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**Article**

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# Is Environmental Quality Worth the Cost?

V. Kerry Smith\*

In outlining the principles for project evaluation over fifty years ago, Otto Eckstein — one of the fathers of benefit-cost analysis and a former member of the NBER Board of Directors — was skeptical about the prospects for reliably measuring the economic tradeoffs that people would make in order to increase the amounts of public goods provided to them through new federal projects.<sup>1</sup> Much has changed in the ensuing five decades: benefit cost analyses are now a standard part of the information used in evaluating new major rules, with President Obama's revision to Executive Order 12866 continuing the practice started in 1981, and efforts to measure the tradeoffs that people would make to enjoy increases in the public goods (or reductions in the "bads") that are intended to come from those rules are more common. The Environmental Protection Agency (EPA) has led the way among regulatory agencies in developing guidelines for how these analyses should be conducted. Nonetheless, these analyses are not without controversy.

Many popular accounts today describe environmental regulations as "job-killers" and neglect their potential benefits. Indeed, the EPA's release of their report on the benefits and costs of the Clean Air Act Amendments in March of this year barely made the headlines.<sup>2</sup> This research summary describes some of the studies that have tried to document the benefits from environmental policies, so that there can be an appropriate weighing

of benefits and costs. It also outlines the opportunities for future work.

## Research Strategies for Measuring Valuation

### *The Hedonic Model*

The hedonic property value model has been a workhorse in demonstrating that spatially delineated amenities (and disamenities) influence housing prices. A decade and a half ago, Ju Chin Huang and I took stock of the record and found that consistent and plausible measures of the tradeoffs for air pollution had been derived using hedonic property value studies.<sup>3</sup> Today we have a more nuanced view. The ability to estimate the role of location-specific public goods, such as air quality, relies on spatial variation. Often there are unobservable attributes important to the price of a house that co-vary with the local public good of interest. Equally important, self selection of households based on preferences is another potential source of bias in hedonic estimates. In the absence of a careful identification strategy with credible instruments, we now realize that significant bias is possible.<sup>4</sup> However, controlled simulation analyses evaluating strategies using spatial fixed effects to absorb the confounding effects of omitted variables, and quasi-experimental methods to purge time varying omitted variables, suggest that both strategies can be effective.<sup>5</sup>

Of course, there are important caveats. When the nature of the amenity varies with spatial scale, it is important to recognize the potential for an overlap between the spatial scale for capitalization of a local amenity and the scale for the variation of the omitted variable.<sup>6</sup> Equally important, we now have a better understanding of how measuring a capitaliza-

tion effect may differ from estimating a marginal willingness to pay. Adopting a research design that exploits current methods to control for omitted variables and selects a strong instrument does not assure that the estimated capitalization effect has a welfare interpretation.<sup>7</sup>

### *Travel Cost Methods*

Next year will be the 65<sup>th</sup> anniversary of Harold Hotelling's letter to the National Park Service proposing the travel cost strategy for estimating recreation demand. Models based on his insight<sup>8</sup> are used routinely to evaluate the quality of recreation sites. Even though prices (travel costs) are given, the most recent work in this area has recognized the potential endogeneity of some site amenities, such as congestion. We have developed consistent estimates that allow evaluation of policies to enhance conditions at a site, recognizing their potential effects in inducing changes in undesirable attributes.<sup>9</sup> These non-market general equilibrium responses parallel advances in using the conditions for a locational equilibrium to estimate partial and general equilibrium measures of benefits for changes in spatially delineated amenities.

### *Models of Sorting*

Over a decade ago, Epple and Sieg developed a vertical sorting model for estimating households' preferences for public goods.<sup>10</sup> Since then, environmental economists have used the model to estimate partial and multi-market benefits for improved air quality,<sup>11</sup> to evaluate the distributional effects of these policies,<sup>12</sup> and to incorporate endogenous amenities into the equilibrium sorting process.<sup>13</sup> This research is closely related to structural hedonic models, and to mod-

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els introduced in industrial organization for evaluations of market structure in a framework that recognizes product differentiation as a means to gain market power.<sup>14</sup>

The most recent work in this area links housing and employment decisions and includes housing supply, which makes it possible to extend the model to consider supply-side policy to affect open space, habitat protection, and land use within a consistent general equilibrium framework.<sup>15</sup>

Three important insights emerge from the research to date: first, the differences between partial and general equilibrium measures of the economic benefits from policies can be important, but judgments about the relative size of the measures that follow from these two perspectives will vary with different spatially delineated amenities. As a result, we cannot use the conclusions about the relative importance of general equilibrium effects derived from air pollution policies for other contexts, such as open space, or outside the environmental domain, for example in judging local education quality. Second, the findings from sorting models' assessments of different policies appear to be reasonably robust across model specifications—considering vertical versus horizontal preference specifications—and different specifications for the extent of the local market.<sup>16</sup> Finally, the distributional implications of local policies can be pronounced, suggesting that some groups, notably those at the lower end of the housing market, may well lose even though air quality uniformly improves in all communities because the improvement is not enough to offset the increase in housing costs.

## Research Opportunities

The importance of general equilibrium effects is not limited to assessments in the context of local housing markets. If we return to EPA's recent Prospective Analysis of the net gains estimated for the 1990 Clean Air Act Amendments (CAAA), it is easy to find an example. Comparing the two chapters reporting

EPA's assessment of the net gains from the amendments, one finds that a partial equilibrium assessment would conclude that for 2010 the annual net benefits are 10 percent of GDP, while the report's assessment using a computable general equilibrium model concludes that they are 0.07 percent of that model's estimate for GDP. So the CAAA policies offer enormous net gains or virtually nothing, depending on the strategy used for evaluation. In the end the results are not the product of estimation uncertainty or flaws in non-market valuation methods. Instead, the devil is in the details of how to conduct general equilibrium assessments of large-scale public policies with non-market amenities, and this is an area that warrants further research. Indeed, Jared Carbone and I assess the effects of the treatment of amenities in household preferences for measuring the results of imposing a modest energy tax increase, and that helps us to explain these differences.<sup>17</sup> When we consider the importance of the assumed size of the substitution-versus-complementarity association between air quality and leisure, it is possible to change the size of the general equilibrium assessment of the benefits, including the air quality improvement together with the associated price changes, by over 90 percent.

The collapse of the housing market throughout many metropolitan areas in this country might be thought to cast a pall over research that relies on market equilibria. Not so—it is an opportunity to understand what thin markets and markets with high transaction costs reveal about amenities. Preliminary research suggests a new wave of insights into how aggregate shocks influence the ways that hedonic and sorting models evaluate non-market tradeoffs. This is one important research byproduct of our current hard times.

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<sup>1</sup> See O. Eckstein, "The Economics of Project Evaluation," Water Resource Development, Cambridge, MA: Harvard University Press, 1961, and H.S. Banzhaf, "Two Historically Competing Visions for Benefit-Cost Analysis," Land Economics

Vol. 85(1): 2009, pp.3–23.

<sup>2</sup> U.S. Environmental Protection Agency, "The Benefits and Costs of the Clean Air Act from 1990 to 2020," Final Report, Office of Air and Radiation, March 2011.

<sup>3</sup> V.K. Smith and J.C. Huang, "Can Markets Value Air Quality? A Meta Analysis of Hedonic Property Value Models," Journal of Political Economy, Vol. 103(1): 1995, pp.209–27.

<sup>4</sup> K.Y. Chay and M. Greenstone, "Does Air Quality Matter? Evidence from the Housing Market," NBER Working Paper No. 6826, December 1998, and Journal of Political Economy, Vol. 113(2): 2005, pp.376–424.

<sup>5</sup> N.V. Kuminoff, C.F. Parmeter, and J.C. Pope, "Which Hedonic Models Can We Trust to Recover the Marginal Willingness to Pay for Environmental Amenities?" Journal of Environmental Economics and Management, Vol. 60(3): 2010, pp.145–60.

<sup>6</sup> J.K. Abbott and H.A. Klaiber, "An Embarrassment of Riches: Confronting Omitted Variable Bias and Multi-Scale Capitalization in Hedonic Price Models," Review of Economics and Statistics (in press, 2011).

<sup>7</sup> The original hedonic paper is S. Rosen, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," Journal of Political Economy, Vol. 82(1): 1974, pp. 34–55. For a discussion of limitations in how recent analyses can be interpreted, see N.V. Kuminoff and J.C. Pope, "Rosen Bias' in the Willingness to Pay for Nonmarket Goods," Working Paper, September 2011, and H.A. Klaiber and V.K. Smith, "Quasi Experiments, Hedonic Models, and Estimating Tradeoffs for Local Amenities," August 2011, earlier version was NBER Working Paper No. 14957, May 2009.

<sup>8</sup> See D.J. Phaneuf and V.K. Smith, "Recreation Demand Models" in K.G. Maler and J.R. Vincent, eds., Handbook of Environmental Economics, Vol.2 (Amsterdam: North Holland): 2005, pp.671–761, and Roger H. von Haefen, D.J. Phaneuf, and G.R. Parsons, "Estimation and Welfare Analysis with Large Demand Systems," Journal of Business & Economic Statistics, Vol.

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<sup>9</sup> C. Timmins and J. Murdock, "A Revealed Preference Approach to the Measurement of Congestion in Travel Cost Models," *Journal of Environmental Economics and Management*, Vol. 53(2): 2007, pp.141–290.

<sup>10</sup> D. Epple and H. Sieg, "Estimating Equilibrium Models of Local Jurisdiction," NBER Working Paper No. 6822, December 1998, and *Journal of Political Economy*, Vol. 107(4):1999, pp.645–81.

<sup>11</sup> H. Sieg, V.K. Smith, H.S. Banzhaf, and R. Walsh, "Estimating the General Equilibrium Benefits of Large Changes in Spatially Delineated Public Goods," NBER Working Paper No. 7744, June 2000, and *International Economic Review*, Vol. 45(4): 2004, pp. 1047–77.

<sup>12</sup> H.S. Banzhaf and R.P. Walsh, "Do People Vote with Their Feet? An Empirical Test of Tiebout's Mechanism," *American Economic Review*, Vol. 98(3): 2008,

pp.843–63, and V.K. Smith, H. Sieg, H.S. Banzhaf, and R. Walsh, "General Equilibrium Benefits for Environmental Improvements: Projected Ozone Reductions under EPA's Prospective Analysis for the Los Angeles Air Basin," *Journal of Environmental Economics and Management*, Vol. 47(3): 2004, pp. 559–84.

<sup>13</sup> H.A. Klaiber and V.K. Smith, "Developing General Equilibrium Benefit Analyses for Social Programs: An Introduction and Example," Working Paper, Evans School of Public Affairs, University of Washington, Benefit-Cost Analysis Center, March 2011; D. J. Phaneuf, J.C. Carbone, and J.A. Herriges, "Non-Price Equilibria for Non-Marketed Goods," *Journal of Environmental Economics and Management*, Vol. 57 (1):2009,pp. 45–64.

<sup>14</sup> N.V. Kuminoff, V.K. Smith, and C. Timmins, "The New Economics

of Equilibrium Sorting and its Transformational Role for Policy Evaluation," NBER Working Paper No. 16349, September 2010.

<sup>15</sup> D.G. Hallstrom and V.K. Smith, "Habitat Protection Policies and Open Space: A General Equilibrium Analysis of 'Takings' and 'Givings,'" Working Paper, 2003.

<sup>16</sup> N.V. Kuminoff, V.K. Smith, and C. Timmins, "The New Economics of Equilibrium Sorting and its Transformational Role for Policy Evaluation," NBER Working Paper No. 16349, September 2010.

<sup>17</sup> J.C. Carbone and V.K. Smith, "Evaluating Policy Interventions with General Equilibrium Externalities," *Journal of Public Economics*, Vol. 92(5-6): 2008, pp.125–74, and "Valuing Ecosystem Services in General Equilibrium," NBER Working Paper No.15844, March 2010.

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## NBER Profile: John R. Graham

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John Graham is a Research Associate in the NBER's Corporate Finance Program and a professor of Finance at Duke University. He is also faculty co-director of Duke's Center for Financial Excellence.

Graham received his bachelor's degree in math and economics at the College of William and Mary in 1983, his Masters of economics at Virginia Commonwealth University in 1988, and his Ph.D. in finance at Duke University in 1994. Prior to joining the faculty at Duke, he taught at the University of Utah and worked as a senior economist at Virginia Power.

Graham's research focuses primarily on corporate finance issues including the choice of capital structure, payout policy, risk man-

agement, corporate diversification, taxes, and compensation. He is co-author of a textbook, *Corporate Finance: Linking Theory to What Companies Do*, now in its third edition and published by South-Western Cengage Learning. Graham is also co-editor of the *Journal of Finance*, director of the Global Business Outlook quarterly survey of CFOs, and Vice President of the Western Finance Association.

Graham was born in Beaumont, Texas and grew up primarily in Wilmington, Delaware. He currently lives in Chapel Hill, NC with his wife Suzanne and three children: Matt, Laura, and Rebecca. He spends his free time gardening, playing and coaching sports, and participating in church activities.

