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The Demand for Educational Quality: Combining a Median Voter and Hedonic House Price Model

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ABSTRACT

Communities differ in both the bundle of amenities offered to residents and the implicit price of these amenities. Thus, households are faced with a choice of which bundle to select when they select their residence. This choice implies households make tradeoffs among the amenities; that is, the amenities are substitutes or complements. We focus on estimating the demand for one of the most important amenities -- public school quality. We use transaction prices from the housing market and the hedonic house price model to generate the implicit prices of community amenities. The median voter model is used to estimate the income and price elasticities of demand for educational quality. We find that the own price elasticity of demand for schooling is about -0.5 and the income elasticity of demand is about 0.5. New findings include estimates of a set of cross-price elasticities of demand for school quality. We find that a community's income level, percentage white households, and level of public safety are substitutes for school quality.

1. INTRODUCTION

Estimating the demand for education is an important topic in economics. Primary and secondary education is an investment by parents in their children, and highly-educated children enter the labor force with higher human capital. A number of studies have investigated the determinants of the demand for schooling (Rubinfeld 1977; Jud and Watts 1981; Reid 1990; Brasington 2000). Surveying the literature, Reiter and Weichenrieder (1997) report that estimates of own price elasticities of demand for school quality generally range from –0.20 to –0.40. Bergstrom et al. (1982, p.1199) report a range of -0.25 to -0.50. Previous studies generally find income levels to be positively related to the demand for public schooling. Cross-elasticities of the demand for school quality with other community attributes have not been reported.

Our study furthers the empirical investigation of the demand for education, and it relies on information gathered from the housing market to specify the prices of local amenities. The most often used approach to estimate the demand for public school quality is through the median voter approach. A key requirement is that the price of educational quality be observed. We use the hedonic house price model (Rosen 1974) to determine this price, this approach feasible because public school quality is generally found to be an important determinant of the variation in house prices among communities (Haurin and Brasington 1996; Hite, et al. 2001; Downes and Zabel 2002; Figlio and Lucas 2004; Brasington and Haurin, 2006).

The hedonic model also can be used to measure the implicit prices of other local amenities and thus it allows us to estimate various cross-price elasticities of demand for school quality.

We find that the own price elasticity of demand for public schooling is about -0.5, the tax elasticity of demand is smaller, about -0.2, and the income elasticity of demand is 0.5. We estimate what appear to be the first measures of the cross-price elasticities of demand between public school quality and other neighborhood attributes. Specifically, we find that school quality and living in high-income neighborhoods are substitutes, with a cross-price elasticity of about 0.2. A similar result is found for the cross-price elasticity with respect to the percentage white households, while the elasticity with respect to changes in the price of public safety is slightly smaller.

2. THE MEDIAN VOTER APPROACH

A common approach to estimating the demand for a local public good or service such as the quality of public schools is the median voter model, whose empirical origins trace back to Bergstrom and Goodman (1973). In this model, the median voter is assumed to be decisive in determining a community's consumption of a local public good or service. The median voter's demand for quality public schooling is assumed to be a function of the price of schooling in a community and the median voter's characteristics such as income.[1] The demand for schooling

should also be a function of the prices of other local amenities, thus incorporating substitutes and complements into the choice.

Often, data measuring the median value of household characteristics are available for local jurisdictions. Measures of the price of schooling are more difficult to identify, with the local tax price being the most common measure. However, it has long been recognized that the price of owner-occupied housing is influenced by the value of local amenities, including school quality and the level of safety, as well as community characteristics such as the level of income and the percentage of households that are white. Households, when making their locational choice, are clearly affected by the implicit market prices of these characteristics. Thus, while a household may prefer a locality that offers high quality public schools, that community could have high local taxes and/or a relatively high price of housing due to capitalization of school quality. The levels of other community attributes also are likely capitalized into house prices. A household thus must make tradeoffs among various bundles of local amenities, with each amenity priced in the housing market. Through the hedonic price model these implicit prices can be estimated. The availability of these implicit prices allows us to measure the own and cross-price elasticities of demand for schooling.

For example, consider a family with children that has a strong preference for high educational quality. To achieve a good outcome for their child, they prefer localities with good schools, but also value a safe environment, and perhaps good

peers for their child. These preferences will induce demands for local amenities, but if the amenities' relative prices vary across communities, the household will substitute among them when maximizing utility. Whether safety and public school quality are substitutes or complements must be estimated empirically, with similar questions about the relationship of the demand for education and the income and racial composition of a community.

Does the rate of local amenity capitalization vary spatially? Brasington (2002) found that there is an inverse relationship between the elasticity of housing supply and capitalization rates. Specifically, he found that the capitalization of schooling and crime was weaker toward the edge of an urban area where housing supply elasticities and developer activity are greater. Thus, the "entry price" into a community offering a particular bundle of schooling and other amenities varies over space not only because the bundle differs but also because the implicit prices of a community's amenities differ.

Goldstein and Pauly (1981) criticized the median voter approach, suggesting that because of imperfect Tiebout sorting (1956) the median voter should not be chosen based solely on income, and thus we estimate two versions of the model. The first is the traditional median voter approach and the second includes additional variables suggested by Rubinfeld, Shapiro, and Roberts (RSR 1987) that mitigate Goldstein and Pauly's "Tiebout bias".

The median voter model to be estimated takes the following form:

1) $$\log s_k = \gamma_1 \log (y_k) + \gamma_2 \log (\tau_k) + \sum_{i=1}^{n} \gamma_{3ik} \log (p_{ik}) + \gamma_4 (z_k) + \varepsilon_1$$

where s is school quality in the k-th community, y is median income, τ is the tax price, $p_{i=s}$ is the own price of school quality, the other p_i are other goods' prices, and z is a matrix of controls suggested by RSR (1987) to mitigate Tiebout bias.[2] In our analysis of substitutes and complements for school quality, we focus on community-level attributes such as community safety, income, and racial composition. In general, a household has the choice of many types and sizes of houses within a community and thus it need not face tradeoffs between school quality and house characteristics.

Using the hedonic price model, we derive implicit prices of housing attributes including those of the community such as school quality. The price function's form is:

2) $$\ln e_{Hjk} = \beta \Lambda_{jk} + \delta \Phi_k + \varepsilon_{jk},$$

where the j-th household's expenditure on housing is $e_{Hjk,}$ k represents the community selected by the household, Λ is a vector of house and lot characteristics, Φ represents community characteristics, and ε_{jk} is the error term. Following Brown and Rosen (1982), we use 2) to calculate the implicit prices p_1, p_2,...p_n of the components of housing.[3]

4. DATA AND IMPLEMENTATION

The primary source of data for the hedonic house price regressions is a record of single family home purchases that occurred during 1991 in Ohio (Amerestate 1991). We focus on non-farm urban properties and thus any house with lot size greater than two acres is deleted. Houses that transact at prices above $400,000 ($1991) are deleted as being unrepresentative, and houses that transact for less than $10,000 are deleted because they likely are either uninhabitable or a gift between family members. In addition, properties that are outliers in square feet of housing and garage size are deleted. Any community with less than 17 house transactions is deleted for fear of not producing a reliable hedonic estimates. Our sample consists of 40,116 houses in 134 communities, and the mean deflated house value is $73,107.[4] The *School District Data Book* (MESA Group, 1994), the Ohio Department of Education, and the Office of Criminal Justice Services of the State of Ohio provide the remainder of the explanatory variables. Variable means and standard deviations are in Table 1.

[INSERT TABLE 1]

The first step of the empirical analysis is to estimate the implicit prices of community characteristics. We estimate six hedonic house price equations covering six Ohio MSAs (Akron, Cincinnati, Cleveland, Columbus, Dayton, and Toledo). The estimation of multiple house price equations and a single demand equation identifies the demand equation from the house price hedonics (Brown

and Rosen 1982; Clark and Cosgrove 1990; Beron, Murdoch and Thayer 2001; Brasington and Hite 2005). The dependent variable in the house price hedonic equation is the log of house price and the results are listed in Table 2.

The hedonic estimations fit the data well and the explanatory variables have the expected signs. School quality is measured by the performance of a community's students on a proficiency test that measures the percentage of students in each school district who pass all four sections of the statewide ninth grade proficiency exam. Its coefficient is positive and significant implying a positive implicit price. Median community income, the level of safety, and the percent of white residents in a community all have positive implicit prices. Income is significant in all six MSAs, safety is significant in two, and the percentage white is significant in five. The implicit prices of community amenity variables differ among communities within an MSA because they are functions of the average house value in the community, and they vary between MSAs for this reason and because their coefficients in the hedonic equation differ.

[INSERT TABLE 2]

The form of the median voter equation is specified in 1). The dependent variable is the natural log of the school quality measure. Explanatory variables include the community's median household income, the tax price of local public goods[5], the own price of school quality, the prices of other community attributes, and the set of RSR variables to capture the sorting of residents to desired public

service levels. The RSR variables are a central city dummy variable and the proportion of new residents. The central city dummy variable represents the resident's lack of choice among public good bundles; people may sort to central cities for reasons not related to public good bundles, such as access to work is more convenient or they face discrimination. The proportion of residents who have lived in the community for less than six years is chosen to represent newcomers. Because newcomers have moved in recently, the level of public services provided is probably similar to the level that induced the residents to move to the community.

5. RESULTS

Means for the variables used in the demand estimation are presented in Table 3 and the regression results are shown in Table 4. Nearly all of the variables have statistically significant parameter estimates.

[INSERT TABLES 3 AND 4]

Table 4 shows that the estimate of the price elasticity of demand for school quality ranges from -0.56 to -0.53 in the two specifications. The implication is that that greater the extent that school quality is capitalized into house prices, the lower the median voter's demand for schooling. Households also pay for school quality through local taxes and higher taxes generate a demand response with elasticity estimates ranging from -0.05 to -0.11. Prior studies found tax price elasticities of demand for schooling between -0.20 and -0.40; however, they did not also control

for the impact of school quality on house prices (Reiter and Weichenrieder, 1997). The median voter model also yields an estimate of the income elasticity of demand for public school quality. We find the two estimates are 0.46 and 0.57, higher than that found all previous studies except Jud and Watts (1981), who find an income elasticity of 0.70.

Our study is unique in that it analyzes the complements and substitutes for public schooling consumption. Our hedonic house price estimates indicate that high income in a community is valued as an amenity and it increases the price of housing. We also find that the quality of public schooling in a community and the presence of high-income neighbors are substitutes. The magnitude of the effect is relatively small, though, with elasticity estimates ranging from 0.18 to 0.20. We also find that public schooling and public safety are substitutes. Again, the elasticity is small, the estimate being 0.14. Finally, we find that public school quality and racial composition are substitutes, with the cross-price elasticity estimate being 0.14 to 0.16.

6. CONCLUSION

Voting models argue that the demand for public goods and services can be determined from the choice of the median voter in a community. Communities differ in the cost to households of local public goods due to variations in both the tax price and their market prices as revealed through variations in house prices,

both within and across metropolitan areas. These variations imply that the median voter household must select among local amenity bundles. The demand relationships among the set of local public goods and services have not been estimated in prior studies. The cross-price elasticities with respect to public schooling are particularly interesting because of the importance of school quality in household locational choices.

The implicit prices of local amenities are generated from a hedonic house price estimation using Ohio data. The sample consists of house-level data drawn from a large number of communities in six MSAs. We use these prices to estimate own and cross-price elasticities of demand for public school quality. We find the price elasticity of demand for schooling is between -0.5 and -0.6 and the income elasticity of demand is about 0.5. The cross-price elasticity between public safety and school quality is about 0.15 suggesting they are weak substitutes. The cross-price elasticity between the percentage white in a community and the quality of public schools also is about 0.15. Finally, we find the cross-price elasticity of demand between school quality and a household's decision to locate in a high-income neighborhood is about 0.2.

These results expand our understanding of the choices made by households when faced with an array of implicit prices for a vector of local public goods. While the cross-price elasticities simply reveal empirical relationships among a set of goods, they are plausible. For example, if the price of safety in a

locality is high, the median voter's demand for school quality rises. Good schools may be viewed as a substitute for a safe environment for children. Similarly, if high-income neighbors results in a good set of peers for children, then if the price of a high-income neighborhood is high (good peers are more expensive), the median voter's demand for public school quality rises. Again, the estimated relationship is reasonable.

	Table 1 Variable Definitions and Means: Hedonic House Price Model	
Variable Name	Definition (Source)	Mean (Std. Dev.)
House Price	Sale price of house, deflated by the urban area's cost of living index (1)	62.27 (26.58)
Air Conditioning	Dummy variable for whether a house has air conditioning (1)	0.31 (0.46)
Fireplace	Dummy variable for whether a house has at least one fireplace (1)	0.32 (0.47)
Lot Size	Size of lot, in thousands of square feet (1)	9.16 (6.09)
Age	Newness of a house = maximum age of a house in the sample in years (166) less the actual age of a house (1)	122.60 (23.82)
Rooms	Number of rooms the house has (1)	5.93 (1.14)
Garage	Dummy variable for whether the house has a garage (1)	0.84 (0.36)
Full Bathrooms	Number of full bathrooms (1)	1.21 (0.42)
Part Bathrooms	Number of partial bathrooms (toilet but no shower) the house has (1)	0.29 (0.46)
Deck	Dummy variable for whether the house has a deck (1)	0.09 (0.29)
Pool	Dummy variable for whether the house has a swimming pool (1)	0.01 (0.11)
Q2	Dummy variable for whether the house was sold in the second quarter of the year (1)	0.30 (0.46)
Q3	Dummy variable for whether the house was sold in the third quarter of the year (1)	0.27 (0.45)
Q4	Dummy variable for whether the house was sold in the fourth quarter of the year (1)	0.24 (0.43)
Income	Average income of the community (school district) in thousands of dollars, deflated by urban area cost of living index (2)	30.62 (12.46)
Proficiency Test Score	Percentage of students passing all four sections of the Ohio 9th grade proficiency test in 1990. The sections are math, reading, writing, and citizenship (3)	31.60 (17.10)
Distance	Distance of centroid of the school district from the central business district of relevant urban area, in miles	21.64 (6.83)
Safety	Inverse of the number of serious crimes per 1,000 community residents. Serious crimes include murder, forcible rape, robbery, aggravated assault, motor vehicle theft, and arson (4)	0.78 (0.13)
Percent White	Proportion of community residents who are white, non-Hispanic (2)	0.82 (0.18)
The number of observations is 33,876. Sources: (1) Amerestate (1991); (2) *School District Data Book* (MESA Group, 1994); (3) Ohio Department of Education; (4) Office of Criminal Justice Services (1994)		

Table 2 Hedonic House Price Regression						
Variable	Akron	Cincinnati	Cleveland	Columbus	Dayton	Toledo
Intercept	6.17**	8.04**	7.52**	7.49**	7.52**	5.95**
Air Conditioning	0.08**	0.12**	0.05**	0.12**	0.13**	0.10**
Fireplace	0.14**	0.16**	0.14**	0.19**	0.13**	0.16**
Lot Size	0.002	0.016**	0.016**	0.034**	0.018**	0.032**
Lot Size Squared	-0.20×10^{-5}	-0.17×10^{-3}	-0.21×10^{-3}**	-0.46×10^{-3}**	-0.23×10^{-3}**	-0.50×10^{-3}**
Age	-0.001	0.007**	0.014**	-0.000	0.008**	0.028**
Age Squared	0.34×10^{-4}**	-0.11×10^{-4}*	-0.36×10^{-4}**	0.14×10^{-4}*	-0.14×10^{-4}**	-0.86×10^{-4}**
Rooms	0.19**	0.06**	0.10**	0.17**	0.18**	0.03**
Rooms Squared	-0.010**	0.001	-0.004**	-0.007**	-0.008**	-0.011**
Garage	0.22**	0.14**	0.21**	0.10**	0.26**	0.29**
Full Bathrooms	0.16**	0.12**	0.12**	0.13**	0.11**	0.21**
Part Bathrooms	0.11**	0.03**	0.13**	0.10**	0.11**	0.15**
Deck	0.032	0.052**	0.070**	0.046**	0.092**	0.083**
Pool	0.042	0.034	0.028	0.078	0.086**	0.058
Q2	0.044**	0.051**	0.062**	0.072**	0.050**	0.016
Q3	0.049**	0.058**	0.065**	0.070**	0.043**	0.023
Q4	0.054**	0.063**	0.066**	0.070**	0.039**	0.003
Log Proficiency Test Score	0.30**	0.11**	0.14**	0.12**	0.072**	0.088
Income	0.0049**	0.0033**	0.0058**	0.0057**	0.0057**	0.0039**
Distance	0.004	0.011**	0.011**	0.028**	0.018**	0.014
Safety	0.17	0.51**	0.14**	0.02	0.06	0.22
Percent White	1.76**	0.16*	0.33**	0.63**	0.51**	0.20
Number of observations	2550	5240	13963	7602	6879	3882
Adjusted R-Sq.	0.68	0.71	0.66	0.60	0.70	0.74
Parameter estimates are shown. **significant at .05, *significant at .10, otherwise statistically insignificant. Dependent variable is the natural log of House Price.						

Table 3 Variable Definitions and Means: Median Voter Model	
Variable	Means
Own Price: Implicit price of school quality, in dollars	185
Income: The median community income, in thousands of dollars	39.1
Price of Income: Implicit price of community income, in dollars	272
Price of Race: Implicit price of the percent of community residents who are white, in dollars	26.91
Price of Safety: Implicit price of lack of violent crimes, in dollars	10.35
Tax Price: House value multiplied by the community property tax rate, divided by taxable property valuation per pupil	0.03
Central City: A dummy variable, 1 if central city	0.03
Newcomer: Proportion of residents who have lived in the community for less than six years	0.45
Number of observations is 135 communities (school districts).	

Table 4 Demand for School Quality		
Variable	School Quality	School Quality
Log Own Price	-0.56**	-0.53**
Log Median Income	0.57**	0.46**
Log Price of Income	0.18**	0.20**
Log Price of Race	0.14*	0.16**
Log Price of Safety	0.14**	0.14**
Log Tax Price	-0.05	-0.11**
Central City	-	-0.23*
Newcomer	-	0.85**
Intercept	0.86*	0.40
Adjusted R-square	0.77	0.79
** = significant at 0.05, * = significant at 0.10. The dependent variable is the natural log of School Quality and the number of observations is 135 communities (school districts).		

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ENDNOTES

[1] Data sets do not identify the median voter, so researchers must find proxies for the values of the explanatory variables of the median voter.

[2] Rubinfeld, Shapiro, and Roberts (1987) show that household sorting can bias estimates of demand elasticities in both micro level and aggregate data. They identify variables that are likely to affect sorting but not demand (p. 432) such as the percentage of recent movers and a variable that indicates the amount of jurisdictional choice that is available.

[3] The implicit prices are the partial derivatives of house price with respect to each house characteristic. Here they equal the coefficient of an explanatory variable multiplied by the house value. Recent examples of the calculation of the implicit price of characteristics from house price hedonics include Brasington (2000), Beron, Murdoch and Thayer (2001), and Brasington and Hite (2005).

[4] Dollar denominated variables are deflated (1991 base year) using cost of living estimates at the metropolitan statistical area level (ACCRA 1991, 1992).

[5] The tax price is defined to be house value multiplied by the community property tax rate, divided by taxable property valuation per pupil. The taxable property value per pupil depends on multiple factors exogenous to the median voter such as the number of pupils in the community and the amount of nonresidential property.