House Prices and the Structure of Local Government: An Application of Spatial Statistics

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Abstract

When two internally homogeneous communities decide to jointly provide a public service, residents of each community lose some control over the public service provision. The loss of control over public schooling provision contributes to a $2929 or 3.5 percent drop in constant-quality house value. Increased heterogeneity of the consolidated district is responsible for almost all the drop; the increased number of service recipients alone is responsible for almost none of the drop. The mixed regressive spatially autoregressive hedonic, corrected for sample selection bias, also suggests economies of scale gains from school district consolidation must be worth at least $3369—4% of house value.

JEL Reference: H11, H40, R50, R21
Keywords: structure of local government, consolidation, spatial autoregression, capitalization

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April 9, 2002

Introduction

People sort into communities based on their most preferred level of public good provision (Tiebout, 1956). Imagine two neighboring communities. Each is internally homogeneous, but the communities differ from each other demographically and in most-preferred levels of local public good provision. The two communities may decide to jointly produce a local public good to gain scale economies, but this means they must agree on a single level of joint provision. Since the communities liked different service levels before consolidation, consolidating public service supply deepens the conflict over the optimal level of provision (Ferris and Graddy, 1988; Borck, 1998). The loss of control over service provision may be capitalized into house value.

Local government consolidation is an important and under-studied topic in economics. One local governmental unit that has experienced rapid consolidation is the school district: the number of public school districts in the United States has fallen from 125,000 in 1900, to 84,000 in 1950, to 14,805 in 1997. The theoretical model shows that the decision of communities to consolidate school districts depends on how much the communities' preferences for local public services differ. Going from independent provision to consolidated provision means a loss of control for each community in two ways: more heterogeneous preferences and a larger number of voters.

The empirical section estimates a hedonic house price equation using spatial statistics. The hedonic results suggest that, all else constant, having a consolidated school district instead of an independent school district is associated with a 3.5 percent drop in house value. At the mean house price of $83,695 this 3.5% discount translates into a decline of $2929. The discount stems from loss of control over the education agenda.

The loss of control discount is almost entirely caused by more heterogeneous preferences rather than by an increase in the size of the district. Further analysis suggests much of the heterogeneity discount may stem from increased racial heterogeneity. From the hedonic estimations, it is possible to see how scale economy gains from consolidation affect house price. Scale economy gains from consolidation contribute at least $3369 toward the average house's value.

Theoretical Model

Several recent papers theoretically model the decision of communities to jointly provide public services (Austin, 1999; Brasington, 1999a; Martinez-Vazquez, Rider and Walker, 1997; Ellingsen, 1998). The main contribution of the current paper is its empirical testing of the capitalized value of the presence of a consolidated school district; still, it is useful to describe a theoretical framework that motivates the empirical test. The model now presented is a customized version of Borck (1998). Among other modifications, the funding mechanism is converted from an income tax to a property tax. The property tax is the primary source of school funding in the sample used in the empirical section of the paper. The model abstracts from many of the complex issues involved in the school district consolidation decision, but it shows the consolidation decision depends on income, taxes, population, and provision levels, all of which are critical to the empirical analysis.

Tiebout (1956) describes a world in which people sort into communities based on their most preferred level of public good provision. Each community in Tiebout's model is internally homogeneous. The homogeneity assumption is useful, but unrealistic; the current model allows for imperfect Tiebout sorting. Within each jurisdiction there is a range of socioeconomic levels uniformly distributed over the interval [s_l, s_h].

People have utility functions U of the following form:

$$U = v(x) + u(g) \tag{1}$$

where v is indirect utility, x is a composite private good, and g is the publicly provided good.

People choose to live in jurisdiction j = {A,B}, and population N is normalized to be one. Therefore $N_A + N_B = 1$. In Tiebout equilibrium no one wants to move to the other jurisdiction because utility would be no higher.

The local public good costs c per unit to provide. The total cost C of providing g units of the local public good is

$$C = c(N_j)*g \tag{2}$$

Note that the unit cost c is a function of population; to allow scale economies in service provision, assume that $\frac{\partial c}{\partial N_j} \leq 0$.

Property taxes finance the public service. Variation in socioeconomic status s within a jurisdiction means there is also some variation in house value ►, which is distributed uniformly across the interval [► $_l$, ► $_h$]. A person's budget constraint is

$$y = x + ►► \tag{3}$$

where y is income and ► is the property tax rate upon which people vote. In addition to residential property, there is also industrial property ●$_j$ in jurisdiction j.

The public budget constraint is

$$c(N_j)*g = ► \int_{\lambda} d\lambda + ► ● \tag{4}$$

Let T be the jurisdiction's tax revenue. Let t = (▶ ▶ N)/T be a voter's tax share. Each voter chooses g to maximize utility in equation (1) subject to the constraints in (3) and (4). After substituting (3) and (4) into (1), voters choose g to maximize the following function:

$$U = u(g) + v\left(y - \frac{c(N_j) * g\lambda}{\int_{\lambda} d\lambda + \Lambda}\right) \tag{5}$$

The following first-order condition results:

$$\frac{\partial u}{\partial g} = \frac{\partial v}{\partial g} \frac{c(N_j)\lambda}{\int_{\lambda} d\lambda + \Lambda} \tag{6}$$

The median voter's most-preferred level of g will not lose to any other proposed amount in a pairwise election. Let the median voter in jurisdiction j own the house of median value λ_j^m, and let g_j^m be the equilibrium level of the local public good that results from majority voting in each separate community.

Assume that there is free mobility between communities and that preferences over g vary monotonically with property value. The following three things are then true (Borck, 1998). First, if the jurisdictions are separate, they segment the house value interval [▶ $_l$, ▶ $_h$]. Second, there is a boundary household ▶ ′ that is indifferent between living in A or B. Call A the poor community with population ▶ ′-▶ $_l$ and median house value λ_A^m = (▶ ′+▶ $_l$)/2. Call B the rich community with population ▶ $_h$-▶ ′ and median house value λ_B^m = (▶ $_h$+▶ ′)/2. Third, the tax and service packages can be ordered by the median house value in the community. It follows that $g_A^m < g_B^m$: the rich community provides more local public good than the poor community.

Jurisdictions A and B may provide the public service separately or cooperate. If they cooperate the new level of public service is decided by voting in the consolidated jurisdiction. The resulting public service level is g^m.

A person will vote to consolidate public service provision with the neighboring community if his or her utility is higher under consolidation than under separation. The utility levels may be compared as follows:

$$\Delta U_j = u(g^m) + v(y\text{-}tcg^m/N) - u(g_j^m) - v(y - t_j c_j g_j^m/N_j) \tag{7}$$

where the subscript j denotes a person living in community j, and the absence of subscripts denotes conditions in the consolidated community.

Consolidation changes utility for three reasons. First, the level of provision changes. Second, scale economy gains are reaped. Third, there is a loss of control over the service level. The sum of the three effects must be positive for a community to sanction consolidation. The relationship between each of the three effects and house price is discussed.

Equation (7) shows that school district consolidation changes the level of provision from g_j^m to g^m. New demographic preferences in the consolidated district are responsible for some of the change in provision level; however, school district consolidation increases enrollment. There is some evidence that larger enrollment is related to lower school quality (Stern, 1989; Brasington, 1997; Friedkin and Necochea, 1988).

Equations (7) and (4) show consolidation may reap scale economy gains: a lower tax rate may provide the same level of public service. Some research finds evidence of potentially large scale economies in public schooling (Lewis and Chakraborty, 1996;

Duncombe, Miner and Ruggiero, 1995; Ratcliffe, Riddle and Yinger, 1990). Other research finds little evidence of scale economies (Young, 1994; Deller and Rudnicki, 1992; Kenny, 1982). The current study provides what appears to be the first estimate of the change in house prices caused by the scale economy gains of consolidation.

Consolidation causes a loss of control over the educational agenda. Control over the educational agenda is different than control over spending: it is control over *how* the money is spent, whether students are required to wear uniforms, and which books should be banned from the school library. Control means a voter's interests are represented in any school policy decisions that may arise. Equation (7) shows the loss of control from consolidation stems from two sources: 1) an increase in the size of the community from N_j to N, and 2) differences in pre- and post-consolidation service levels g_j^m and g^m. The current study provides the first estimate of the house price discount from the loss of control of living in a consolidated school district.

Data and Institutional Background

The data used in the hedonic regressions are actual single-family detached housing purchases that occurred during 1991 in Ohio (Amerestate, 1991). To keep the sample urban, any house with lot size greater than two acres is suspected of being a farm and deleted. Houses that transact for more than $400,000 are deleted for being unrepresentative, and houses that transact for less than $10,000 are deleted for suspicion of being either uninhabitable or a gift between family members. In addition, outliers in square feet of housing and garage size are deleted.[1]

Ohio law makes forming and disbanding a consolidated school district fairly easy. To consolidate, both communities' boards of education basically just need to vote in favor of consolidation; consolidation fails if one of the boards votes against it (Baldwin's Ohio Revised Code, 1995). After consolidation voters elect a new unified school board and the pre-consolidation school boards disband. If two communities cooperate in the provision of schooling, it must be for all grade levels: kindergarten through twelfth grade. The communities must be contiguous; the law forbids consolidation between communities that do not share a geographical boundary.

Consolidation has gained and lost favor in waves. The number of school districts in Ohio fell from 1,936 to 611 between the 1930s and the 2001-2002 school year. Most of the consolidation happened in the 1930s and the 1960s. County offices encouraged consolidation in the 1930s wave, while the State Board of Education encouraged consolidation in the 1960s wave. Legal threats and financial incentives were not used to promote consolidation. Since 1985 three consolidated school districts formed, one school district disbanded for lack of students, and two split into their pre-merger components (Ohio Department of Education, 1996, 2002).

The analysis excludes central cities for two reasons. First, central city boundaries are usually historical artifacts rather than conscious choice based on Tiebout sorting. Inflexibilities may prevent the redrawing of jurisdictional boundaries (Epple and Zelenitz, 1981; Garasky and Haurin, 1997). Second, the theoretical model examines the consolidation decision between communities that are relatively internally homogeneous. Central cities boast much more demographic diversity than the suburban communities that surround them.

Before 1955, if territory was annexed, residents had a new mayor and were automatically assigned to the school district of the city that annexed them. But in 1955 the law changed so that although municipal boundaries changed, the school district assignment did not necessarily change. Consequently, community political boundaries do not always coincide with school district boundaries. Data constraints limit the analysis to communities that send their children to a single school district; any community with a large portion of land assigned to more than one school district is excluded from the sample.

To restrict the sample to urban communities, any school district on the edge of the metropolitan area that includes a large portion of rural land is omitted. Consolidated school districts typically have schools in each of their member communities. Sometimes very small communities have no school buildings and are therefore said to contract out for educational services. Small communities are omitted if a larger community completely encompasses them; they are kept if the small community can choose between contracting partners. This extensive cleaning is necessary to get a sample consisting of strictly urban communities, with school districts that are clearly independent or consolidated, containing houses that are clearly the result of arms' length transactions.

The cleaned sample consists of 14,619 houses in 72 school districts, and the mean deflated sale price is $83,695. ACCRA (1991, 1992) provides the data from which MSA deflators are constructed. All nominal values are deflated, including housing sale prices, to adjust for regional cost of living differences. The *Places Rated Almanac* (Savageau and Boyer, 1993), the U.S. Bureau of the Census (1990), the Ohio Department of Education, the Office of Criminal Justice Services (1993) and the Ohio Environmental

Protection Agency (1994) provide the explanatory variables. Table 1 shows variable definitions, sources and means.

(Insert Table 1)

To conserve space not all variables are discussed; however, three variables deserve discussion: school quality, the consolidated dummy variable, and taxes. There are many choices for measures of school quality. Brasington (1999b) runs 444 regressions using 37 school quality measures and finds that proficiency tests are consistently valued by the housing market. Proficiency tests are therefore used to measure school quality in the current study. A dummy variable representing whether the house is in a consolidated school district is also included in the hedonic regressions. Cities decide whether to form consolidated school districts with their neighbors, but to people purchasing a house the decision on whether the school district should consolidate or not has already been made. Because the data are individual housing purchases, the consolidated dummy variable may be treated exogenously. Finally, some researchers have suggested that school district income taxes need to be included in the regression. Many Ohio school districts have income taxes, but such districts tend to be rural. In fact, in the urban sample at hand only one school district has an income tax, so it is fair to focus on property taxes.

Estimation Technique

The sample only includes houses that sell, and it only includes houses in school districts that are either clearly consolidated or clearly independent. Sample selection bias is therefore a concern. Haurin and Hendershott (1991) were the first to suggest that hedonic house price estimates may suffer from sample selection bias, and Jud and Seaks (1994) were the first to correct for sample selection bias in a housing transaction study. The current study also corrects for sample selection bias; details appear in the appendix.

The current study examines the relationship between house value and the presence of a consolidated school district by using the hedonic estimation technique (Rosen, 1974). Consider the traditional hedonic estimation given by equation (8), where v is house value and x is the vector of explanatory variables:

$$v = \beta x + \varepsilon, \ \ \varepsilon \sim N(0,\sigma^2) \tag{8}$$

Spatial dependence may exist if each house price influences other nearby house prices (LeSage, 1997, 2001). Estimating (8) with ordinary least squares does not account for the spatial interplay between observations, which may lead to biased, inefficient and inconsistent parameter estimates (Anselin, 1988, p. 58-59). A study by He and Winder (1999) demonstrates bi-directional price causality between three adjacent housing markets in Virginia, suggesting that there may indeed be spatial effects in housing markets. There are three potential sources of spatial dependence: 1) through the prices of neighboring houses, 2) through the x-characteristics of neighboring houses and communities, and 3) through the error term. To address these potential sources of spatial dependence, OLS is replaced by a mixed regressive spatially autoregressive model with a spatial autoregressive error term (Pace and Barry, 1997a; Anselin, 1988, p. 35): [2]

$$v = \rho W v + \beta x + \alpha W x + \varepsilon \tag{9}$$

$$\varepsilon = \lambda W \varepsilon + \mu, \ \mu \sim N(0,\sigma^2)$$

Two important symbols appear in (9) that do not appear in (8): ρ and W. ρ is the spatial autoregressive parameter to be estimated. It tells how strongly a house's value is influenced by the value of neighboring houses. Neighboring houses affect each other more than houses far away from each other; consequently, a nearest-neighbors spatial weight matrix W is constructed to summarize the spatial configuration of the houses.[3]

The ρWv term in (9) captures the extent to which the price of each house is affected by the price of neighboring houses. Such spatial interplay is appropriate because, among other reasons, when a house is put on the market, the offer price is often set with the knowledge of the selling price of similar houses in the neighborhood. Multiple listing services publish offer prices and newspapers publish sale prices, so typically offers and bids on houses will be influenced by offers and bids on nearby houses.

The αWx term in (9) allows the structural characteristics of neighboring houses to influence the price of each house. A common saying in real estate is to never own the largest (or the smallest) house on the block: the market will force such a house to sell at a discount, an example of the type of impact captured by αWx. The αWx term also allows other structural characteristics of neighboring houses to affect the sale price of each house. Glower, Haurin and Hendershott (1998) find that the degree to which a house is atypical influences its time on the market and sale price, so it may be important to incorporate the structural characteristics of neighboring houses into the house price hedonic.

The αWx term also captures the influence that the neighborhood characteristics of nearby houses have on the sale price of each house. For example, many neighboring houses will be in the same school district as the observation in question, but not if the house is near the edge of the school district. In such a case, the αWx term allows the quality of the neighboring school district to spill over—possibly through peer group effects—and influence the price of the house in the original school district.

Equation (9) has the following log-likelihood function (Anselin, 1988, p. 181):

$$L = -(n/2)ln\pi - (n/2)ln\sigma^2 + ln\ |I-\rho W| - (1/2\sigma^2)[(I-\rho W)v - x\beta]'[(I-\rho W)v - x\beta] \qquad (10)$$

where n is the number of observations and | • | is the determinant of the matrix. Equation (10) may be simplified to the following concentrated log-likelihood function (Pace and Barry, 1997a):

$$L = C + ln\ |I-\rho W| - (n/2)ln(SSE(\rho)) \qquad (11)$$

where C is a constant and SSE(ρ) is the sum of squared errors associated with a given value of the spatial autoregressive parameter. Ordinarily, repeatedly inverting the 14,619 x 14,619 Jacobian in (11) would tax the computational power of today's fastest personal computers. However, the sparsity of the spatial weight matrix W may be exploited (Pace, 1997; Pace and Barry, 1997a, 1997b) so that a personal computer can handle the large data set estimations with computational ease. This procedure has been demonstrated to greatly improve cross-sectional regression estimates that are spatial in nature (Pace 1998a, 1998b; Pace and Barry, 1997c).

Part of the improvement stems from incorporating the influence of omitted variables (Anselin, 1988, p.103; Pace, Barry and Sirmans, 1998). Traditional hedonic estimation does not address omitted variable bias. Attempts to circumvent the problem include focusing on narrow geographic areas where many influences are already controlled for, or including vast numbers of explanatory variables to capture every influence which diligent data collection can offer. Still, studies with limited geographic coverage have limited appeal, and structural characteristics may be similar within small areas so that multicollinearity problems are exacerbated. In addition, no matter how large the number of explanatory variables, regressions still may omit important influences.

Similar to the way a time lag picks up unobserved influences from the previous period, the non-parametric term ρ picks up unobserved influences that vary across space (Bolduc et al., 1995; Griffith, 1988a, p.82-83). The ρWv term tells how a weighted average of neighbors' house values is related to our own house value. Unmeasured influences help determine the value of neighboring houses and, as explained earlier, the value of neighboring houses is related to the value of our own house. So our own house value is affected by the unmeasured influences of neighboring observations. And the unmeasured influences of neighboring houses are similar to the unmeasured influences for our house because our neighbors are close: the same things that affect our neighbors should affect us, too. So the ρWv term incorporates the influence of omitted variables on the value of our own house.

Furthermore, the model used in the current paper subsumes the case of spatial dependence in the error term. Suppose our regression for house A omits an important variable, like the availability of park services. Our estimation equation has a certain error term. Our regression of house B omits the availability of park services, too. The availability of park services is likely to be similar for nearby houses A and B, so that the error terms are correlated. The mixed regressive spatially autoregressive model used in the current paper accounts for a relationship between the error terms of the neighboring houses, which helps capture the effect of the omitted park service variable, thus addressing omitted variable bias. The spatial model captures air pollution, the presence of shopping centers, interstate highways, lakes, hospitals, and all other omitted variables that vary across space in an analogous manner. In the presence of omitted variable bias, least squares estimates are plagued by a multitude of econometric sins. A detailed proof of how spatial statistics achieves consistent and unbiased parameter estimates, unbiased estimates of the standard errors, and efficient parameter estimates where least squares may not, is available in Griffith (1988a, p. 94-107).

Estimation Results: First Approach

Consolidation may affect house prices through three effects: 1) loss of control, 2) the level of service provision, and 3) the efficiency of service provision. School tax rates are related to efficiency and school quality is related to the level of service provision. To capture the sum of all three effects of consolidation on house prices, it would be necessary to omit the tax rate and public school quality variables. Doing so would seriously misspecify the hedonic. Instead, the hedonic will control for the tax rate and public school quality to isolate the third effect, the capitalization of loss of control. The results of the hedonic regression are found in Column 1 of Table 2:

(Insert Table 2)

The estimated value of the spatial autoregression parameter is 0.32. Because so many explanatory variables are included, 0.32 indicates a moderate degree of spatial autoregressive effects. A likelihood ratio test strongly rejects the null hypothesis of no spatial dependence.[4]

The explanatory variables all have the expected sign, and almost all of them are statistically significant. The inverse Mills ratio is also significant, indicating that sample selection matters. The positive inverse Mills ratio parameter estimate suggests that the houses in the sample are more expensive than the houses excluded from the sample.

The focus variable is CONSOLIDATED. A constant-quality house in a consolidated school district is associated with a 3.5 percent price discount. At the mean, the discount is $2929; having controlled for the school tax rate and school quality the discount is attributed to a loss of control over the provision of public services.

The loss of control discount itself can be split into two components. The first component reflects the fact that the consolidated district is larger than the pre-merger district. More voters means each person's vote matters less. The second component reflects increased heterogeneity in the consolidated district. When two internally homogeneous communities consolidate, the consolidated district has more heterogeneous tastes for schooling. People in the consolidated district must agree on a new level of schooling, a level that is different from the levels provided before consolidation. By controlling for school district size the CONSOLIDATED dummy variable can isolate the portion of the loss of control discount that stems from increased heterogeneity. The regression results are found in Column 2 of Table 2.

As expected, the estimated coefficient of CONSOLIDATED has fallen--but only from 0.035 to 0.033. Controlling for school district size, the discount for being in a consolidated school district is 3.3 percent, or $2762. Almost all the discount from loss of control is triggered by increased heterogeneity of the school district. The capitalized loss of control from an increase in size alone is $2929 - $2762 = $167.

Estimation Results: Second Approach

The preceding analysis has examined the relationship between house prices and the presence of a consolidated school district by focusing on the three primary issues in the consolidation decision: loss of control, the level of service provision, and the efficiency of service provision. It further divided the loss of control into loss of control from increasing the number of people and the loss of control from making the school district more heterogeneous.

The current section of analysis is more directly related to the theoretical model. The theoretical model shows that consolidation may make a community move away from its separately most-preferred level of service provision, tax rate, income levels, and (by extension) racial composition levels. Any move away from the separately most-preferred levels is likely to be reflected in a discount in house prices. The current section finds the gap between the separately most-preferred levels of racial composition, income, school quality and taxes and the actual levels present in the school district. It then tests whether these gaps are reflected in house price discounts.

The easiest gap variables to create are RACE GAP and INCOME GAP. Data is available that tells to which community (municipality) each house belongs. Community racial composition is known, and it is assumed that the racial composition in each community is the preferred amount. Some communities have their own school districts; for such districts RACE GAP, the difference between racial composition in the municipality and racial composition in the school district, will be zero. For communities that have consolidated school districts, RACE GAP will not be zero.[5] When two communities consolidate schooling, the racial composition of the consolidated school district is a mixture of the racial compositions of the communities that belong to the consolidated school district. The extent to which the racial composition of each community differs from the racial composition of the consolidated school district is RACE GAP. INCOME GAP is created in the same way.

SCHOOL QUALITY GAP is more difficult to create. The quality of each school district is observed, but the quality of schooling each community would have if it were independent must be predicted. The difference between predicted and actual school quality is SCHOOL QUALITY GAP, the measure of the extent to which a community has moved away from its separately most-preferred level of school quality. Predicted school quality is calculated with the variables and parameter estimates reported in Brasington (1999a).[6]

A predicted value of TAX RATE must be calculated to find the school tax rate communities in consolidated school districts would choose if they were independent. The tax rate is predicted using variables related to community size and community property valuation.[7] TAX RATE GAP is the difference between the predicted separate tax rate a community would choose and the actual tax rate it faces.

Moving away from most-preferred levels is undesirable, so RACE GAP, INCOME GAP, SCHOOL QUALITY GAP, and TAX RATE GAP are expected to be negatively related to house price. The gap variables are included in the hedonic regression, and the results are found in Column 3 of Table 2.

Three of the four gap variables have negative signs. The parameter estimate of RACE GAP is –0.319. If, by consolidation, school district racial composition changes by ten percent, houses in the community are expected to drop in value by $2670.[8] INCOME

GAP has a parameter estimate of –0.005, which means if a school district consolidation moves average income level away by $10,000, houses in the community are expected to drop in value by $418. Contrary to expectations, SCHOOL QUALITY GAP has a positive sign. The correlation between SCHOOL QUALITY GAP and RACE GAP is 0.54, but experimentation suggests that multicollinearity is not driving the result. TAX GAP has a parameter estimate of –0.004. A consolidation that changes the school tax rate by one mill is expected to reduce house price by $335.

Conclusion

Two communities decide to consolidate if it is in their best interests. School district consolidation affects school quality, efficiency of provision, and control over the educational agenda. If consolidation occurs, the drop in house value from both the loss of control and the decrease in school quality must be offset by increases in scale economies. For the first time, estimates are given for the capitalized value of school district consolidation from all sources.

School district consolidation translates to a decrease in school quality worth $440 in the housing market (Brasington, 1997).[9] The current study suggests the loss of control discount is $2929. Therefore, the capitalized value of scale economy gains from consolidation must be at least $2929 + $440 = $3369, or 4% of the mean house value: otherwise the communities would have voted against consolidation. At the minimum, the magnitude of the effect is almost as large as the capitalized value of central air conditioning. Please note that the $3369 does not represent scale economy gains. It represents the capitalized value of scale economy gains into house price. A direct estimation of the scale economy gains to school district consolidation transcends the scope of the paper.

Table 3 summarizes the relationship between consolidation and house prices:

(Insert Table 3)

A second branch of analysis in the paper examines the house price discount from moving away from most-preferred levels of racial composition, income levels, school quality and tax rates. The racial composition results are perhaps most striking. If school district consolidation changes racial composition by ten percent, house prices are expected to drop by $2670. Recall that the loss of control discount for having a more heterogeneous population was estimated at $2762. Perhaps much of the $2762 discount stems from increasing racial heterogeneity as opposed to income heterogeneity.

Despite its shortcomings, the current study is meant to provide the first estimates of the relationship between house prices and the structure of local government. It has focused on school districts, but future work should explore the relationship between house prices and cooperation in the provision of other public services like public safety. It should also explore the relationship between house prices and political annexation, which affects the provision of all public services.

Appendix: Sample Selection Bias

The sample excludes houses that do not sell, and it excludes houses in school districts that are not clearly consolidated or independent. It is sensible to control for sample selection bias, then. Because there are more theoretical reasons why there may be bias from houses that do not sell, the sample selection discussion will focus less on bias from school districts that are not clearly consolidated or independent.

Haurin and Hendershott (1991) were the first to suggest that hedonic coefficient estimates from a housing sales data set may be biased because certain types of homes are over-represented. Overrepresentation may come from two sources: 1) economic conditions in the neighborhood, and 2) starter homes that sell more frequently than other homes. Jud and Seaks (1994) were the first to correct housing price estimates for sample selection bias. Suppose there is an unobserved variable w* that determines whether or not a house is sold in a census block group during a certain time period. If a house is sold, assume w* is positive and w takes the value 1; if no houses are sold, assume w* is negative and w takes the value 0. The probit that governs the sale is

$$w_i^* = \alpha z_i + u_i, \;\; u_i \sim N(0,1) \tag{A1}$$

$$w_i = 1 \text{ if } w_i^* > 0; \; w_i = 0 \text{ otherwise} \tag{A2}$$

$$\text{prob}\,(w_i = 1) = \Phi(\alpha z_i); \;\; \text{prob}\,(w_i = 0) = 1 - \Phi(\alpha z_i) \tag{A3}$$

where Φ is the cumulative normal function and z is a vector of observable characteristics that determine whether house i is sold.

Let the following represent the traditional hedonic house price estimation:

$$v_i = \beta x_i + \varepsilon_i, \;\; \varepsilon_i \sim N(0, \sigma^2) \tag{A4}$$

where house value v_i is a function of characteristics x_i. In contrast, because house value v_i is only observed when $w_i = 1$,

$$E[v_i \mid w_i = 1] = \beta x_i + \rho\sigma\lambda(\alpha z_i) \tag{A5}$$

where ρ is the correlation between v and w, and λ is the inverse Mills ratio. The bias in (A5) may be ameliorated--but not solved (Kennedy, 1998, p. 252)--by employing the familiar Heckmann (1979) procedure. All the counties that constitute the six major MSAs in Ohio are chosen. A probit is then run in which the dependent variable is a dummy variable for whether the housing transaction or census block group is represented in the sample (EMPTY = 0) or not (EMPTY = 1). Table 1 shows variable definitions, sources and means; Table A1 shows the sample selection probit results.

(Insert Table A1)

It is difficult to guess what might influence the presence of a school district that is not clearly consolidated or independent. It is clearer what might influence the volume of housing sales. The probit results suggest that there are more housing sales in neighborhoods with high incomes, older residents, quick access to work, and a large proportion of white residents. The probit results suggest that there are less housing sales in neighborhoods with high poverty rates, a large proportion of vacant housing units, and a lack of city-provided sewage service. One might expect fewer housing sales in the presence of an environmental disamenity, but the probit results refute the hypothesis.

Although it is possible to criticize the probit for a paucity of explanatory variables, census block groups without housing sales have limited data. Only one available characteristic is excluded from the probit: the percentage of persons holding graduate degrees. Experimentation suggests %GRADUATE DEGREE and %WHITE are somewhat collinear. It is also possible to criticize the probit for having a high ratio of excluded to included observations; however, unequal sampling rates in a probit do not alter the slope coefficients much. Weighting the probit because of unequal sampling rates is unnecessary and improper (Maddala, 1992, p.331). Finally, one may criticize the sample selection probit for being non-spatial while the hedonic regressions use spatial statistics. Finding the precise error structure is a paper in itself (LeSage and Pace, 2002). While imperfect, the sample selection procedure as presented should be no worse than ignoring the problem, and may still do something to ameliorate sample selection bias. The inverse Mills ratio is calculated from the probit and inserted in the hedonic regression.

Table 1
Variable Definitions, Sources and Means

Variable Name	Definition (Source)	Means (Std. Dev.)
	Hedonic Variables	
LOG HOUSE PRICE	House transaction price for 1991 sales, deflated by MSA and logged (1)	11.21 (0.51)
CONSOLIDATED	Dummy variable for whether the school district is consolidated (= 1) or independent (= 0) (4)	0.45 (0.50)
AIR CONDITIONING	Central air conditioning dummy (1)	0.33 (0.47)
FIREPLACE	Fireplace dummy (1)	0.42 (0.49)
OUTBUILDINGS	Number of detached structures on lot (1)	0.03 (0.16)
LOT SIZE	Size of lot in tens of thousands of square feet (1)	1.23 (1.08)
AGE	Age of house in hundreds of years (1)	0.39 (0.22)
HOUSE SIZE	Thousands of square feet of house size (1)	1.51 (0.52)
GARAGE	Garage dummy (1)	0.92 (0.27)
FULL BATHROOMS	Number of full bathrooms (1)	1.32 (0.51)
PART BATHROOMS	Number of partial bathrooms (1)	0.41 (0.51)
PORCH	Porch dummy (1)	0.55 (0.50)
PATIO	Patio dummy (1)	0.15 (0.36)
DECK	Deck dummy (1)	0.12 (0.33)
POOL	Pool dummy (1)	0.013 (0.11)
%WHITE	Proportion of census block group residents who are white (2)	0.91 (0.17)
LOG DISTANCE	Distance from centroid of school district to the central business district in miles, logged	2.39 (0.43)
%GRADUATE DEGREE	Proportion of census block group residents who have a master's or doctorate degree (2)	0.091 (0.093)
INCOME	Average income in census block group in tens of thousands of dollars, deflated by MSA (2)	4.60 (2.08)

%POVERTY	Proportion of persons living under official 1989 poverty income in census block group (2)	0.049 (0.063)
CRIME	Proportion of crimes that are serious. Serious crimes include murder, forcible rape, robbery, aggravated assault, motor vehicle theft, and arson (3)	0.19 (0.13)
ENROLLMENT	Fall enrollment in the school district in thousands of students (5)	5.61 (3.22)
TAX RATE	School property tax rate in mills; property tax collections from school taxes on all real Class 1 (residential) properties divided by 1000, divided by total real Class 1 property valuation (5)	36.4 (7.33)
ENVIRONMENTAL HAZARD	Dummy variable for whether there is an environmental disamenity in the census tract; disamenities are sites "that potentially pose a threat to public health and/or the environment from the release or potential release of hazardous wastes or substances to the environment" (6, p. i)	0.043 (0.20)
LOG PROFICIENCY TEST SCORE	Percentage of ninth-grade students passing the Ohio 9th grade proficiency test in 1990, logged. Average of the passage rates of the math, reading, writing, and citizenship sections (5)	3.67 (0.46)
ARTS	A measure of the number of arts performances, museums, and library holdings in the MSA (7)	0.15 (0.04)
RECREATION	A measure of recreational opportunities in the MSA, including theaters, spectator sports, parks, golf courses, zoos, aquariums, and restaurants (7)	0.23 (0.04)
RACE GAP	Gap between racial composition of school district if district were independent and actual racial composition of school district, in proportions; absolute value of %WHITE of municipality the house is in minus %WHITE of the school district the house is in (2)	0.031 (0.092)
INCOME GAP	Gap between average income levels of school district if district were independent and actual income levels of school district, in tens of thousands of dollars; absolute value of INCOME of municipality the house is in minus INCOME of the school district the house is in (2)	1.25 (1.60)
SCHOOL QUALITY GAP	Gap between predicted proficiency test passage if district were independent and actual proficiency test passage of school district, in percentage points; absolute value of predicted PROFICIENCY TEST SCORE of municipality the house is in minus PROFICIENCY TEST	10.2 (7.6)

	SCORE of the school district the house is in (5,8)	
TAX RATE GAP	Gap between predicted property tax rate if district were independent and actual property tax rate of school district, in mills; absolute value of predicted TAX RATE of municipality the house is in minus TAX RATE of the school district the house is in (5,9)	5.1 (4.6)
	Sample Selection Variables	
EMPTY	Dummy variable for whether the housing transaction or census block group is represented in the hedonic sample (EMPTY = 0) or not (EMPTY = 1)	0.69 (0.46)
AVERAGE AGE	Average age of persons in the census block group in years (2)	34.8 (7.6)
%WHITE	Proportion of census block group residents who are white (2)	0.85 (0.27)
%VACANT	Proportion of buildings in the census block group that are vacant or abandoned (2)	0.044 (0.045)
INCOME	Average income in census block group in tens of thousands of dollars, deflated by MSA (2)	3.99 (2.03)
%POVERTY	Proportion of persons living under official 1989 poverty income in census block group (2)	0.09 (0.11)
HIGH HAZARD	Dummy variable for whether there is an environmental hazard in the census tract rated 'active' by the Ohio EPA (6)	0.006 (0.075)
MEDIUM HAZARD	Dummy variable for whether there is an environmental hazard in the census tract rated 'high' or 'medium' by the Ohio EPA (6)	0.014 (0.12)
LOW HAZARD	Dummy variable for whether there is an environmental hazard in the census tract rated something other than 'high', 'medium' or 'active' by the Ohio EPA (6)	0.025 (0.16)
NO SEWER SERVICE	Proportion of buildings in the census tract that do not have city sewage services (2)	0.044 (0.15)
COMMUTE TIME	Time of commute for average person in census block group, in minutes (2)	20.2 (3.3)

Sources: (1) Amerestate (1991); (2) U.S. Bureau of the Census; (3) Office of Criminal Justice Services of the State of Ohio; (4) Ohio Department of Education (1985); (5) Ohio Department of Education, Division of Management Information Services; (6) Ohio Environmental Protection Agency; (7) *Places Rated Almanac* (Savageau and Boyer, 1993); (8) Brasington (1999a); (9) Ohio Municipal Advisory Council (1993). Number of observations: 14,619 for hedonic variables; 46,745 for sample selection probit variables.

Table 2 Hedonic Regression Results			
Variable	Column 1	Column 2	Column 3
CONSOLIDATED	-0.035* (6.4)	-0.033** (11.4)	-0.033 (0.6)
ENROLLMENT	- -	0.010** (11.2)	0.009* (7.6)
AIR CONDITIONING	0.052** (83.6)	0.046** (73.6)	0.048** (74.0)
FIREPLACE	0.056** (106.6)	0.049** (86.4)	0.054** (90.4)
OUTBUILDINGS	0.010 (3.4)	0.012 (1.8)	0.009 (1.0)
LOT SIZE	0.059** (75.4)	0.069** (82.6)	0.071** (89.6)
LOT SIZE SQUARED	-0.005** (28.6)	-0.006** (36.0)	-0.006** (39.0)
AGE	-0.624** (162.0)	-0.831** (266.8)	-0.824** (266.4)
AGE SQUARED	0.157** (62.2)	0.322** (105.8)	0.323** (92.6)
HOUSE SIZE	0.444** (316.2)	0.415** (274.6)	0.416** (275.4)
HOUSE SIZE SQUARED	-0.047** (48.8)	-0.040** (35.6)	-0.039** (34.2)
GARAGE	0.104** (145.6)	0.098** (143.8)	0.099** (147.4)
FULL BATHROOMS	0.053** (65.6)	0.052** (60.0)	0.056** (73.0)
PART BATHROOMS	0.051** (82.6)	0.051** (85.2)	0.054** (94.6)
PORCH	0.011** (10.4)	0.009** (10.4)	0.008** (10.0)
PATIO	0.021** (11.4)	0.015** (10.8)	0.011** (12.0)
DECK	0.039** (33.6)	0.041** (33.6)	0.044** (34.8)
POOL	0.034 (3.0)	0.038 (4.2)	0.032 (2.8)
%WHITE	0.145** (121.6)	0.148** (99.2)	0.152** (61.4)
LOG DISTANCE	-0.022** (167.6)	-0.089** (76.6)	-0.151** (53.6)

%GRADUATE DEGREE	0.178** (97.0)	0.127** (44.8)	0.196** (41.8)
INCOME	0.009** (112.2)	0.010** (76.6)	0.018** (24.6)
%POVERTY	-0.392** (104.8)	-0.122** (75.2)	-0.020** (57.2)
CRIME	-0.203** (30.2)	-0.079** (27.2)	-0.010** (18.8)
TAX RATE	-0.004** (35.2)	-0.004** (32.6)	-0.003** (18.8)
ENVIRONMENTAL HAZARD	-0.014** (44.6)	-0.007** (27.6)	-0.026** (18.0)
LOG PROFICIENCY TEST SCORE	0.057** (412.2)	0.040** (174.4)	0.037** (106.8)
ARTS	0.484** (34.6)	0.406** (20.4)	0.402** (14.6)
RECREATION	0.415** (25.2)	0.377** (13.4)	0.345* (8.8)
INVERSE MILLS RATIO	0.001** (9.6)	0.001* (8.6)	0.001 (3.6)
RACE GAP	- -	- -	-0.319* (5.6)
INCOME GAP	- -	- -	-0.005* (4.6)
SCHOOL QUALITY GAP	- -	- -	0.005* (7.4)
TAX RATE GAP	- -	- -	-0.004 (2.2)
CONSTANT	7.964** (9934.4)	6.477** (3582.6)	5.673** (1913.8)
Optimal unrestricted log likelihood	-51,352.7	-51,172.8	-51,145.2
Optimal lag coefficient, ρ	0.32	0.27	0.40
SSE	311.9	179.8	135.3
Adjusted R-square	0.92	0.95	0.96

Parameter estimates shown with likelihood ratio statistic (LR) in parentheses below. LR = -2*(optimal unrestricted log likelihood – optimal restricted log likelihood), which is asymptotically distributed as chi-square with degrees of freedom equal to the number of restrictions (two in this case: the variable and its spatial lag are set to zero in the restricted model). Parameter estimates for spatially lagged explanatory variables are suppressed in output but available upon request. **significant at 0.01; *significant at 0.10. Number of observations = 14,619. Dependent variable is LOG HOUSE PRICE.

Table 3
Summary of Relationship Between Consolidation and House Prices

Change in House Value Due To	In Dollars	In Percent
Loss of Control, Total	-$2929	-3.5%
Loss of Control from Increased Heterogeneity	-$2762	-3.3%
Loss of Control from Increased Size	-$167	-0.2%
Change in School Quality►	-$440	-0.5%
Economies of Scale	► $3369	► 4.0%

► From Brasington (1997). All other values come from the current study.

Table A1
Sample Selection Probit

AVERAGE AGE	-0.030** (742.0)
%WHITE	-0.315** (82.8)
%VACANT	3.691** (337.7)
INCOME	-0.058** (244.0)
%POVERTY	2.478** (515.2)
HIGH HAZARD	-0.500** (34.4)
MEDIUM HAZARD	-0.286** (22.1)
LOW HAZARD	-0.641** (209.9)
NO SEWER SERVICE	0.714** (260.2)
COMMUTE TIME	-0.087** (1655.6)
CONSTANT	3.493** (2264.3)

Dependent variable is EMPTY. Parameter estimates shown with Wald F in parentheses below. ** = significant at 0.01. Number of observations = 46,745.

End Notes

1. Haurin and Brasington (1996) use the same cleaning criteria to include those houses in urban areas that are not atypical.

2. One reason a simple spatial autoregressive model is not estimated is that SAS could not handle the large data set with the programming provided by Griffith (1988b). The mainframe computer's capacity was exceeded by at least a factor of six. Spacestatpack statistical software has been designed by Kelley Pace to specifically handle large data sets, and it uses the mixed regressive spatially autoregressive model. Thanks to Kelley Pace for providing Spacestatpack free of charge on the internet at http://finance.lsu.edu/re/kelleyresume.html and www.spatial-statistics.com.

3. See LeSage (1997, 2001) for an excellent, intuitive discussion of the spatial weight matrix in particular and spatial statistics in general.

4. With a critical chi-square of 50.9 at the 0.01 level, the calculated chi-square is 901.6.

5. RACE GAP can still be zero for houses in consolidated school districts if each community in the consolidated district miraculously has the same racial composition.

6. The variables used are related to size, property value and demographic characteristics. School inputs like the pupil/teacher ratio and teacher salary are not available at the municipality level; they are only observed at the school district level. Details of the predicted school quality calculations are available upon request.

7. Regression results are available upon request.

8. The marginal effect of a semilog functional form $\ln y = \beta x$ is βy, which is –0.319*$83,695 = -$26,699. Because the units of RACE GAP are measured in proportions it means a 100% change in racial composition leads to a $26,699 drop. Therefore 10% change leads to about a $2670 drop. Other gap variable interpretations are calculated similarly.

9. Brasington (1997, p. 53) reports that a consolidation that doubles enrollment translates to a $400 drop in constant-quality house price at the mean of $76,115. Adjusting for the higher mean house price of $83,695 in the current study yields a $440 drop in constant-quality house price.

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