The Effect of School Quality on House Prices:
A Meta-Regression Analysis

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Abstract

The evidence on whether school quality affects house prices is uncertain. This paper employs meta-regression analysis on 48 studies to understand what factors influence the discrepancy among analogous studies. We estimate Fischer's Z transformation, ordered probit, and linear regression models to incorporate eight different school quality variables. Our results suggest the Fischer's Z model is less preferred to the ordered probit model given the entire sample of school quality measures, and to the linear regression model given a reduced sample of studies with only the primary school test score measure.

1. Introduction

People choose to migrate from one location to another based on many factors, one of which is school quality. The framework most often associated with such behavior is the Tiebout (1956) model, which states that voters reveal their preferences for public goods by locating in jurisdictions that offer them an optimal mix of expenditures and taxes. Tiebout assumed local governments provide services to people under their jurisdictions and charge a price for those services in the form of taxes. If that is true, property values should change based on services such as schooling (Tiebout implies the effect of education services on house prices ought to be positive and significant), an assumption that has driven many researchers (i.e. Oates, 1969; Hamilton, 1976; Rosen and Fullerton, 1977; Gurwitz, 1980; Jud and Watts, 1981; Dubin and Goodman, 1982; Hayes and Taylor, 1996; Black, 1999; Downes and Zabel, 2002; Brasington and Haurin, 2006; Clapp et al., 2008; Chiodo et al., 2010) to use house price models to understand the role that schools play in migration patterns and property values.

Services in the context of schooling have been measured in different ways across the relevant literature. Many studies have analyzed the impact of school inputs on parents' migration decisions by estimating the effect of per pupil expenditures on house prices. Several studies have used test scores, as it reflects both the quality of education being offered and the characteristics of students (Kane et al., 2005). Others have preferred measures of peer effects over school inputs and outputs.

The purpose of this paper is to understand what has caused previous studies to reach inconclusive results across the house price literature. Two primary differences include the measurement of school quality and the magnitude of impact on house prices, though there are other factors in addition. Our work examines not only U.S. studies but also other North American and European studies that have examined the effect of school quality based on the hedonic price framework. We use meta-regression analysis to identify the factors that have caused disparities among studies that have examined the effects of different measures of education services on house prices.

We reviewed 48 house price studies that observed the impact of primary and secondary school test scores, expenditures per pupil, peer racial and socioeconomic composition, value added and pupil/teacher ratio. Our results suggest that of the three separate models used for our analysis, the Beta model provides the most meaningful interpretation by quantifying the magnitude of different variables (e.g. how house prices are measured, functional form of the primary study). This provides an understanding of how much the inclusion of certain variables in house price analyses matters.

The paper is arranged as follows. Section 2 summarizes relevant studies that have examined the impact of school quality on house prices. Section 3 provides background on the primary models used to understand whether and to what extent school quality gets capitalized into house prices. Section 4 describes the meta-regression analysis method and Section 5 describes the data sample. The final two sections provide empirical results and the conclusion.

2. Literature Review

The seminal study by Oates (1969) examined the effect of school quality on housing prices and set the stage for several studies to examine variations of that effect. Oates assumed the consumer maximizes his utility and chooses to reside in the locality which provides him with the greatest surplus of benefits over costs, supportive of the Tiebout (1956) model. Oates stated that if a community increases its property tax rate to expand its output of public services, net rental income to property owners may increase, providing a way to determine the validity of the Tiebout model.

Oates employed school expenditures as a proxy for the output level of educational services, which has been deemed inappropriate due to its ineffectiveness in measuring student outcomes (Pollakowski, 1973; Gustely, 1976; Rosen and Fullerton, 1977). The preference for school outputs (i.e. test scores and high school graduation rates) over school inputs (i.e. expenditures and pupil/teacher ratio) has developed as a result of school inputs lack of impact on student outcomes (Hanushek, 1986, 1997). Furthermore, test scores have been found to be more effective in explaining property values, which, if modeled correctly, should provide an indicator of peoples decisions to migrate based on school quality (Rosen and Fullerton, 1977; Dubin and Goodman, 1982; Johnson and Lea, 1982; Jud, 1985; Black, 1999; Downes and Zabel, 2002; Loubert, 2005; Brasington and

Haurin, 2006; Sedgley et al., 2008).

Another measure of school quality is value added, which refers to the marginal effect of school quality outcomes over a period of time. A good school has been described as one with high value added, meaning that it takes its students as given and noticeably adds to their level of knowledge (Boardman and Murnane, 1979; Aitkin and Longford, 1986; Hayes and Taylor, 1996; Hanushek and Taylor, 1990; Brasington, 1999; Downes and Zabel, 2002; Dills, 2004; Brasington and Haurin, 2006). The absence of such a measure could mean that school outcomes would reflect students innate aptitudes or their parents characteristics, leading to endogeneity bias if not accounted for properly (i.e. an increase in a childs math test score over time is thought to indicate the importance of school quality in peoples decisions to choose a locality more effectively than a childs current math test score).

Results on the significance of value-added measures are inconclusive, as some researchers (i.e. Downes and Zabel, 2002; Brasington and Haurin, 2006) found that compared to the level of test scores, value-added measures are not capitalized by housing prices. Hayes and Taylor (1996), however, found that homebuyers are willing to pay a premium for marginal effects of the school on student performance.

Still another measure of school quality is peer effects, which describe the impact(s) peers have on one another and can be measured by the socioeconomic level of school childrens parents (Ladd, 2002). This is based on the observation that the average achievement of students within a school is highly correlated with the socioeconomic and racial composition of the student body. Factors including student race composition (i.e. percent students black, Hispanic or Asian) and percent students enrolled in reduced-price lunch have been used as indicators of peer effects. Among the house price literature, results based on the socioeconomic composition of peers (Jud, 1985; Weimer and Wolkoff, 2001; Dills, 2004) are mixed.

3. House Price Models

The hedonic price model described below is often used to explain housing markets. Several studies have also modified the traditional model to permit spatial effects. Can (1990) noted the assumption of fixed structural parameters (i.e. the marginal price for one structural attribute in one area is the same as in another) as specified by other models does not incorporate the spatial dynamics operating in local urban housing markets. This, she stated, fails to take into account the diversity among neighborhood structures within metropolitan areas. Brasington (1999) likewise found that ordinary least squares estimation of the house price model produces biased and inconsistent estimates, as each house price influences nearby house prices, leading to spatial autocorrelation.

Hedonic Price Model

A hedonic price function (Rosen, 1974) describes the house transaction sales price (or assessed value, i.e. Rosen and Fullerton, 1977; Johnson and Lea, 1982; Jud, 1985; Brasington and Hite, 2005) as a function of the characteristics of a house and its neighborhood. The price associated with each characteristic represents that of the marginal purchaser and is defined as the implicit or hedonic price.

The hedonic price model offers a way to estimate the prices of separate characteristics that comprise housing, a composite good. Characteristics typical to most house price studies are structural characteristics (i.e. number of bedrooms and bathrooms, lot size, living area size), neighborhood characteristics (i.e. crime rate, air quality, socioeconomic demographics of the residents) and school characteristics (i.e. expenditures per pupil, test scores, racial composition of peers).

The regressor of primary interest for most house price studies is school quality, which is measured in different ways as indicated above. The typical model (Downes and Zabel, 2002) is as such

$$ln(V_{it}) = \alpha + X_{it}\beta_1 + N_{it}\beta_2 + S_{it}\beta_3 + \epsilon_{it}, \qquad (1)$$

where $i = 1, \ldots, N$; $t = 1, \ldots, T$; $\ln(V_{it})$ is the linear function of house characteristics X_{it}, neighborhood characteristics N_{it} and school characteristics S_{it}; and ϵ_{it} is an unobservable stochastic random variable. The coefficients for X_{it}, S_{it} and N_{it} are assumed to be constant over time. The next section explains the methodology used for instances when that assumption does not hold.

While equation (1) shows the typical model used to measure property values, its linear form has been disapproved of by some researchers.

Chiodo et al. (2010) found the linear specification for test scores underestimates the house price premium at high levels of school quality and overestimates the premium at low levels of school quality (as the linear model assumes house prices have the same premium despite the level of school quality), thereby creating non-linear effects.

Spatial Dependence

The previous model has been extended to include spatial effects as an attempt to explain house prices more effectively. Can (1990) used the expansion method to account for neighborhood externalities that may cause spatial autocorrelation. Brasington and Hite (2005) used spatial statistics to estimate hedonic house price equations using the distance from each house to the nearest hazard as their measure of environmental quality. Brasington (1999) used the spatial Durbin model from Pace and Barry (1997a) to address the problem of spatial autocorrelation. The model is as such

$$v = \rho W v + Z\beta + WZ'\alpha + \epsilon, \epsilon \sim N(0, \sigma^2 I_n), \tag{2}$$

where v represents the average house value, ρ is the spatial autoregressive parameter to be estimated, W is an n by n spatial weight matrix, Z is the vector of explanatory variables, Z' is the explanatory variable matrix Z with the intercept excluded, and α is the parameter associated with the spatial lag of the explanatory variables. The Wv term captures the extent to which house prices in one area are affected by the price of houses in neighboring areas.

4. Method

Meta-regression analysis provides a way to summarize results from disparate studies of the same topic and has been expressed as the regression analysis of regression analyses (Stanley and Jarrell, 1989). This analysis has been used mostly for medical research, though it has also made its way into the public finance and economic literature (Ballal and Rubenstein, 2009; Nelson and Kennedy, 2009). The hedonic house price model, in particular, has been studied via meta-regression analysis (Smith and Huang, 1995; Nelson, 2004; Sirmans et al., 2005, 2006) and by survey

(Boyle and Kiel, 2001; Gibbons and Machin, 2008; Black and Machin, 2009). However, meta-regression analysis is more effective than survey, as it goes beyond literature review and attempts to identify the underlying factors that separate one study from another.

Meta-regression analysis is useful since many have examined the effect of school quality on property values, which does not have the same magnitude and/or sign across studies. Furthermore, the estimation method differs among ordinary least squares, two-stage least squares and maximum likelihood estimation. Stanley and Jarrell suggested the following meta-regression model to help explain diverse findings

$$b_j = \beta + \sum_{k=1}^{K} \alpha_k Z_{jk} + e_j \qquad j = 1, 2, \ldots, L, \tag{3}$$

where b_j is the reported estimate of β (i.e. the effect size of school quality on property values) of the j^{th} study of L studies, β is the true value of the parameter of interest, Z_{jk} is the vector of meta-independent variables which measures relevant study characteristics and explains their systematic variation from other results in the literature, and e_j is the meta-regression disturbance term.

The inclusion of different school quality variables causes variation across effect sizes (bj) and should be accounted for when summarizing results from a group of studies. Cooper et al. (2009) analyzed the mixed effects linear model, which combines fixed effects and random effects. The former tackles the variation caused by omitted variables (i.e. specification variables that account for differences in functional form across studies, sample size, selected characteristics of the authors of studies, and measures of data quality) that lead to misspecification of primary studies. The impact of omitted variables may be reduced by adding dummy variables for important study characteristics. The latter introduces a random effect representing unobserved sources of heterogeneity of effect size. Koetse et al. (2010) used Monte Carlo simulations to address the behavior of the ordinary least squares estimator, the weighted least squares estimator and the mixed effects estimator in the presence of those types of variation.

This study analyzes and compares the results from a range of model specifications. While regression estimates seem a logical choice for the effect size, studies that have examined the effect of school quality on house prices differ with respect to data, sample size and definition of independent variable. This creates the potential for heteroskedasticity of the error terms, which may be combated through the use of t-statistics as suggested by Stanley and Jarrell. However, Becker and Wu (2007) pointed out important drawbacks of that method, as the t-statistic, which contains information on sample size, precision and magnitude, can be large when the slope is large or the standard error is small. Therefore, one cannot draw definite conclusions on the effectiveness and efficiency of the parameter estimate based on the t-statistic alone.

The effect size may also be expressed as an ordered variable taking on different values based on its p-value (Koetse et al., 2006), which is calculated from the t-statistic. The outcomes of the primary studies used for this analysis differ largely with respect to the magnitude and direction of the effect size. The use of an ordered probit model would circumvent the issue of comparing apples and oranges, which refers to the incomparability of estimates across studies using school inputs, outputs, and/or value added. We specifically give the dependent variable three values: positive signficant, negative significant and not significant.

The effect size may be alternatively expressed as a correlation coefficient (Hedges, 1988; Crouch, 1996; Root et al., 2003; Hunter and Schmidt, 2004) and should be used by researchers in public policy and the social sciences (Ringquist, 2013). The formulas for the correlation coefficient and its variance are

$$r = \sqrt{[t^2/(t^2 + df)]}, \qquad V[r] = (1 - r^2)^2/(n - 1), \tag{4}$$

where *t* is the t-statistics and *df* is the degrees of freedom (n - k - 1) associated with the regression parameter estimate from study *i*. The bias resulting from this measure is likely to be trivial with respect to the number of independent variables *k*. While increasing *k* will decrease the degrees of freedom *df*, the change in *df* will be more influenced by the sample size *n*, which causes the bias to disappear in large *n* (Ringquist, 2013). The correlation coefficient as given above, however, does have shortcomings such that it is bounded by -1 and 1 and that its variance depends on the value calculated in equation (4). Therefore, a transformation of the correlation coefficient, Fishers Z, is often used in meta-analysis

$$Z_r = \frac{1}{2} ln[\frac{1 + r}{1 - r}], \qquad V[Z_r] = 1/(n - 3) \tag{5}$$

Effect-size estimates often have non-homogeneous variances due to different primary sample sizes, different sample observations and different estimation procedures, and estimates with smaller variances are more reliable (Nelson and Kennedy, 2009). To tackle that issue, meta-analysts often weight the effect sizes by the inverse variance. We use the formula for variance from equation (7) to weight the effect sizes.

5. Data

This study examines 48 U.S. and other (Gibbons and Machin, 2003; Kim et al., 2003; Rosenthal, 2003; Cheshire and Sheppard, 2004; Gravel et al., 2006; Gibbons and Machin, 2008; Ries and Somerville, 2010) house price studies. Table 1 provides the meta-regression analysis variables and descriptions, Table 2 provides the summary statistics and Table 3 provides the summary of studies.

We conducted an extensive search of house price studies in the context of school quality. We examined journal articles, dissertations, reports and working papers largely through the EBSCOhost Business Source Premier, EBSCOhost Academic Search Premier, Elsevier ScienceDirect Complete, LexisNexis Academic, JSTOR and ProQuest Research databases using the keywords *school quality, house prices, property values*, and *Tiebout sorting*. Based on those papers, we identified further, relevant studies (i.e. snowball method).

Furthermore, we consulted Gibbons and Machin (2010), who reviewed the literature on school quality and performance through housing valuations, and included pertinent studies that we had not previously identified. Although the house price literature measures various effects in addition to school quality (i.e. school choice and prevalence of private schools, air quality, incidence of crime, and the conglomeration of groups by race) we restrict our sample to studies whose aim was to estimate the effect of school quality on house prices through separate school input or output variables (i.e. Brasington and Haurin (2009) create composite school, parents and peer group components, which makes it hard to infer the meaning of the estimates, and therefore does not comprise this meta-regression analysis).

We include dummy variables for study characteristics to reduce omitted variable bias in the meta-regression analysis. It is important to take account of the various estimation methods (i.e. ordinary least squares, two-stage least squares, maximum likelihood estimation), as their exclusion could be cause for estimation bias. Several studies found the application of two-stage least squares estimation unnecessary, as they used others methods to ensure the absence of endogeneity bias (i.e. Black (1999) used a regression discontinuity design to account for neighborhood characteristics).

Dummy variables for different estimation methods are accompanied by a neighbor characteristics variable, as studies that accounted for neighborhood traits through some type of discontinuity design may or may not have incorporated additional neighborhood variables. While Black did not, Chiodo et al. (2010) found the inclusion of observable neighborhood characteristics such as age, sex and race of the population in addition to boundary fixed effects is necessary for understanding the true effect of school quality on house prices.

We construct the *Neighborhood* variable based on the presence of socioeconomic and demographic variables in study i (e.g. *Neighborhood* equals 1 if study i contains a measure of noise, resident age, resident educational attainment, crime, effective tax rate or industry characteristics). Several studies have examined the impact of introducing neighborhood quality variables such as air quality (Harrison and Rubinfeld, 1976; Li and Brown, 1980), crime rate (Kain and Quigley, 1970; Dubin and Goodman, 1982; Brasington, 1999; Brasington and Haurin, 2006) and measures of racial heterogeneity (Hayes and Taylor, 1996; Downes and Zabel, 2002; Loubert, 2005) to the house price model.

Some studies used novel approaches to avoid the accommodation of neighborhood quality variables. Figlio and Lucas (2004) used panel data on repeat real estate transactions involving single-family houses in neighborhoods that developed at about the same time with similar style, square footage and lot size to control for unobserved, time-invariant, property-specific effects. Black (1999) stated that attempts to estimate the causal effect of school quality on house prices have been complicated by the fact that better schools tend to be located in better neighborhoods. To combat this problem, she, and later others (Kane et al., 2005; Bayer et al., 2007; Chiodo et al., 2010; Ries and Somerville, 2010), compared houses on opposite sides of attendance district boundaries and thereby attempted to control for variation in property tax rates and school spending. However, Chiodo et al. found that inclusion of neighborhood characteristics plus boundary fixed effects notably decreases the magnitude of the school quality measure.

The variable *Sales*, which is coded 1 if study *i* used transaction sales price and 0 otherwise; the variable *Assessed*, which is coded 1 if study *i* used assessed house value and 0 otherwise; and the variable *Rent*, which is coded 1 if study *i* used monthly rent and 0 otherwise, are important to include since those measures are not the same. The assessed value refers to that which a countys property tax office uses to determine the property tax paid for each tax year, and the sales price refers to the amount for which a home sells in the real estate market. Furthermore, house rent is measured on a monthly basis while the other two are not.

We include the *Aggregate* variable to account for whether study i used aggregate house price data (i.e. median house value) or individual micro data. This point is of importance to the literature, as some studies (Black, 1999; Loubert, 2005) have the noted the possibility of heterogeneity across school districts with respect to structural, neighborhood and school characteristics. Therefore, studies that employ micro data (e.g. individual house prices for one or more similar school districts) seemingly explain house prices better than those that do not, especially when tax rates are controlled for (Palmon and Smith, 1998).

Table 1. Descriptive Statistics

Variable	*Description*	*Mean*	*Std.Dev.*	*Min*	*Max*
Beta Estimate	Regression estimate from study i	-1.711	108.275	-1433.080	262.6
Zr 1	Fischer's Z transformation of beta estimate	0.059	0.158	-0.332	1.386
Zr 2	reduced sample	0.045	0.069	-0.062	.465
Average year	Average year of study i	1990.626	11.597	1930	2004
Published	1 if published in scholarly journal	0.775	0.418	0	1
Fixed Effects	1 if study included fixed effects	0.359	0.480	0	1
Sales	1 if study used sales price	0.669	0.471	0	1
Assessed	1 if study used assessed value	0 .331	.471	0	1
Rent	1 if study used monthly rent	0.151	0.359	0	1
Aggregate	1 if study used aggregate house price data	0.207	0.406	0	1
Room	1 if study used measure of number of bedrooms, bathrooms or half-bathrooms	0.705	0.456	0	1
Amenity	1 if study used measure of heating structure, air conditioner, fireplace, basement or plumbing	0.568	0.496	0	1
Outside	1 if study used measure of brick exterior, visual quality, house condition, patio,deck, pool or number of stories	0.452	0.498	0	1
Neighborhood	1 if study used measure of noise, air quality, resident age, resident educational attainment, crime or tax rate	0.630	0.483	0	1
Traditional	1 if study used traditional hedonic price model and =0 if spatial model	0.897	0.304	0	1
ln(house)	1 if study used natural log of house prices as dependent variable	0.717	0.451	0	1
ln(school)	1 if study used natural log of school quality as the independent variable	0.118	0.323	0	1
2SLS	1 if study employed 2SLS	0.236	0.425	0	1
OLS	1 if study employed OLS	0.632	0.483	0	1
US	1 if estimates are for the U.S.	0.899	0.301	0	1
Can	1 if estimates are for Canada	0.064	0.245	0	1
Eng	1 if estimates are for England	0.035	0.184	0	1
Fra	1 if estimates are for France	0.002	0.044	0	1
Pts, dx0	1 if study used primary school test score, conditional variable for Pts (follows for other school quality measures)	0.517	0.5	0	1
Sts, dx00	1 if study used secondary school test score	0.087	0.282	0	1
Exp, dx1	1 if study used expenditures	0.163	0.370	0	1
Af, dx2	1 if study used measure of African American students	0.062	0.241	0	1
Hisp, dx3	1 if study used measure of Hispanic students	0.027	0.163	0	1
Lin, dx4	1 if study used measure of low-income students	0.064	0.245	0	1
VA, dx5	1 if study used value-added measure	0.045	0.207	0	1
Ptr, dx6	1 if study used pupil/teacher ratio	0.035	0.184	0	1
Other school	1 if study used more than 1 school quality measure	0.477	0.5	0	1

Table 2. Summary of Studies

Study	*Obs*	*Pub*	*Time*	*SchoolQty*	*Study*	*Obs*	*Pub*	*Time*	*SchoolQty*
Orr (1968)	1	Y	1960	Exp	Black (1999)	7	Y	1993-1995	Pts, Exp, Ptr
Oates (1969)	2	Y	1960	Exp	Brasington (1999)	12	Y	1991	Pts
Heinberg and Oates (1970)	5	Y	1960	Exp	Bogart and Cromwell (2000)	5	Y	1983-1988	Pts, Af
Kain and Quigley (1970)	1	Y	1967	Pts	Clauretie and Neill (2000)	16	Y	1995	Pts, Lin
Pollakowski (1973)	7	Y	1960	Exp	Weimer and Wolkoff (2001)	35	Y	1997	Pts, Sts, Lin, Ptr
Edel and Sclar (1974)	6	Y	1930-1970	Exp	Brunner et al. (2002)	4	Y	1982	Pts, Exp
Gustely (1976)	5	Y	1970	Exp	Downes and Zabel (2002)	26	Y	1987 and 1991	Pts, Exp, Af, His, Lin, VA
Meadows (1976)	9	Y	1960 and 1970	Exp	Gibbons and Machin (2003)	15	Y	1998-2001	Pts
Schnare and Struyk (1976)	9	Y	1971	Exp	Kane et al. (2003)	63	N	1993-2001	Pts, Af, VA
McMillan and Carlson (1977)	4	Y	1970	Exp	Rosenthal (2003)	10	Y	1996	Sts
Rosen and Fullerton (1977)	8	Y	1970	Pts, Exp	Cheshire and Sheppard (2004)	8	Y	1999	Pts, Sts
Harrison and Rubinfeld (1978)	3	Y	1970	Ptr	Dills (2004)	13	Y	1994-1999	Pts, Sts, Af, His, Lin
Brueckner (1979)	2	Y	1960	Exp	Brasington and Hite (2005)	6	Y	1991	Pts
Gurwitz (1980)	1	Y	1970	Exp	Kane et al. (2005)	24	N	1994-1999	Pts, Af, VA
Li and Brown (1980)	3	Y	1971-1972	Pts	Loubert (2005)	12	Y	1990 and 1997	Pts, Exp, Af
Jud and Watts (1981)	4	Y	1977	Pts, Af	Brasington and Haurin (2006)	18	Y	2000	Pts, Sts, Exp, VA
Dubin and Goodman (1982)	12	Y	1978	Pts, VA, Ptr	Gravel et al. (2006)	1	Y	1989	Ptr
Johnson and Lea (1982)	2	Y	1978	Pts	Bayer et al. (2007)	62	Y	1994	Pts
Krantz (1982)	1	Y	1979	Exp	Clapp et al. (2008)	24	Y	1994-2004	Pts, Af, His, Lin
Cushing (1984)	1	Y	1970	Exp	Sedgley et al. (2008)	12	Y	2002	Pts, Sts
Longstreth et al. (1984)	4	Y	1975	Ptr	Caetano (2009)	9	N	2000	Pts
Jud (1985)	6	Y	1980	Pts, Af	Winters (2009)	1	N	2002-2007	Pts
Hayes and Taylor (1996)	10	N	1987	Pts, Exp, VA	Chiodo et al. (2010)	9	N	1998-2001	Pts
Goodman and Thibodeau (1998)	1	Y	1995-1997	Pts	Ries and Somerville (2010)	18	Y	1999	Pts, Sts

6. Discussion

Results for models using all eight school quality variables are provided in Table 3. The ordered probit model has greater explanatory power than the Fisher's Z model, as indicated by the adjusted R^2. The models are estimates using the *metareg* command in STATA, which incorporates random-, or mixed-effects regression. The coefficients in the Fischer's Z model are interpreted following Hunter and Schmidt's interpretation for correlation coefficients (2004).

The Fischer's Z model produces several significant house price variables (i.e. *sales, rent* and *aggregate*). The coefficients on *sales* and *rent* indicate that, all else equal, estimates from studies that used house transaction sales prices or rent found smaller estimates than studies that did not, implying the specification of house value matters for hedonic models. For example, a one standard-deviation increase in *sales* leads to a .016-unit decrease (-.103*.158, the standard deviation for *Zr* 1 reported in Table 1) in the effect size, which measures the effect of school quality on house prices. The coefficient on *aggregate* indicates that estimates from studies that examined aggregate house data (e.g. median house value) instead of individual data found a .019-unit larger estimate than those that did not. Many studies in our meta-regression analysis examined submarkets and thereby used aggregate data. The results therefore support the idea that capitalization may occur only in a small submarket within a jurisdiction (Johnson and Lea, 1982).

Relevant studies have attempted to prove Tiebout's claim through estimation of hedonic functions and found that house value is positively related to its structural, neighborhood and public service characteristics but negatively related to property taxes. In that manner, it is plausible that previous studies have achieved support for the Tiebout model by defining house value in a manner that explains the capitalization of property taxes and public services as measured by school quality (Sonstelie and Portney, 1980).

The results indicate that secondary school test scores, percent of Hispanic students and pupil/teacher ratio are significant. The positive sign on the first two estimates implies studies that examined the effect of secondary school test scores or a measure of student racial composition on house prices found larger estimates (.012 units and .014 units larger, respectively) than those that did not. If Tiebouts model holds, this indicates that people are eager to migrate to localities with higher high school test scores, thereby raising house prices. The sign on percent of Hispanic students is less clear, as schools with larger test score gains have been found to be those with higher proportions of white and non-poor students, which often excludes Hispanics (Clotfelter and Ladd, 1996; Ladd and Walsh, 2002). If greater student achievement implies higher house prices, the sign should contrarily be negative. As for pupil/teacher ratio, the negative sign implies studies that examined the effect of school size and capacity found a .022-unit smaller estimate than those that did not.

All School Quality Variables

Table 3. Regression Results

Variable	*Fischer's Z*	*s.e.*	*OrderedProbit*	*s.e.*
Average year	0.002	0.001	0.009	0.008
Published	0.014	0.026	0.175	0.168
Fixed effects	0.039	0.018	-0.003	0.117
Sales	-0.103**	0.043	0.396	0.275
Rent	-0.131**	0.048	-0.045	0.289
Aggregate	0.119***	0.035	0.064	0.239
Room	-0.008	0.027	-0.466**	0.200
Amenity	-0.035	0.026	0.135	0.161
Outside	0.031	0.021	0.113	0.126
Neighborhood	0.000	0.022	-0.026	0.128
Traditional	-0.002	0.027	0.348**	0.158
ln(house)	-0.006	0.034	-0.527**	0.269
ln(school)	-0.034	0.031	0.152	0.249
2SLS	0.000	0.026	0.186	0.148
OLS	0.001	0.029	0.064	0.168
pts	0.013	0.032	-0.915***	0.173
sts	0.076*	0.040	-0.766***	0.216
exp	0.017	0.037	-0.565**	0.204
af	-0.028	0.040	-0.323	0.224
his	0.091*	0.052	-0.352	0.285
lin	-0.005	0.041	-0.279	0.224
ptr	-0.140**	0.047	-0.133	0.270
other school	0.013	0.019	0.150	0.116
constant	-3.848	2.542	-14.935	16.853
Adjusted R^2	21.70		24.25	
N = 516				

Country dummy variables are incorporated
*** p<.001 ** p<.05 * p<.1

Table 3 provides a preliminary understanding of the effects of various school quality measures on house prices. The things we gain from the analysis are: the inclusion of some house price and school quality variables affect the magnitude and direction of the effect size, namely, the effect of school quality on house prices. We cannot make claims about the strength of the results mainly because primary studies used in the meta-regression analysis may have been misspecified themselves. Furthermore, the inclusion of several different school quality variables complicates the interpretation of the true effect size. Therefore, we reduce the sample size to include only estimates derived from the regression of primary school test scores on house prices, as those have been used most frequently across the literature. This allows us to provide more meaning interpretations of the results, which are provided in Table 4.

The Beta model, which uses the original beta coefficient given by primary studies as the effect size, has greater explanatory power than the Fischer's Z transformed model as given by the larger adjusted R^2 of 83.05. However, the explanatory variables themselves are more significant in the Fischer's Z model. The house price (i.e. *sales, rent* and *aggregate*), the structural (i.e. *room*), functional form (i.e. *ln(school)* and *2SLS*) and school control variables (i.e. control for percent Hispanic students and for pupil/teacher ratio) are significant for the Fischer's Z model, while only the natural log variables are significant for the Beta model.

The interpretation of the variables is similar to above. The coefficient on the variable *2SLS*, for example, indicates that studies which employ two-stage least squares estimation find a .002-unit larger estimate (.036*.069, the standard deviation for the reduced-sample Zr 2 reported in Table 1) than those that do not. This coincides with the argument of several researchers (i.e. Oates, 1969; McMillan and Carlson, 1977; Rosen and Fullerton, 1977) that studies which use ordinary least squares estimation generate biased estimates.

Interpretation of the Beta model is more straightforward. For example, a study which uses a log specification for house prices should obtain a .003-unit (.344/100) increase in effect size compared to studies which do not. Similarly, a study which uses a log specification for school quality should obtain a .013-unit (1.255/100) increase in effect size.

Primary School Test Score Only

Table 4. Regression Results

Variable	*Fischer's Z*	*s.e.*	*Beta*	*s.e.*
Average year	0.003**	0.001	-0.006	0.006
Published	-0.007	0.015	-0.083	0.096
Fixed effects	-0.010	0.007	-0.058	0.058
Sales	-0.145***	0.026	-0.131	0.185
Rent	-0.296***	0.036	0.045	0.216
Aggregate	0.039**	0.020	-0.029	0.121
Room	-0.042**	0.015	0.059	0.117
Amenity	0.000	0.016	-0.060	0.101
Outside	0.000	0.012	-0.096	0.075
Neighborhood	0.000	0.013	-0.027	0.070
Traditional	-0.029*	0.015	-0.002	0.091
ln(house)	-0.118	0.027	0.344*	0.202
ln(school)	-0.053**	0.023	1.255**	0.418
2SLS	0.036**	0.014	-0.002	0.073
OLS	0.015	0.018	0.010	0.098
dx00	-0.005	0.019	0.029	0.098
dx1	-0.019	0.014	-0.063	0.075
dx2	-0.004	0.012	-0.067	0.071
dx3	0.054**	0.020	-0.027	0.110
dx4	-0.002	0.013	0.002	0.079
dx5	0.021	0.026	-0.099	0.190
dx6	-0.037**	0.019	0.002	0.102
constant	-4.894	2.239	11.964	12.323
Adjusted R^2	56.73		83.05	
N = 267				

Country dummy variables are incorporated
*** p<.001 ** p<.05 * p<.1

7. Summary and Conclusions

This meta-regression analysis examines the effect of school quality on house prices from various angles. We pool data from 48 studies and separate school quality into different categories: primary school test scores, secondary school test scores, expenditures per pupil, value added, peer racial and socioeconomic composition and pupil/teacher ratio. An initial analysis of those school quality measures implies that the inclusion of house price and school quality variables affects the magnitude and direction of the effect size based on the Fischer's Z model. However, the ordered probit model provides greater explanatory power and implies the inclusion of functional form and the primary and secondary school test scores and per pupil expenditures measures of school quality impact the effect size. In particular, the model finds that studies which use primary or secondary school test scores or per pupil expenditures find smaller estimates than those that do not.

We reduce the sample size to studies that used only primary school test scores to draw further conclusions regarding the specification of house price models. The Fischer's Z model indicates that house price, structural, functional form and school control variables affect the statistical significance of the effect size. However, the Beta model has greater explanatory power and implies that studies which specify house prices and school quality measures as logarithms find larger estimates than those that do not.

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