Tiebout Goes to College: Evidence From the HOPE Scholarship Program

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Abstract - Georgia's HOPE Scholarship program, which began in the fall of 1993, uses new lottery funds to provide free tuition at state universities to high school graduates with at least a B average. The introduction of this popular program provides a novel opportunity to evaluate the impact of local public goods on residential choice. This empirical study addresses whether there was a Tiebout response to the introduction of the HOPE Scholarship by evaluating its impact on the volume and value of new single-family residential construction. This study employs 1990-1996 data from the Census Bureau's Building Permits Surveys for the permit-issuing places in three Metropolitan Statistical Areas (MSA): Chattanooga, TN-GA; Columbus, GA-AL and Augusta-Aiken, GA-SC. The identification strategy employed in this study exploits the fact that these unique MSA include permit-issuing municipalities on both sides of the Georgia state line. The "difference-in-differences" and fixed-effects estimates based on this research design suggest that the HOPE Scholarship program had dramatic and empirically robust effects, increasing the volume and value of residential construction on the Georgia side of these MSA by 30-45% relative to neighboring out-of-state jurisdictions. Similarly specified models of enrollments in public elementary schools provide supporting evidence for these results. However, there is also qualified evidence that the magnitudes of these effects are declining over time.

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I. INTRODUCTION

Those who live in the metropolitan area surrounding Chattanooga, Tennessee enjoy the option of choosing to reside either within Tennessee or across the state border in northwestern Georgia. The conventional wisdom in this region has historically been that there is an incentive to prefer a residence in Tennessee since there is no income tax in that state. However, Georgia's new college scholarship program may have sharply changed the dimensions of these locational decisions. The HOPE (Helping Outstanding Pupils Educationally) Scholarship program, which began in a limited way in the fall of 1993, uses lottery funds to provide free tuition at state colleges and universities for Georgia high school students who have at least a B average. [1] Both realtors and home-builders in the Chattanooga metropolitan area have claimed that the introduction of the HOPE Scholarship program had a dramatic impact on their business, shifting the pattern of housing demand and residential construction sharply to the Georgia side of the state line (Carey, 1997).

These anecdotal observations suggest that the introduction of the HOPE Scholarship program may provide a novel and highly illustrative example of the Tiebout model in action. The seminal model of Charles Tiebout (1956) envisions a world in which the choice of where to live is influenced in part by the quality and tax cost of local public goods like education. Beginning with a celebrated paper by Oates (1969), a number of empirical studies have tested the Tiebout hypothesis by estimating the impact of public good attributes on outcomes in real estate markets. In particular, much of this literature has focused on whether the attributes of elementary and secondary public schools are capitalized into property values.[2] The basis for these tests is straightforward: if the Tiebout hypothesis is correct, residents should "vote with their feet" and, in the process, increase the demand and equilibrium price for residential properties in areas with relatively high-quality, low-cost public goods.[3]

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[1] The development of the HOPE Scholarships is described in more detail later in this paper.
[2] For recent examples, see Black (1997) and Bogart and Cromwell (1997).
[3] In theory, an elastic supply-side response combined with flexible zoning could attenuate, if not negate, such capitalization effects. In practice, these conditions do not appear to exist and the phenomena of capitalization has been identified in a wide variety of studies (Yinger et. al., 1988).

The introduction of the HOPE Scholarship program in Georgia presents a unique opportunity to evaluate the responsiveness of residential choice to local public goods. In large part, this is because the HOPE Scholarship program provides a dramatic and plausibly exogenous shock to the set of public goods linked with residence in Georgia.[4] Most empirical studies of Tiebout behavior have, by necessity, relied on the relatively small and possibly confounded variation in public sector inputs (e.g. per-pupil school expenditures) or outputs (e.g. elementary and secondary student test scores). More specifically, a standard empirical conundrum in this literature involves effectively distinguishing the effects of the public good attributes from the unobserved neighborhood attributes that are also likely to influence outcomes in real estate markets (e.g. Epple, 1987). For example, residences in high-quality school districts command a higher price. However, it is often unclear whether this link reflects the entire value that parents place on school quality or the many unobserved neighborhood features that are likely to be correlated with both school quality and higher property values.[5] In contrast, the introduction of the HOPE Scholarship program led to a sharp and plausibly independent change in the quality of Georgia's public goods: the promise of a highly subsidized post-secondary education. If the Tiebout hypothesis is accurate and residential choice is responsive to such public goods, the introduction of the HOPE Scholarships should have increased the demand for residences within Georgia.

This empirical study addresses whether there was a Tiebout response to the introduction of the HOPE Scholarship by evaluating its effects on the volume and value of new single-family residential construction. This study employs 1990-1996 annual data from the Census Bureau's Building Permits Surveys for the permit-issuing places in three Metropolitan Statistical Areas (MSA): Chattanooga, TN-GA; Columbus, GA-AL and Augusta-Aiken, GA-SC. Evaluating the activity in these three border MSA

[4] Another unique contribution of evaluating the Tiebout response to the HOPE Scholarship program would be the focus on inter-state locational choice in response to a state-level good (i.e. higher education). Traditional tests of the Tiebout hypothesis have largely focused on local rather than state-level public goods (e.g. elementary and secondary schooling).

[5] Black (1997) addresses this concern through an unusual research design that effectively compares neighboring properties that differ only in their associated schools. She finds that this approach reduces the magnitude of the estimated Tiebout response by 50%.

focuses the attention of this study on the three ostensible Tiebout markets in which a behavioral response to the HOPE Scholarships is most likely to have occurred. It also facilitates a compelling identification strategy. Each of these MSA includes permit-issuing municipalities on both sides of Georgia's state line. The "difference-in-differences" and fixed-effects estimates presented here exploit this fact and the panel nature of the data to introduce controls for the unobserved time-varying determinants of residential construction activity that might otherwise be confounded with the true effect of the HOPE Scholarships.

The results of these estimations strongly support the casual empiricism of observers within these communities. The introduction of the HOPE Scholarship program is associated with a dramatic shift in the pattern of new residential construction activity. More specifically, the results presented here suggest that the HOPE Scholarship program increased the construction of single-family housing units on the Georgia side of these MSA by roughly 30% relative to neighboring out-of-state jurisdictions. Similarly, these results also suggest that the HOPE Scholarship program increased the real value of new residential construction by over 40%. These dramatic effects are both empirically robust and, in preferred specifications, statistically significant.[6] As an important robustness check for these findings, this study also presents estimates from similarly specified models of a different outcome: enrollments in elementary public schools. These models are based on annual district-level data from the National Center for Education Statistics' Common Core of Data for the 1990-95 school years. Like the results based on housing permits, the evidence from the school enrollment data supports the existence of a large, empirically robust and statistically significant Tiebout response to the HOPE Scholarship program.[7] In other words, the evidence from both data sources suggests that the HOPE Scholarship program has provided novel and dramatic evidence on the responsiveness of residential choice to the goods and services provided by governments.

[6] However, there is also qualified evidence that the magnitudes of this effect are declining over time. The qualification on any conclusions regarding dynamic adjustments is due in part to the limitations created by the fairly limited amount of time-series variation in construction activity after the HOPE Scholarships.

[7] More specifically, the HOPE Scholarship program is associated with a 4% increase in elementary school enrollments. The plausibility of the magnitudes of the estimated responses from the two data sets is discussed later.

II. DATA

This study employs annual data on new residential construction, which are drawn from the Census Bureau's 1990-1996 Building Permit Surveys. These surveys are based on responses by local building permit officials to mailed questionnaires but are also supplemented with information from the Survey of Use of Permits (SUP). The units of observation for these data are the permit-issuing jurisdictions (e.g. municipalities, counties, townships, unincorporated areas, etc.). The two key variables drawn from these annual surveys are the number of permits for new privately owned single-family housing units and the valuation on those units. This study's focus on the construction of single-family housing units should increase the power of the statistical inferences since demand for them is most likely to change in response to the HOPE Scholarships and because the supply of such units should be more immediately responsive.[8] Additionally, having measures for both the volume and value of this residential construction makes it feasible to examine the possible existence and magnitude of both quantity and price responses to the HOPE Scholarships.[9]

The initial selection of a data set for this study was based on extracting annual permit and valuation data from the 1990-96 period for permit-issuing places in the Chattanooga MSA (Catoosa, Dade and Walker counties in Georgia; Hamilton and Marion counties in Tennessee), in the Augusta-Aiken MSA (Aiken and Edgefield counties in South Carolina; Richmond, McDuffie and Columbia counties in Georgia) and in the Columbus MSA (Russell County in Alabama; Harris, Muscogee and Chattahoochee counties in Georgia). This selection produced a data set with 300 observations. However, six permit-issuing places did not have data for each of the seven years addressed in this study. Their deletion reduced the sample size to 280.[10] The data for Richmond County and Augusta, GA were effectively

[8] Nonetheless, similar results emerge in models based on total housing units.
[9] However, it is important to note that the relative growth in value does not necessarily suggest capitalization since the mix of housing attributes may have also changed in response to the HOPE Scholarship program.
[10] The six places were New Ellenton, SC; Unincorporated Catoosa County, GA; Monteagle, TN; Whitwell, TN; Pine Mountain, GA and Unincorporated Chattahoochee County, GA. The "unbalanced" panel nature of these few observations could reflect a selection that relates to the HOPE Scholarship program. Therefore the subsequent inferences should be benignly understood as conditional on belonging to the "balanced sub-panel."

reported together for 1996. Therefore, the reported values for prior years were aggregated as well, reducing the data set to 273 observations.

For fourteen of the smaller permit-issuing places in this data set, there are some periods in which it was reported that no permits were issued. In the analyses presented here, the data for such places were aggregated with the data for neighboring places within the same county. This aggregation created 6 permit-issuing places out of the group of fourteen (see Table 1). A central motivation for this modest aggregation is that it helps ameliorate the widely varying scales of these permit-issuing places. In particular, it allows a logistic transformation of the key variables to be defined.[11] In this case, the use of this standard transformation also improves the priors for making valid statistical inferences.[12] The final data set consists of 217 observations: 31 panel observations observed annually over a 7-year period (see Table 1). The average number of new single-family housing units built in these places annually was 163.[13] In 1996 dollars, the average valuation of this construction was $14,654,000 (Table 2). This implies that the average real value of a new housing unit was just over $89,900.

III. HELPING OUTSTANDING PUPILS EDUCATIONALLY (HOPE)

The funds for the HOPE Scholarships are drawn from Georgia's recently created state lotteries. On November 2, 1992, 52.2% of Georgian voters approved an amendment to the state constitution that allowed the Governor to initiate lottery operations in Georgia. The stated purpose of these lotteries was to provide new funds for educational purposes.[14] In particular, the lottery revenues set aside for educational purposes are spent in three general areas: the HOPE Scholarships, pre-kindergarten programs for at-risk

[11] The semi-log specification made possible by this transformation is frequently employed in this literature (e.g. McGibany, 1991) and is used for the results presented here as well.
[12] The transformed variables have skewness and kurtosis substantially more like those of the normal distribution. Nonetheless, estimations of simple linear specifications which do not aggregate these data return similarly signed though less precise results than those reported here.
[13] The Bureau of the Census imputes some of these data. However, estimations based on the smaller panel of unimputed data generate similar though less precise results.
[14] In fact, the Georgia laws are explicit in that 31% of lottery revenues are reserved for education, 50% are returned as prizes and 19% are for operating costs and commissions (Stanley, 1994).

children and equipment and capital needs for schools.[15] The first sale of state lottery tickets after this vote began on June 29, 1993. The per-capita sales in the first year of the new Georgia lotteries were surprisingly high ($132.05) and surpassed the previous marks set by California and Florida lotteries (Stanley, 1994).[16]

The HOPE Scholarship program began providing support to students in the 1993-94 academic year. For students at state colleges and universities, HOPE Scholarships cover tuition, mandatory fees and a book allowance.[17] However, in part because of the considerable uncertainty over the magnitude of lottery revenues, support in the HOPE Scholarship's first year was limited to the roughly 8,600 freshman and sophomores in state colleges with annual income of no more than $66,000 (Vickers, 1994). In the 1994-95 school year, the income cap for HOPE Scholarships was expanded to $100,000 and, in the 1995-96 school year, the income caps were removed entirely. By the 1996-97 school year, the HOPE Scholarship program supported roughly 124,000 students at a direct cost of $159 million (Applebome, 1996).

In the empirical models presented here, the covariates of interest are designed to represent the introduction of the HOPE Scholarship program. More specifically, the most basic key variable, *HOPE Scholarship*, is a binary indicator that equals one for Georgia permit-issuing places after 1993 and zero for all other observations. By construction, this formulation assumes that an effect on residential construction activity would not be observed until 1994. Given the early uncertainty regarding the scope of the HOPE Scholarship and the lag time required to organize new construction activity, this design of the key covariate seems appropriate a priori.[18] However, one limitation of the *HOPE Scholarship* variable is that it assumes that the effect of the HOPE Scholarships in 1994 is equivalent to its effects in

[15] Some of the education funds are also set aside as insurance against a decline in lottery revenues. In principle, all of this lottery-funded educational spending could generate a Tiebout response. However, the broad applicability and popularity of the HOPE program as well as the unclear link between school district spending and school quality suggest that the HOPE program is the likely source of a Tiebout response.

[16] Four of the five states that border Georgia have no lotteries and sales along these borders are strong.

[17] HOPE Scholarships also provide support for attending the state's two-year technical colleges and a voucher for in-state private colleges and universities.

[18] Redefining the HOPE variable to include 1993 observations confirms this prior expectation.

1995 and 1996. There are several reasons to think this might not be so. First, the expansion of HOPE's support over this period to higher income brackets may have meant that the effect of the scholarship program was growing over this period.[19] The possibility of this sort of dynamic effect is reflected in a variable that interacts *HOPE Scholarship* with *Years Since 1993*. The variable, *Years Since 1993*, equals 1 in 1994, 2 in 1995, 3 in 1996 and 0 for all other observations. The admittedly ad-hoc construction of this interaction term is meant to detect a marginal effect that is relatively small in 1994 but grows linearly in 1995 and 1996.

A second possible dynamic response to HOPE Scholarships would be reflected in a marginal impact whose magnitude diminished over time. For example, this might be appropriate if most families that wished to move in response to the HOPE program did so in its early years. This sort dynamic response is heuristically modeled by an interaction between *HOPE Scholarship* and *Years From 1997*. The variable, *Years From 1997*, equals 1 in 1996, 2 in 1995, 3 in 1994 and so on. Because this variable is interacted with the binary *HOPE Scholarship* variable, the interaction is only "turned on" for Georgia observations between 1994 and 1996. The interaction of *HOPE Scholarship* and *Years From 1997* is meant to detect a marginal effect that is largest in 1994 and then diminishes linearly in both 1995 and 1996. Both of these interaction terms will provide some evidence on the early dynamic adjustment of residential construction to the HOPE Scholarships. However, the evidence generated by models that include these variables is qualified both by the functional constraints implicit in the variable construction as well as by the limited time-series dimension available to identify these effects. Descriptive statistics for the 3 variables representing the HOPE Scholarships are presented in the second column of Table 2.

IV. DIFFERENCE-IN-DIFFERENCES ESTIMATES

The estimation strategy this study employs to identify a potential Tiebout response to the HOPE Scholarship program is based explicitly on the panel nature of the data and the fact that in these 3 MSA,

[19] However, when the income cap was at $100,000 only 5 percent of Georgia's families were then ineligible.

there are permit-issuing jurisdictions on both sides of Georgia's border. In particular, the source of identification in these empirical models can be clearly illustrated by constructing simple "difference-in-differences" estimators. In this context, a difference-in-differences estimator is based on evaluating the following basic model:

$$Y_{ist} = \mu_s + \nu_t + \gamma H_{st} + \varepsilon_{ist} \quad (1)$$

where variable, Y_{ist}, represents the logistic transformation of either the number of residential building permits or the real valuation of those permits for place i in state s at time t. The term, μ_s, is a binary indicator equal to one for places in Georgia and zero for places outside of Georgia. The term, ν_t, is a binary indicator equal to one for places when in the post-HOPE Scholarship period (1994-1996) and 0 for the prior period. The variable, H_{st}, is the binary *HOPE Scholarship* indicator introduced in the previous section and ε_{ist} is a mean-zero random error. Under the assumptions implicit in this simple model, it is straightforward to show (Meyer, 1995) that an unbiased estimate of γ takes the following form:

$$\gamma_{DD} = [E(Y_{ist}|\mu_s=1, \nu_t=1) - E(Y_{ist}|\mu_s=1, \nu_t=0)] - [E(Y_{ist}|\mu_s=0, \nu_t=1) - E(Y_{ist}|\mu_s=0, \nu_t=0)] \quad (2)$$

The first bracketed term on the right-hand side of equation (2) consists of the evaluation parameter of interest, γ and the contemporaneous time-series effect, ν_t. Their combination represents the average change in the volume (or real value) of Georgia's residential construction after the HOPE Scholarships. It might be a mistake to attribute all of this within-state variation to the HOPE Scholarships since that could confound the program's true effect, γ, with those of the other time-varying determinants measured by ν_t. The difference-in-differences estimator, γ_{DD}, corrects for this possibility by subtracting the second bracketed term, which represents the time-varying changes in neighboring places across the Georgia border. The difference in these differences, γ_{DD}, ostensibly represents the changes in Georgia due solely to the HOPE Scholarships. The key identifying assumption is that, given the controls in equation (1), γ would equal zero were it not for the effect of the HOPE Scholarships. In other words, as in any classical regression, the regressor, H_{st}, must be independent of the error term. The history of the HOPE Scholarship program discussed in previous section suggests that its introduction was independently given.

The regression-adjusted models presented in the next section provide additional and more direct evidence on the orthogonality of H_{st}.

There is, however, an important caveat to how the magnitude of the evaluation parameter, γ, can be interpreted here. It is rooted in how we understand the source of the hypothesized increase in demand for single-family residences in Georgia. In most similarly specified econometric evaluations, one can assert that the treatment of interest (in this context, the HOPE Scholarships) had absolutely no effect on the neighboring jurisdictions that provide a control for the unobserved time-series variation. However, in this application, it is reasonable to suppose that the HOPE Scholarship program had an indirect effect on the neighboring communities in Alabama, Tennessee and South Carolina. More specifically, the HOPE Scholarships may have increased the demand for new Georgia residences among those who would have otherwise built within the MSA but outside of Georgia. This implies that γ_{DD} may overestimate the absolute effect the HOPE Scholarships have had in Georgia's communities. For example, suppose that all of the demand for new housing in Georgia that was inspired by HOPE Scholarships came at the expense of the demand in neighboring communities. Parametrically, this can be captured by having the variable *HOPE Scholarship* equal –1 for communities outside Georgia when it equals 1 for those in Georgia. It is straightforward to show that the γ implied by this variable construction is one-half that implied by the conventional difference-in-differences and fixed-effects estimates presented here. Because of this ambiguity, the magnitudes of the estimated γ reported here are always interpreted as shifts relative to the neighboring communities.

Fortunately, this issue of interpretation does not influence the ability of these empirical models to identify a Tiebout response. A positive γ is consistent with the Tiebout model. However, a potentially more serious flaw with these models is that the estimated γ may be positive in the absence of a Tiebout response simply because of the income effects the HOPE Scholarships created for residents already on the Georgia side of these MSA. Fortunately, the upward bias introduced by these income effects should be relatively small. In part, this is because the HOPE Scholarships provide an income shock that is

transitory and that only affects those households with children anticipating post-secondary education. Furthermore, a residential move is not required of Georgia residents as it is of the out-of-state residents who wish to take advantage of the HOPE Scholarship. Additionally, the sizes of the marginal effects reported here also suggest that the bias due to local income effects is likely to be relatively small. For example, suppose that 50% of the households already in Georgia benefited from the HOPE Scholarships and that this transitory income shock constituted an increase in lifetime income that increased their demand for new housing by a full 10%. These conservatively large estimates would imply an increase in new housing starts due to Georgia-specific income effects of only 5%, which is fairly small relative to the marginal effects reported here. Nonetheless, the caveat that the reported γ may somewhat overstate the Tiebout response because of income effects should be understood.[20]

With these qualifications in hand, the results of constructing difference-in-differences estimators implied by equations (1) and (2) are presented in Table 3. Since the conditional means are for the logistic transformations of the key variables, the differences reported there can be understood as percent changes. For example, the data in the first row demonstrate that, in Georgia, the construction of new single-family housing units grew by more than 22% after the introduction of the HOPE Scholarships. Over the same period, in neighboring jurisdictions that happened to be across the Georgia state line, the number of new single-family housing units fell by 7.5%. The difference in these two differences suggests that the introduction of the HOPE Scholarships increased the construction of new single-family housing units on the Georgia side of the state line by nearly 30% relative to the neighboring out-of-state jurisdictions. Estimates regarding the value of this new construction are even more dramatic. After the introduction of the HOPE Scholarships, the real stated value of these newly constructed units rose by nearly 44%. In the neighboring jurisdictions without HOPE Scholarships, the real value of new housing units rose by only 2.4%. The difference-in-differences estimator implied by these changes suggests that the HOPE

[20] The robustness check based on models of public elementary school enrollments provides evidence on the empirical relevance of this concern. In those models, the income effect should produce a downward bias since private schooling is a normal good.

Scholarship program increased the total value of new single-family residential construction on the Georgia side of the MSA by 41.5% relative to neighboring jurisdictions. Both results suggest that there has been a fairly dramatic Tiebout response to the introduction of HOPE Scholarships and, by implication, that locational decisions are indeed responsive to the goods and services provided by local governments.

V. REGRESSION-ADJUSTED ESTIMATES

The simple difference-in-differences estimators provide suggestive evidence on the existence of a dramatic Tiebout response to the introduction of HOPE Scholarships. However, several caveats may qualify this interpretation. For example, despite the size of the two marginal effects (γ_{DD}) reported in Table 3, the hypotheses that each is equal to zero cannot be rejected in the difference-in-differences specification. The sparse set of conditioning covariates included in equation (1) contributes to the large estimated variances for γ_{DD} and may also imply an omitted variables bias.[21] Additionally, plausible alternative formulations of the error term in equation (1) were also not addressed. Such concerns may also have important implications for the quality of inferences regarding γ.

These concerns are addressed here by evaluating richer panel specifications. However, the identification strategy implicit in these empirical models is entirely analogous to that of the simpler difference-in-differences framework presented in the previous section. In other words, possible Tiebout responses to the HOPE Scholarships are identified by the variation within the Georgian jurisdictions over time conditional on the controls that neighboring jurisdictions outside Georgia provide for other relevant variation over time. This approach is achieved by estimating variations of the standard two-way fixed-effects model:

$$Y_{ist} = \mu_i + \nu_t + \gamma H_{st} + \varepsilon_{ist.} \tag{3}$$

[21] However, the plausible exogeneity of H_{st} suggests that omitted variables are less likely to be an important specification concern.

where μ_i now represents fixed effects specific to each of the 31 permit-issuing jurisdictions and ν_t represents fixed effects for each of the seven years included in the data set. In this specification, the variable H_{st} is again the *HOPE Scholarship* variable. However, in some specifications, H_{st} represents ad-hoc variables that may identify alternative dynamic responses to the HOPE Scholarships (i.e. interactions of *HOPE Scholarship* with *Years Since 1993* and with *Years From 1997*).

In equation (3), place-specific fixed effects unambiguously control for the time-invariant features that make each jurisdiction unique. Similarly, the year fixed-effects control for the determinants shared by all observations that make each year unique. This sharply increased set of regressors may improve the precision of the estimated γ as well as provide evidence on the role of omitted variables. Some reported specifications introduce further controls to equation (3) by providing regressors that represent the time-series variation specific to each of the three MSA. The motivations for including these controls is that the basic specification in equation (3) makes the possibly confounding assumption that the time-varying determinants captured by the year fixed effects are common to each of the three MSA. This concern is addressed first by including in equation (3) linear trend variables specific to each MSA (i.e. interactions of a linear trend variable and MSA fixed effects). Less restrictive controls for the MSA-specific time-series variation are introduced by simply replacing the year fixed effects with sets of year fixed effects specific to each of the three MSA. Some specifications will also include the county unemployment rate. While this is arguably an endogenous regressor, the possible robustness of the evaluation parameter to including it provides evidence on whether the introduction of the HOPE Scholarship program is confounded with local macroeconomic trends.

A separate set of concerns involving the specification in equation (3) involves the nature of the regression errors, ε_{ist}. For example, the error term in equation (3) is likely to be heteroscedastic since the permit-issuing jurisdictions are of widely varying sizes.[22] Because of this concern, estimates of γ are

[22] In White (1980) tests with these models, the hypothesis of homoscedasticity is uniformly rejected at conventional levels of statistical significance.

reported with consistent standard errors (White, 1980). Another concern is that the classical assumption of serial independence may be unwarranted for such data on new housing construction. In particular, there may be place-specific autocorrelations in these series. In larger jurisdictions, a positive error in one period may imply omitted variables that suggest there will be a positive error in its next period as well. In contrast, in small jurisdictions, a positive shock to the residential construction in one period could imply that the error in the next period would be more negative. However, the very short time-series dimension to these data (i.e. T=7) suggests both that the existence of autocorrelation cannot be determined very reliably and that its influence is unlikely to be problematic. Furthermore, given the plausible orthogonality of H_{st}, the presence of autocorrelation will not bias the estimates of γ. However, autocorrelations could reduce or overstate the precision with which the evaluation parameter, γ, is estimated. In order to address this concern, place-specific, first-order autocorrelation parameters, ρ_i, were estimated by the correlation coefficients between ε_{ist} and ε_{ist-1}. The average magnitudes of the 31 ρ_i in these models are between .12 and .23, suggesting a modest and positive serial correlation. Though these ρ_i may not be reliably estimated, some models are estimated using these ρ_i in a Prais-Winsten transformation of equation (3) as a robustness check (Kmenta, 1997).[23]

Table 4 presents the key results from estimates of equation (3) when the dependent variable is the natural logarithm of new single-family housing units. Model (1), which includes state and year fixed effects, is similar to the sparsely specified difference-in-differences model (equation (2)) and explains only 10.1 percent of the variation in the dependent variable. The estimate of γ in Model (1), like the difference-in-differences estimate in the previous section, implies that the HOPE Scholarships increased the construction of new single-family housing units by roughly 30 percent relative to neighboring jurisdictions. However, the large standard error also indicates that this estimate cannot be statistically distinguished from zero. Models (2) through (5) introduce additional controls like place fixed effects,

[23] Since the regression error may be simultaneously characterized by both heteroscedasticity and autocorrelation, White standard errors are also reported for these transformed data.

MSA-specific time-varying covariates and the county unemployment rate. The share of explained variation in these models increases dramatically to over 93 percent. However, the estimates of γ are largely invariant, suggesting a marginal effect of 26.8 to 30.6 percent. The stability of the estimated γ underscores the plausible orthogonality of H_{st}. The additional controls also increased the precision of the estimated γ considerably. In particular, in Models (2) through (5), the hypothesis that γ equals zero can be rejected at conventional levels of statistical significance.

The evidence presented in the first two rows of Table 4 suggests that there has been a large and statistically significant Tiebout response to the introduction of the HOPE Scholarships. The remainder of Table 4 presents the results of estimating equation (3) under alternative assumptions about possible dynamic Tiebout responses to the HOPE Scholarships. For example, the specification that interacts *HOPE Scholarship* with *Years Since 1993* provides evidence on whether the Tiebout response has increased over time. The results of estimating this specification suggest that the response grew by 7.3 to 9.0 percent per year. However, given the relatively large standard errors, none of these estimated effects is statistically distinguishable from zero. The final specification in Table 4 provides evidence on whether a Tiebout response diminished over time by interacting *HOPE Scholarship* with *Years From 1997*. The results of those estimations suggest that, in the first full year of the HOPE Scholarships (i.e. 1994), the construction of new single family housing units on the Georgia side of these MSA grew by as much as 44.1 percent (3 x .147) relative to neighboring jurisdictions. This model also suggests that this effect fell by 14.7 percent in each of the next two years. In Models (2) through (5), these marginal effects are statistically distinguishable from zero at conventional levels of significance. While this evidence is highly qualified by the limited time period study and the assumptions inherent in the interaction terms, it nonetheless suggests that the Tiebout response in these MSA has diminished over time.

The results of estimating equation (3) when the dependent variable is the natural logarithm of the real value of new single-family housing units are presented in Table 5. The five models presented in the first row of Table 5 generated estimates of γ between .410 and .460. In other words, these estimates,

which are again quite similar to the difference-in-differences estimate, suggest that the introduction of the HOPE Scholarship program increased the relative real value of new single-family residential construction on the Georgia side of these MSA by over 40 percent. However, relatively little of the variation in the dependent variable is explained by the difference-in-differences model and the similarly specified Model (1) of Table 5. The implied lack of precision means that the estimated γ cannot be statistically distinguished from zero in these models. But, in Models (2) through (5), which includes more covariates, the goodness of fit and the precision of the estimated γ increased considerably. In particular, in all four models, the estimated γ is at least three times larger than its standard error. The hypothesis that γ equals zero can be rejected at conventional levels of statistical significance in each of these three models. The fact that HOPE Scholarships increased the value of new housing construction more than the volume suggests that they may have been capitalized into housing values. However, that interpretation may not be accurate since this evidence is also consistent with the hypothesis that HOPE Scholarships changed the mix of new housing attributes on the Georgia side of the state line.

The remaining models presented in Table 5 provide some limited evidence on the character of a possibly dynamic Tiebout response to the HOPE Scholarships. For example, the models in which *HOPE Scholarship* is interacted with *Years Since 1993* suggest that the relative real value of newly constructed single-family housing units rose by 13 to 15 percent on the Georgia side of the MSA each year after the introduction of the HOPE Scholarships. In Models (2) through (5), these estimated effects are sufficiently precise to reject the hypothesis of no effect. However, the models in which *HOPE Scholarship* is interacted with *Years From 1997* suggests the existence of an alternative dynamic. More specifically, these models imply that in the first full year after the introduction of the HOPE Scholarships (i.e. 1994), the real value of single-family residential construction on the Georgia side of the MSA rose by roughly 60 percent relative to neighboring jurisdictions. The magnitude of this estimated marginal effect diminished by nearly 20 percent with each of the next two years. In Models (2) through (5), the estimates of these marginal effects are quite precise (nearly four times the size of their standard errors). The hypothesis that

these effects equal zero is easily rejected. However, given the limited time period under study and the ad-hoc nature of the "dynamic" regressors, it is difficult to ascertain which of the dynamic patterns represented in Table 5 is most accurate. Nonetheless, the relative precision of the final model combined with the evidence from Table 4 and the robustness checks in Table 6 provides some qualified evidence for the assertion that the magnitude of the Tiebout response is diminishing over time.

The results in Table 6 present robustness checks that are based on correcting for panel-specific autocorrelation and heteroscedasticity. The results of these estimations are very similar to those presented in Tables 4 and 5. As a baseline for comparison, Models (1) and (3) in Table 6 repeat the results reported in Tables 4 and 5 for the specifications that included place and year fixed effects. Models (2) and (4) in Table 6 correct for panel-specific first-order autocorrelation through a Prais-Winsten transformation. The classical standard error implied by this transformation is reported in parentheses. The standard error in brackets is the heteroscedastic-consistent standard error implied by the transformed data (White, 1980). The marginal effects reported in Models (2) and (4) are uniformly smaller than those reported in Models (1) and (3). However, in each case, the magnitude of this difference is small (i.e. within one standard error). Furthermore, like the prior results, these estimates suggest that the HOPE Scholarship program had dramatic and statistically significant effects on the pattern of new housing construction. Furthermore, these estimations also provide suggestive evidence that the magnitude of the Tiebout response has declined over time.

VI. SCHOOL ENROLLMENTS

The empirical models based on building permits data provide consistent evidence of a large, empirically robust and statistically significant Tiebout response to the HOPE Scholarship program. The estimated size of this response suggests that this phenomenon may be statistically detectable in other outcomes. As a final robustness check, this section considers whether evidence from a different data set confirms the dramatic results based on the permits data. More specifically, this section evaluates whether a Tiebout response to HOPE Scholarship program is evidenced in the enrollments of public schools.

Public school enrollments provide a natural choice for this check since the available data are both sufficiently precise geographically as well as collected longitudinally. In particular, the National Center for Education Statistics (NCES) collects annual data on school enrollments in its Common Core of Data (CCD). The CCD is a universe survey of schools and school districts with data available for as recently as the 1995-96 school year. The estimates presented here are based on district-level enrollments in kindergarten through eighth grade. These district-level data are drawn from the 18 school districts in the three cross-state MSA and for each of the six school years from the fall of 1990 to 1995. The total number of observations is 108 (i.e. 6 x 18). The focus on the K-8 grade span is necessary since the HOPE Scholarship may have increased high school enrollments in Georgia independent of any Tiebout response. Similarly, this study also omits pre-kindergarten enrollments since lottery funds may have created new pre-K programs on the Georgia side of these MSA. However, increased enrollments in the K-8 grade span would be consistent with the existence of a Tiebout response to HOPE Scholarships.

The estimated effect of *HOPE Scholarship* on K-8 public school enrollments is reported in Table 7. These estimates are based on the same semi-log specifications employed in Tables 4 and 5.[24] Model (1), which includes only state and year fixed effects, suggests that the HOPE Scholarship program increased school enrollments by 4 percent. However, this estimate is quite imprecise and the R^2 for this regression is only 0.028. Models (2) through (5) add place fixed effects, MSA-specific controls and the county unemployment rate. The coefficient on *HOPE Scholarship* is quite robust to including these additional covariates. Furthermore, these additional controls increase the precision of the estimated effect considerably. In Models (2) through (5), the hypothesis that the HOPE Scholarship program had no effect on public school enrollments on the Georgia side of these MSA can be rejected at conventional levels of statistical significance.

The existence of a *HOPE Scholarship* effect on public school enrollments is consistent with that observed in the building permits data. However, given the uncertainty over the exact characteristics of

[24] Since there are only two post-HOPE Scholarship years for these data, the interactions that reflect possibly dynamic responses are not reported here.

those who move and whether they purchase new or old houses, it is difficult to reconcile precisely the magnitudes of the estimates reported in Table 7 with those in Tables 4 through 6. Nonetheless, a crude comparison is possible. The average K-8 enrollment for the 18 districts in this data set is 7,824. Therefore, a 4 percent marginal effect implies an increase of roughly 313 students. For the 31 permit-issuing places, the average number of housing starts was 163. A 30 percent marginal effect implies an increase of 49 housing units. A crude re-scaling of this effect so that it is comparable to the district-level result implies an increase of 84 housing units (49 x 31/18). These calculations therefore suggest that there were 3.7 (313/84) new elementary school students for every house built due to the impact of the HOPE Scholarship program. Since some students were undoubtedly moved to older houses, these numbers are not necessarily inconsistent. In fact, the relatively large size of the enrollment effects reported here provides some evidence that the limitations inherent in the permits data are not problematic.[25]

VII. CONCLUSIONS

The lottery-funded HOPE Scholarship program changed the set of public goods linked with residence in Georgia. Because this change was both dramatic and plausibly exogenous, the introduction of this program provides a novel and fairly powerful opportunity to test whether residential choice is responsive to the character of local public goods. This study provided evidence on that question by estimating the effect of the HOPE Scholarships on the volume and value of new single-family residential construction in the permit-issuing jurisdictions of the three MSA that straddle Georgia's border. The identification strategy employed in these estimations effectively used the communities near but outside the Georgia border as a control for the time-varying changes in Georgia that might otherwise be confounded with the introduction of the HOPE Scholarships.

Both the "difference-in-differences" and fixed effects estimates based on this research design

[25] More specifically, this evidence suggests that the upward bias generated by income effects in the models of housing starts is not very relevant empirically. In the public school enrollment equations, such income effects should generate a downward bias.

suggest that there has been a dramatic Tiebout response to the HOPE Scholarship program. On the Georgia side of the three MSA, the introduction of the HOPE Scholarships increased the relative volume of new single-family housing units by roughly 30 percent. The increase, due to the HOPE Scholarships, in the relative real value of such construction was even more dramatic (roughly 42 percent). Both of these estimated responses appeared robust and, in preferred specifications, statistically significant. Evidence from similarly specified models of public elementary school enrollments provided additional results that are consistent with these findings. However, this study also presented qualified evidence that the magnitude of this Tiebout response declined over time. Nonetheless, in the three metropolitan areas that cross Georgia's border, the introduction of the HOPE Scholarships appears to provide a highly illustrative example of the Tiebout model in action: residents "voting with their feet" in response to a change in the character of local public goods.

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Table 1
Panel Observations, 1990-1996

MSA	State	Permit-Issuing Place(s)
Augusta-Aiken	GA	Augusta, Unincorporated Richmond County
Augusta-Aiken	GA	Unincorporated Columbia County
Augusta-Aiken	GA	Grovetown, Harlem
Augusta-Aiken	GA	Blythe town, Hephzibah
Augusta-Aiken	GA	Thomson, Unincorporated McDuffie County
Augusta-Aiken	SC	Aiken
Augusta-Aiken	SC	Unincorporated Aiken County
Augusta-Aiken	SC	Edgefield County
Augusta-Aiken	SC	North Augusta
Chattanooga	GA	Chickamauga
Chattanooga	GA	Fort Oglethorpe, Ringgold
Chattanooga	GA	La Fayette
Chattanooga	GA	Lookout Mountain
Chattanooga	GA	Rossville
Chattanooga	GA	Trenton
Chattanooga	GA	Unincorporated Walker County
Chattanooga	TN	Chattanooga
Chattanooga	TN	Collegedale
Chattanooga	TN	East Ridge
Chattanooga	TN	Unincorporated Hamilton County
Chattanooga	TN	Jasper town, Kimball town, New Hope
Chattanooga	TN	Unincorporated Marion County
Chattanooga	TN	Lakesite
Chattanooga	TN	Soddy-Daisy
Chattanooga	TN	Lookout Mountain town
Chattanooga	TN	Red Bank
Chattanooga	TN	Signal Mountain town
Chattanooga	TN	South Pittsburg
Columbus	GA	Columbus
Columbus	GA	Unincorporated Harris County, Hamilton, Cussetta
Columbus	AL	Phenix City

Table 2 – Descriptive Statistics for Permit-Issuing Places
Of 3 Cross-State Metropolitan Statistical Areas, 1990-1996

Variables	Mean[26]	Minimum	Maximum
New Single-Family Housing Units	163 (241.4)	1	943
Total Value of New Units, thousands of 1996 dollars	$14,654 (22767)	$35	$108,368
HOPE Scholarship	.194 (.396)	0	1
HOPE Scholarship Years Since 1993*	.387 (.870)	0	3
HOPE Scholarship Years From 1997*	.387 (.870)	0	3

[26] Standard deviations are reported in parentheses.

Table 3 – The Effect of HOPE Scholarships on New Single-Family Housing Units and and their Real Valuation, Difference-in-Differences Estimates

Dependent Variables	Means in Georgia		Difference	Means Outside Georgia		Difference	Difference in Differences
	1990-93	1994-96		1990-93	1994-96		
ln(*New Single Family Housing Units*)	3.567	3.789	.222	3.814	3.739	-.075	.297
ln(*Total Value of New Units, thousands of 1996 dollars*)	7.795	8.234	.439	8.328	8.352	.024	.415
Number of Observations	56	42		68	51		

Table 4 – OLS Estimates of Semi-Log Equations for New Single-Family Housing Units, Augusta-Aiken, Chattanooga and Columbus Metropolitan Statistical Areas, 1990-1996[1]

Independent Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
HOPE Scholarship	.296 (.503)	.296 (.134)	.268 (.133)	.300 (.132)	.306 (.139)
R^2	.101	.933	.933	.937	.937
HOPE Scholarship Years Since 1993*	.087 (.227)	.087 (.066)	.073 (.065)	.089 (.065)	.090 (.067)
R^2	.100	.932	.933	.936	.936
HOPE Scholarship Years From 1997*	.143 (.217)	.142 (.049)	.133 (.048)	.143 (.048)	.147 (.052)
R^2	.101	.933	.934	.937	.937
State Fixed Effects	Yes	No	No	No	No
Place Fixed Effects	No	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	No	No
MSA-Specific Trend Variables	No	No	Yes	No	No
MSA-Specific Year Fixed Effects	No	No	No	Yes	Yes
County Unemployment Rate	No	No	No	No	Yes

[1] Heteroscedastic-consistent standard errors are reported in parentheses (White, 1980).

Table 5 – OLS Estimates of Semi-Log Equations for the Real Value of New Single-Family Housing Units, Augusta-Aiken, Chattanooga and Columbus Metropolitan Statistical Areas, 1990-1996[2]

Independent Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
HOPE Scholarship	.415 (.507)	.415 (.137)	.410 (.136)	.445 (.134)	.460 (.142)
R^2	.117	.931	.931	.935	.936
HOPE Scholarship Years Since 1993*	.131 (.223)	.131 (.064)	.127 (.064)	.147 (.064)	.150 (.066)
R^2	.115	.929	.929	.934	.934
HOPE Scholarship Years From 1997*	.190 (.220)	.190 (.052)	.187 (.051)	.197 (.051)	.206 (.054)
R^2	.117	.931	.931	.936	.936
State Fixed Effects	Yes	No	No	No	No
Place Fixed Effects	No	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	No	No
MSA-Specific Trend Variables	No	No	Yes	No	No
MSA-Specific Year Fixed Effects	No	No	No	Yes	Yes
County Unemployment Rate	No	No	No	No	Yes

[2] Heteroscedastic-consistent standard errors are reported in parentheses (White, 1980).

Table 6 – Robustness Checks, HOPE Scholarships and the Volume and Real Value of New Single-Family Housing Units, Augusta-Aiken, Chattanooga and Columbus Metropolitan Statistical Areas, 1990-1996[3]

Independent Variables	Dependent Variables			
	Housing Starts		Real Value of Housing Starts	
	Model (1)	Model (2)	Model (3)	Model (4)
HOPE Scholarship	.296 (.134)	.253 (.125) [.112]	.415 (.137)	.356 (.129) [.121]
HOPE Scholarship Years Since 1993*	.087 (.066)	.068 (.058) [.057]	.131 (.064)	.106 (.060) [.058]
HOPE Scholarship Years From 1997*	.142 (.049)	.116 (.053) [.042]	.190 (.052)	.156 (.055) [.046]

[3] All models include place and year fixed effects. Models (1) and (3) report heteroscedastic-consistent standard errors in parentheses. Models (2) and (4) report standard errors corrected for panel-specific first-order autocorrelation in parentheses. The standard errors reported in brackets are corrected for both autocorrelation and heteroscedasticity.

Table 7 – OLS Estimates of Semi-Log Equations for K-8 Public School Enrollment, Augusta-Aiken, Chattanooga and Columbus Metropolitan Statistical Areas, 1990-1995[4]

Model Specification	Estimated Coefficient for *HOPE Scholarship*
Model (1)	.040 (.522)
Model (2)	.040 (.015)
Model (3)	.039 (.014)
Model (4)	.039 (.014)
Model (5)	.037 (.017)

[4] The model specifications correspond to those in Tables 4 and 5. Heteroscedastic-consistent standard errors are reported in parentheses (White, 1980).