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Partial identification of amenity demand functions ☆

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ABSTRACT

This paper presents a new hedonic framework for reduced form estimation of the demand for spatially delineated nonmarket amenities. We begin from a conventional model of market equilibrium where an amenity is conveyed to homeowners by virtue of their residential location choices. Different housing markets may have different hedonic price functions due to variation across markets in the joint distribution of preferences, income, regulations, and technology. In this setting, taste-based sorting within and across markets confounds point identification of reduced form descriptions for amenity demand curves. However, we demonstrate that basic knowledge of the sorting process is sufficient to construct instruments that identify bounds on demand curves. Bounds on demand curves can be translated into ranges of welfare measures for non-marginal changes in amenities. We find these ranges to be potentially informative in a demonstrative application to evaluating the benefits of improved lake water clarity in the Northeast.

"*Through the early history of applied hedonic analyses of urban housing markets the primary estimation problems have been (i) the interpretation of the estimated coefficients in terms of demand and supply functions, and (ii) coefficient bias introduced by omitted variables*."Peter Linneman (1980)

Introduction

How little has changed! Omitted variable bias and the "second stage" identification of demand parameters are still perceived to be the two main problems with using hedonic models to estimate the demand for amenities. Both problems must be addressed in order to develop a credible estimate of the willingness to pay for a *non-marginal* change in a spatially delineated amenity. Yet, the recent empirical literature has devoted far more attention to the omitted variable problem. Numerous studies have developed ways to mitigate the bias from correlation between observed and unobserved amenities (e.g. Abbott and Klaiber, 2013; Gamper-Rabindran and Timmins, 2013; Kuminoff and Pope, 2014; Muehlenbachs et al., 2012). In comparison, there has been relatively little progress on the identification of demand parameters. The purpose of this paper is to suggest a new approach to the main endogeneity problem with "second stage" demand estimation.

Rosen (1974) suggested a simple two-stage reduced form approach to estimating demand curves for individual attributes of a differentiated good, such as housing. The first stage involves regressing product prices on product attributes

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(i.e. estimating a hedonic price function). The resulting estimates for marginal effects then become dependent variables in a second-stage regression of implicit marginal prices on attribute levels and demand shifters (i.e. estimating an inverse demand curve). While Rosen's first-stage model of hedonic pricing is now among the foremost tools of nonmarket valuation, his vision for a second-stage model of demand remains unfulfilled. The main problem is that taste-based sorting within and between markets for differentiated goods undermines the point identification of demand curves (Bartik, 1987; Epple, 1987).

Researchers have sought to mitigate the bias from taste-based sorting by adding more information to the problem. One strategy is to assume a parametric form for the utility function (e.g. Bajari and Benkard, 2005; Bajari and Kahn, 2005; Chattopadhyay, 1999; Klaiber and Phaneuf, 2010; Kuminoff, 2009; Sieg et al., 2004; Smith et al., 2004). Another strategy is to collect data from multiple markets and estimate demand curves under the maintained assumption that consumers do not sort themselves across markets (e.g. Bartik, 1987; Kuminoff and Pope, 2012; Palmquist, 1984). A third strategy, developed by Bishop and Timmins (2008) combines and extends the first two ideas.[1] While all of these proposals are intriguing, none have been widely adopted.

In this paper, we propose a fundamentally different way to extract information about the demand for a spatially delineated amenity, while returning to a simple reduced-from approach to estimation that can be implemented using data that are widely available. Our main observation is that the endogeneity problem that arises from taste-based sorting is only fatal if we limit ourselves to the extremes of point identification. By taking a broader perspective on the nature of identification, consistent with Leamer (1983), Manski (2007), Kuminoff (2009), and Nevo and Rosen (2012), we demonstrate that it is possible to identify *bounds* on demand elasticities and *ranges* of welfare measures in the presence of taste-based sorting within and between markets. Specifically, we develop a partial identification strategy for using hedonic price functions to identify consistent bounds on demand curves for nonmarket amenities and consistent ranges of estimates for the Marshallian consumer surplus. Our microeconometric strategy exploits Nevo and Rosen's (2012) recent results on the partial identification of linear instrumental variable models.

The rest of the paper is organized as follows. We begin by reviewing the endogeneity problem with hedonic demand estimation and explaining the economic intuition behind our econometric approach to the problem. Then we adapt Nevo and Rosen's econometric results to illustrate how basic assumptions about spatial sorting behavior are sufficient to identify bounds on demand curves and welfare measures. In order to provide an empirical demonstration of the main ideas, we use data on the characteristics of homebuyers and their lakefront houses in Maine, New Hampshire, and Vermont to estimate bounds on the willingness to pay for a non-marginal improvement in lake water quality. While taste-based sorting leads to uncertainty about the exact level of benefits, we find that our bounds on willingness-to-pay have the potential to be informative for policymakers.

Economic intuition for the identification strategy

The endogeneity problem with hedonic demand estimation

Consider a market, m, where households obtain utility from housing services and a composite private good, b. A market could be a town, city, or metropolitan area. Any house in the market may be decomposed into a bundle of private characteristics describing its structure (e.g. bedrooms, bathrooms, size of living area) and public characteristics describing its location (e.g. air quality, school quality, access to open space). We will use x to denote a vector of all the public and private characteristics other than the amenity of interest, which will be denoted by g. Under the standard assumptions of Rosen's (1974) model, interactions between buyers and sellers define an equilibrium hedonic price schedule for the market, $p^m(x,g,\beta)$, where β is a parameter vector describing the shape of the price function.

Each individual household with income y and preferences α maximizes utility over x, g and a numeraire good, b, subject to a budget constraint defined, in part, by the hedonic price function:

$$\max_{x,g,b} U(x,\ g,\ b;\ \alpha) \quad \text{s.t.} \quad y = p^m(x,g,\beta) + b, \tag{1}$$

which produces the first order conditions from Rosen's model:

$$p_g^m \equiv \frac{\partial p^m(x,g,\beta)}{\partial g} = \frac{\partial U(x,g,b;\alpha)/\partial g}{\partial U(x,g,b;\alpha)/\partial b} \tag{2a}$$

$$p_x^m \equiv \frac{\partial p^m(x,g,\beta)}{\partial x} = \frac{\partial U(x,g,b;\alpha)/\partial x}{\partial U(x,g,b;\alpha)/\partial b}. \tag{2b}$$

The household chooses levels of each characteristic such that their willingness to pay for an additional unit (MWTP) equals its marginal implicit price. If we further assume that the marginal utility of income is constant, then the MWTP function to the right of the equality in (2a) defines the household's demand for g.[2]

[1] Bishop and Timmins track individuals who migrate across markets, write down a parametric specification for their indirect utility functions, and identify parameters of that function under the assumption that it is stable over time.

[2] If the marginal utility of income is not constant then the marginal rate of substitution functions do not have the same properties as traditional Hicksian or Marshallian demand curves because the hedonic budget constraint is generally nonlinear. Rosen noted this in his original paper (p. 49) and McConnell and Phipps (1987) provide a detailed explanation. Studies that do not explicitly assume constant marginal utility of income often refer to the marginal rate of substitution function as a "MWTP function" rather than a demand curve.