.123	0.028						
% 22-44 years old	0.451	0.087						
% 45-64 years old	0.275	0.057						
% 65+ years old	0.135	0.061						
% female headed households with children	0.015	0.008						
median household income (\$1000s)	54.4	16.2						
% below poverty level and under 65	0.004	0.007						
% with bachelors degree	0.149	0.057						
% with graduate degree	0.104	0.071						
% with less than high school diploma	0.081	0.056						
N=	22,679		10,657		6,824		4,594	

¹ Deflated to \$1993 using quarterly median house sales price in Boston. Source: National Association of Realtors.

² Gathered at the school district level with the exception of test scores, which are measured at the elementary school level. Source: Massachusetts Department of Education.

³ Represents the sum of the reading and test MEAP scores taken in the fourth grade, averaged over 1988, 1990, and 1992 as measured at the elementary school level. Source: Massachusetts Department of Education.

⁴ Indicates the existence of a free or reduced-cost preschool program in the school district.

⁵ Measured in term of percentage per \$1000.

⁶ Gathered at the census block group level from the 1990 census with the exception of distance to Boston.

⁷ Distance to Boston is measured in straight miles and does not take into account driving distance.

Table 2
Distributions of Variables of Interest¹
Full Sample

	mean	standard deviation	minimum	maximum	10th percentile	median	90th percentile
house price ² (\$1993), tax adjusted	188,076	113,923	26,337	4,684,239	101,156	157,931	306,635
reading	13.8	0.68	11.77	15.3	12.8	13.9	14.6
math	13.8	0.77	11.87	15.8	12.8	13.8	14.77
social studies	13.7	0.65	11.8	15.8	12.9	13.8	14.5
science	13.7	0.63	11.7	15.4	12.8	13.8	14.4
reading +math ³	27.59	1.41	23.8	30.67	25.73	27.63	29.37

¹All test scores represent the average over 1988, 1990, and 1992 from the fourth grade MEAP test and are measured at the elementary school level. Source: Massachusetts Department of Education.

²Deflated to \$1993 using quarterly median house sale price in Boston. Source: National Association of Realtors.

³This is the variable used in the regression results reported in the following tables.

Table 3
Regression Results¹
 (Adjusted Standard Errors in Parenthesis²)
 Dependent Variable=log(house price, tax adjusted)

	(1)	(2)	(3)	(4)
Distance from Boundary: Variable	All Houses ⁴	.35 Mile from Boundary (616 yards)	.20 Mile from Boundary (350 yards)	.15 Mile from Boundary (260 yards)
elementary school test score ³ (avg of reading & math)	.032 (.004)	.016 (.007)	.013 (.0065)	.015 (.007)
bedrooms	.032 (.004)	.038 (.005)	.037 (.006)	.033 (.007)
bathrooms	.148 (.013)	.143 (.018)	.135 (.024)	.167 (.027)
bathrooms squared	-.014 (.003)	-.017 (.004)	-.015 (.005)	-.024 (.006)
lot size (1000s)	.003 (.0003)	.005 (.0005)	.005 (.0005)	.005 (.0007)
internal square footage (1000s)	.202 (.01)	.193 (.01)	.191 (.01)	.195 (.02)
age of building	-.002 (.0003)	-.002 (.0002)	-.003 (.0005)	-.003 (.0006)
age squared	.000003 (.0000001)	.000003 (.0000006)	.00001 (.000002)	.000009 (.000003)
Boundary Fixed Effects	NO	YES	YES	YES
Census Variables	Yes	No	No	No
N=	22,679	10,657	6,824	4,594
Number of Boundaries	N/A	175	174	172
Adjusted R-Squared	0.6462	0.6745	0.6719	0.6784

¹Each regression includes quarter year dummies. Dummies are also included to indicate missing bedroom data, bathroom data, lotsize data, and age of establishment data.

²Standard errors are adjusted for clustering at the attendance district level.

³Test scores represent the sum of the reading and math scores from the 4th grade MEAP test averaged over three years (1988, 1990, and 1992).

⁴This regression also includes neighborhood characteristics such as the percentage of Hispanics, the percentage of non-Hispanic blacks, the age distribution of the neighborhood, the percentage of female headed households with children, the percentage below poverty and under 65 years old, the educational distribution of the neighborhood, and the median household incomes, all of which are measured at the census block group level from the 1990 Census, along with school district characteristics such as per pupil spending in 1993, the pupil/teacher ratio, the existence of a low-cost or free preschool program, and the property tax rate, all of which are measured at the school district level. See Appendix Table 2 for these estimates.

Table 4
Differences in Means¹

Distance from Boundary: Variable	full sample		.35 mile		.20 mile		.15 mile	
	difference in means	t-statistic ⁴	ratio of .35 to full sample ³	t-statistic ⁴	ratio of .20 to full sample ³	t-statistic ⁴	ratio of .15 to full sample ³	t-statistic ⁴
House Characteristics								
bedrooms	0.02	1.68	0.90	0.91	-0.35	-0.30	0.25	0.18
bathrooms	0.03	2.98	0.23	0.52	-0.02	-0.05	-0.07	-0.12
lotsize	2011	11.39	0.22	2.14	0.24	1.95	0.12	0.83
internal square footage	31	2.93	0.61	1.32	0.61	1.07	0.84	1.17
age of building	-3.13	-6.92	0.75	-3.71	0.94	-3.76	1.09	-3.52
Neighborhood Characteristics²								
% Hispanic	-0.008	-0.79	2.50	-1.35	2.50	-1.21	2.50	-1.26
% non-Hispanic black	-0.007	-1.50	0.43	-0.54	0.00	-0.07	-0.14	0.16
% 0-9 years old	.005	3.30	0.16	0.63	-0.08	-0.31	-0.30	-1.21
% 22-44 years old	-0.01	-1.42	0.80	-1.07	0.40	-0.43	0.16	-0.16
% 45-64 years old	.002	0.68	0.75	0.56	1.25	0.98	1.50	1.18
% 65+ years old	-.01	-2.04	0.40	-0.72	0.67	-1.28	0.60	-0.95
% female headed households with children	-.001	-3.67	1.00	-3.17	1.20	-2.53	1.00	-2.38
% below poverty level and under 65	-.001	-3.05	0.50	-1.23	0.50	-1.18	0.20	-0.61
% with bachelors degree	.002	1.06	0.75	0.64	1.00	0.74	0.75	0.67
% with graduate degree	.008	3.32	0.88	2.77	0.88	3.02	0.88	3.31
% with less than high school diploma	-.005	-2.19	1.20	-2.02	0.80	-1.57	0.34	-0.64
median household income	2,135	2.87	0.60	1.90	0.65	2.11	0.52	1.61

¹T-statistics represent the t-statistic for the null that the difference in means between the better and worse sides of the boundary (as measured by the sum of the reading and math 4th grade MEAP test scores averaged over 1988, 1990, and 1992) are equal.

²Neighborhood characteristics are measured at the census block group level and are from the 1990 Census.

³The ratios represent the difference in means of houses on opposite sides of the boundary for the restricted sample over the difference in means of houses on opposite sides of the boundary for the whole sample.

⁴All t-statistics are adjusted for clustering at the attendance district level.

Table 5
Magnitude of Results

	(1)	(2)	(3)	(4)
	Basic Hedonic Regression	.35 Sample Boundary Fixed Effects	.20 Sample Boundary Fixed Effects	.15 Sample Boundary Fixed Effects
coefficient on test scores(average of reading and math)	.032 (.004)	.016 (.007)	.013 (.0065)	.015 (.007)
magnitude of effect (% change in house price as a result of a 5% change in test scores)	4.5%	2.3%	1.8%	2.1%
\$ Value (at mean tax adjusted house price of \$188,000 in \$1993)	\$8,460	\$4,324	\$3,384	\$3,948
\$ Value (at median tax adjusted house price of \$158,000 in \$1993)	\$7,110	\$3,634	\$2,844	\$3,318

¹Approximately a one standard deviation change in the average test scores at the mean.

²Regression includes house characteristics, school characteristics measured at the school district level, and neighborhood characteristics measured at the census block group level. See Table 3 Column 1 and Appendix Table 2 for more complete results.

Table 5a
Another View of the Results:
Moving Along the Distribution of Test Scores

Movement along the distribution of test scores ¹	% change in house price ²	\$ value evaluated at the mean tax adjusted house price ³	cumulative effect
5th to 25th percentile	2.7%	\$5,076	
25th percentile to median	1.4%	\$2,632	\$7,708
median to 75th percentile	1.5%	\$2,820	\$10,528
75th to 95th percentile	1.7%	\$3,196	\$13,724

¹Sum of the reading and math scores for the 4th grade MEAP test, averaged over 1988, 1990, and 1992.

²The estimate from the .15 sample is used.

³The mean house price is \$188,000 in \$1993.

Table 6
Specification Tests
 (Heteroskedasticity Adjusted Standard Errors in Parenthesis)¹
 All regressions include boundary fixed effects²

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	No Roads ⁷	Pseudo-diffs-in-diffs		Census Variables ⁸	Tests		Bedrooms ¹¹
Dependent Variable	log(price)	log(price)	log(price) ¹⁰	log(price)	internal square footage	lotsize	log(price)
elementary school test score ³	.013 (.005)			.012 (.0066)	.045 (.104)	2.1 (1.6)	
high side of boundary dummy ⁴		.024 (.009)					
Artificial control "hi" dummy ⁵			-.001 (.009)				
test score*(3 or more bedroom dummy)							.017 (.007)
test score*(1- or 2-bedroom dummy)							.006 (.008)
House Characteristics ⁶	Yes	Yes	Yes	Yes			Yes
Quarter Year Dummies	Yes	Yes	Yes	Yes			Yes
N	8,190	6,824	6,023	10,651	9,355	10,398	10,657
Adjusted R Squared	.6689	.6722	.6900	.6779	.3307	.4454	.6750

¹ Standard errors are adjusted for clustering at the attendance district level.

² All regressions include data within 1/3 a mile of the boundary except for columns 2 and 3, which include data within 1/5 a mile of the boundary. Results from 1/5 mile were similar but less precisely estimated.

³ Test scores represent the sum of the reading and math scores averaged over three years (1988, 1990, and 1992) from the 4th grade MEAP test.

⁴ This dummy is set to one if the house is on the side of the boundary associated with higher average test scores.

⁵ This variable is created for the pseudo-control group (houses within .4 and .8 miles from a boundary). If the control group is on the side of the boundary associated with better test scores, then this variable is set to one for the houses between .6 and .8 miles away. If the control group is on the side of the boundary associated with lower test scores, then this variable is set to one for the houses between .4 and .6 miles away.

⁶ This includes bedrooms, bathrooms, bathrooms squared, lotsize, internal square footage, age of building, age squared, dummies for missing variables, and quarter year dummies.

⁷ This regression has 132 boundaries

⁸ This regression also includes the percentage of Hispanics, the percentage of non-Hispanic blacks, the age distribution of the area, and the percentage of female headed households with children, all measured at the census block group level and taken from the 1990 Census data. The regression also includes the distance to Boston and the distance to Boston squared.

⁹ This regression uses the sample of houses that are within 1/5 a mile of the boundary.

¹⁰ This regression uses the pseudo-control group of houses between .4 and .8 miles from the boundary.

¹¹ This regression also includes a dummy equal to one if the house is a one- or two-bedroom house.

Appendix Table 1¹
(Heteroskedasticity Adjusted Standard Errors in Parenthesis²)

dependent variable:	log(price)		house price (\$1993) ³			
	(1) All Houses	(2) .15 Mile from Boundary	(3) All Houses ⁶	(4) .35 Mile from Boundary (616 yards)	(5) .20 Mile from Boundary (350 yards)	(6) .15 Mile from Boundary (260 yards)
elementary school test score ⁴ (reading+math)	.032 (.004)	.031 (.006)	5,066 (955)	2,881 (1,192)	2,292 (1,191)	1,960 (1,412)
bedrooms	.032 (.004)	.035 (.007)	4,574 (1,190)	5,230 (1,308)	4,301 (1,650)	3,376 (2,058)
bathrooms	.148 (.013)	.196 (.027)	-15,708 (9,091)	-20,439 (6,204)	-41,868 (19,436)	-39,956 (24,281)
bathrooms squared	-.014 (.003)	-.026 (.006)	9,949 (2,441)	10,819 (1,820)	16,502 (5,326)	16,178 (6,743)
lot size (1000s)	.003 (.0003)	.005 (.0002)	623 (106)	1,229 (170)	1,256 (228)	1,176 (206)
internal square footage (1000s)	.202 (.01)	.189 (.01)	60,174 (3,170)	53,967 (4,402)	55,691 (5,560)	58,041 (6,690)
age of building	-.002 (.0003)	-.002 (.0004)	-240 (46)	-296 (49)	-388 (139)	-319 (155)
age squared	.000003 (.0000001)	.000006 (.000002)	.32 (.11)	.36 (.08)	.78 (.66)	.46 (.73)
Boundary Fixed Effects	NO	NO	NO	YES	YES	YES
Census Variables ⁵	Yes	Yes	Yes	No	No	No
N=	22,679	4,589	22,679	10,657	6,824	4,594
Number of Boundaries	N/A	N/A	N/A	175	174	172
Adjusted R-Squared	0.6462	.6586	0.6358	0.7322	0.7361	0.7523

¹Each regression includes dummies to indicate missing bedroom data, bathroom data, lotsize data, and age of establishment data. Regressions with log(price) as dependent variable also include quarter-year dummies.

²Standard errors are adjusted for clustering at the attendance district level.

³House prices are deflated using the median house price in Boston for the quarter/year.

⁴Test scores represent the sum of the reading and math scores from the 4th grade MEAP test averaged over three years (1988, 1990, and 1992).

⁵This regression also includes neighborhood characteristics such as the percentage of Hispanics, the percentage of non-Hispanic blacks, the age distribution of the neighborhood, the percentage of female headed households with children, the percentage below poverty and under 65 years old, the educational distribution of the neighborhood, and the median household incomes, all of which are measured at the census block group level from the 1990 Census, along with school district characteristics such as per pupil spending in 1993, the pupil/teacher ratio, the existence of a low-cost or free preschool program, and the property tax rate, all of which are measured at the school district level. See Appendix Table 2 for these estimates.

⁶The coefficients of the other included variables in this regression are presented in Appendix Table 2, Column 2.

Appendix Table 2
Other Coefficients from Basic Hedonic Regression¹
(Heteroskedasticity Adjusted Standard Errors in Parenthesis)²

dependent variable	log(house price)	house price (\$1993)
School Characteristics		
per pupil spending 1993 (1000s)	.054 (.001)	15,252 (2,846)
pupil/teacher ratio	-.006 (.0035)	862 (862)
preschool program	-.007 (.009)	-1,524 (2,253)
property taxes	-.007 (.0027)	-2,407 (858)
Neighborhood Characteristics		
distance to Boston	-.018 (.002)	-3,641 (619)
distance to Boston squared	.0002 (.00005)	48 (14)
% Hispanic	-.21 (.19)	15,353 (34,229)
% black	-.56 (.51)	-18,984 (115,927)
% 0-9 years old	-.15 (.22)	-38,677 (69,094)
% 22-44 years old	-.52 (.09)	-106,579 (23,647)
% 45-64 years old	-.67 (.11)	-180,730 (38,819)
% 65+ years old	.04 (.13)	27,578 (35,574)
% female headed households with children	-.77 (.69)	349,387 (150,958)
median household income (1000s)	.0002 (.00005)	1,021 (200)
% below poverty level and under 65	.74 (.68)	334,334 (163,723)
% with bachelors degree	.81 (.11)	92,518 (28,073)
% with graduate degree	1.31 (.11)	281,273 (28,580)
% with less than high school diploma	-.40 (.17)	2,171 (25,421)
N=	22,679	22,679
Adjusted R-Squared	0.6462	0.6381

¹This table presents the estimated coefficients that were not presented in Table 3 Column 1 and Appendix Table 1 Column 1. Each regression includes quarter year dummies. Neighborhood variables are at the census block group level.

²Standard errors are adjusted for clustering at the census block group level.

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