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An integrated model of regional and local residential sorting with application to air quality

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ABSTRACT

We examine the interconnectedness of demand for regionally and locally varying public goods using a residential sorting model. We propose a version of the model that describes household choices at the city (MSA) level and, conditional on city, the neighborhood (census tract) level. We use a two-stage budgeting argument to develop an empirically feasible sorting model that allows us to estimate preferences for regionally varying air quality while accounting for sorting at the local level. Our conceptual and empirical approach nests previous sorting models as special cases, allowing us to assess the importance of accounting for multiple spatial scales in our predictions for the cost of air pollution. Furthermore our preferred specification connects the city and neighborhood sorting margins to the upper and lower elements of a nested logit model, thereby establishing a useful correspondence between two stage budgeting and nested logit estimation. Empirically we find that estimates from a conventional model of sorting across MSAs imply a smaller marginal willingness to pay for air quality than estimates from our proposed model. We discuss how the difference is attributable in part to the omitted variable problems arising when tract level sorting is ignored.

Introduction

Residential sorting models have become prevalent in urban, public and environmental economics as a tool for valuing local public goods.[1] Estimates are obtained by observing location decisions in which households make tradeoffs between wage earnings, home prices and local amenities such as air quality and education. The objective is to characterize the utility function parameters and the equilibrating mechanisms, thereby providing a platform for counterfactual welfare analysis. Thus sorting models offer important capabilities relative to hedonic price models, which only characterize the market level equilibrium. The added capabilities do not come for free, however, in that numerous assumptions are needed to implement a residential sorting model. Among the most important of these is how the analyst divides the landscape into discrete, mutually exclusive choice alternatives.

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[1] Recent examples include Sieg et al. (2004) and Tra (2010) for air quality; Bayer et al. (2007) for school quality; Walsh (2007) and Klaiber and Phaneuf (2010) for landscape amenities; and Bayer and McMillan (2012) for racial composition.

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The division of the landscape in existing sorting models has occurred at what we label the *macro*-level (e.g. Bayer et al., 2009, 2011; Bishop, 2012) or *micro*-level (e.g. Sieg et al., 2004; Klaiber and Phaneuf, 2010; Kuminoff, 2012). The former examines which city people locate to from a collection of metropolitan areas across the country, while the latter examines the specific location choice within a city or region. The scale of analysis is determined by the objectives of the study, in that public good levels can vary at the local (e.g. open space; school quality) or regional/national (e.g. certain types of air quality) level. Thus all sorting models of which we are aware begin with a decision on the spatial scale of analysis – macro or micro – and then examine households' behavior exclusively at that level.[2] This, however, ignores the reality that location choices occur at both scales. At the macro-level households select a metropolitan area or region, which conditions the set of specific neighborhoods available at the micro level. The macro-choice may depend on labor market considerations and regionally varying geographical aspects such as climate; the micro (or neighborhood) choice might depend on school quality or access to landscape amenities. Although distinctive, it is possible that the two choice levels are interconnected, so that variation in access to local public goods might affect households' valuations for regionally varying amenities. In addition, it is worth noting that household migration within metropolitan areas is considerably more prevalent than household migration across metropolitan areas, and thus likely to contain useful information regarding preferences.

In this paper we examine the extent to which these two levels of choice are connected, and what the connections might mean for how we use sorting models to value public goods. We begin by developing a horizontal sorting model that formally reflects both the macro- and micro-components of choice.[3] We show how a two-stage budgeting assumption allows us to separately analyze the two choices and then link them in a single model. In particular, the micro-level choice sets and choice behavior are aggregated into a quality adjusted price index, which is then used as a characteristic of the macro-locations. This provides a structurally consistent means of considering the joint role of regional and local public goods in household decisions. We then propose an empirical version of this model at the macro-level that can be estimated with data on micro level location decisions and macro level public goods. Importantly, though our approach accounts for local public goods and housing prices, we do not need to measure amenities at the local level. Rather, the model allows us to account for these local attributes simply based on observed local sorting.

We test how micro-level choices affect macro level valuation using, in our preferred specification, a nested logit model that allows us to estimate the marginal willingness to pay for regionally varying air quality. We focus on air quality both for its policy relevance and because air quality is the focus in Bayer et al. (2009), which we use as our baseline model. We establish an analog between two-stage budgeting in theory and the nested logit model in practice, whereby the 'inclusive value' from the micro level (lower nest) choice is shown to be equivalent to the quality augmented price index in the macro level (upper nest) choice. Thus an added contribution of our paper is to establish a new interpretation for the nested logit framework. We compare the estimates from our preferred model with those from conventional sorting models, models that account for less preference heterogeneity than our preferred model, and conditional logit versions of our two-stage budgeting model.

We find sizeable differences in our estimates of the cost of air pollution when micro-level sorting is considered. In our preferred model the elasticity of willingness to pay with respect to air quality is 0.49. By way of comparison we find an elasticity of 0.31 using the Bayer et al. (2009) macro-only model, which largely replicates their findings. At median levels of income and air pollution these estimates translate to annual marginal willingness to pay predictions of $371 and $232[4], respectively. One explanation for this is that differences arise because neighborhood sorting behavior acts as an omitted variable, which is correlated with air pollution in the macro level regressions. We also find that our nested logit model of two stage sorting leads to a higher marginal willingness to pay compared to the conditional logit model typically used in horizontal sorting models. Taken together our results suggest that the macro and micro dimensions of sorting behavior are connected in ways that can have economically significant effects on valuation measures, meaning that the micro dimension should be controlled for even when the emphasis is on regionally varying public goods. A more general lesson is that attention should be paid to the multiple spatial scales at which households make decisions, the multiple spatial scales at which location-specific public goods vary, and ways of reconciling differences that might arise between the two.

Conceptual basis

In consumer choice theory, two-stage budgeting postulates a budget allocation process in which expenditures are first assigned to broad groups of consumption categories, and then allocated to individual goods within each group. Blackorby and Russell (1997) show that two-stage budgeting is consistent with utility maximization when the first stage satisfies price aggregation and the second stage satisfies decentralisability. The former implies expenditures are allocated to aggregate commodity groups based on group specific price indices and total expenditure. The latter implies commodity demands depend only on group specific prices and group expenditures. When price aggregation and decentralisability are satisfied

[2] A potential exception to this is Kuminoff (2012), who models the joint choice of residential location and labor market using a vertical sorting model. The choice set includes school district and PMSA combinations defined over the San Francisco and Sacramento metropolitan areas.

[3] Horizontal and vertical sorting models are distinguished by whether households rank the bundle of public goods at a location differentially (horizontal) or similarly (vertical). Klaiber and Phaneuf (2010) is an example of the former, while Sieg et al. (2004) is an example of the latter. Horizontal sorting models use the discrete choice format in which the preference function contains a random term that varies over individuals and choice alternatives.

[4] Marginal willingness to pay values are measured in 1990 dollars.