Quality of Life and Environmental Comparisons

Chapter 5 in *The Handbook of Applied Urban Economics*
Edwin S. Mills and Paul Cheshire, Editors

By Joseph Gyourko[*], Matthew Kahn[**], and Joseph Tracy[***]

Latest Draft: September 16, 1997

[*]Real Estate & Finance Departments, The Wharton School, University of Pennsylvania
[**]Economics Department, Columbia University
[***]Federal Reserve Bank of New York

We thank Glenn Blomquist, Charles Leven, and Jerry Hausman for helpful comments on previous drafts. Naturally, the usual caveat still applies.

Abstract

Recent research into the urban quality of life (QOL) is reviewed and analyzed, with a special emphasis on the estimation of implicit prices of environmental attributes. New work work has incorporated traditional concerns of urban theory into QOL analyses, as well as increased our understanding of specification bias problems in hedonic estimations. However, empirical research into the QOL finds itself at a crossroads, as the large city-specific error components in the underlying wage and housing expenditure hedonic specifications result in imprecise measurement of overall QOL values and rankings. Amassing higher quality data bases to deal with this problem should be high on the agenda of those interested in this research program.

Keywords: Quality-of-Life, hedonics, specification bias

I. Introduction 1

II. Theoretical Underpinnings 3

III. Recent Econometric Developments in Estimating the Quality of Life 11

A. Specification Bias Problems and the Interpretation of Capitalization Results 11

B. Group Effects in the Wage and Housing Data 14

IV. New Estimates of the Quality of Life: Results, Comparisons, and Analysis 20

A. Blomquist et al (1988): "New Estimates of the Quality of Life in Urban Areas" 21

B. Gyourko & Tracy (1991): "The Structure of Local Public Finance and the Quality of Life" 23

C. Stover & Leven (1992): "Methodological Issues in the Determination of the Quality of Life in Urban Areas" 26

D. Conclusions 30

V. The Value of the Environment and the Urban Quality of Life--A Detailed Analysis 31

A. Environmental Hedonic Prices: Cross-City and Within-City Data and Results 31

B. Limitations of Capitalization Studies of Environmental Quality 37

C. Econometric Issues 39

D. Alternative Valuation Methods 40

VI. The Challenge of Relaxing the Equilibrium Assumption in Quality of Life Analyses 45

VII. Conclusions 52

VIII. References 54

I. Introduction

Measuring the quality-of-life (QOL) across urban areas has been an important research program in urban economics since Rosen (1979) and Roback (1980, 1982) showed how to identify implicit market prices of local amenities which can serve as the weights in the construction of quality-of-life indexes. Bartik & Smith provide an excellent review of the early theoretical and empirical work from this research project in the 1987 *Handbook of Regional and Urban Economics* (see Ch. 31). Our review takes up the story where theirs left off, beginning with work published in the mid-1980s.

Significant conceptual advances in this literature have been made over the last decade. They include the incorporation of traditional concerns of urban theory such as compensation for distance from the central business district (Hoehn, Berger, & Blomquist (1987)) and agglomeration effects (Blomquist, Berger, & Hoehn (1988)) into the Rosen/Roback framework. There also have been contributions showing how local governments can influence the QOL through their own taxation and service provision decisions (Gyourko & Tracy (1989, 1991)). While interesting in their own right, these theoretical advances also have helped improve our understanding of specification bias problems, which is particularly important when the researcher's interest is on specific capitalization results, rather than the overall QOL. In addition, this new work has expanded our knowledge of the extent of differential capitalization in land versus labor markets.

This chapter also focuses on research into the estimation of implicit prices of environmental attributes. This work is relevant to QOL research for several reasons. First, the

environment is a significant component of the local trait set. Second, both cross-city and within-city data have been used to generate implicit price estimates of environmental attributes, and the differences in results are helpful in understanding the strengths and weaknesses of the empirical work on the overall QOL which relies exclusively on cross-city data. Finally, the greatest experimentation with non-hedonic valuation methods has occurred in the environmental area. Assessing the relative strengths and weaknesses of the varying valuation methodologies yields interesting insights into the QOL literature that, heretofore, has relied on revealed preference techniques.

Despite all these developments, empirical research into the QOL presently finds itself at a crossroads. Recent work by Gyourko & Tracy (1989, 1991) reports the presence of large city-specific error components in the underlying wage and housing expenditure hedonic specifications estimated to determine the local trait prices. After carefully controlling for these error components, it turns out that overall QOL values and rankings are imprecisely estimated. The level of imprecision is such that much better descriptions of local amenity and fiscal conditions, plus superior controls for housing, worker, and job quality are needed in order to minimize the impact of these city-specific error components. Amassing higher quality data bases in the face of budget cutbacks at the key data collection agencies of many national governments will be a difficult and time-consuming process, but it should be high on the agenda of those interested in this research program.

Nevertheless, we are far from pessimistic about the prospects for this research program. Progress can be made in other ways and on other fronts. One which we discuss at length in Section VI involves relaxing the key equilibrium assumption underlying virtually all existing work

in the area. This assumption that the researcher is viewing local land and labor markets in states of long-run equilibrium in any cross section of data is what permits the equating of estimated trait prices with their true market values. The violence done to QOL estimates by this very convenient assumption is unknown, but Greenwood *et al* (1991) have taken the first steps towards informing us.

The chapter is organized as follows. A brief exposition of the Rosen/Roback model is provided in the next section. Section III then discusses the implications of recent econometric developments in estimating the QOL. This is followed by detailed analyses of three major studies that estimated the QOL across a number of metropolitan areas. Section V provides a review of the role of the environment in the QOL, as well as a discussion of alternative valuation techniques. Section VI then focuses on the challenge of integrating mobility into QOL analyses. A brief summary concludes the chapter.

II. Theoretical Underpinnings[1]

At the heart of the Rosen/Roback framework is a compensating differential model in which workers and firms compete for scarce sites, with wages and rents adjusting so that, in equilibrium, the marginal worker and firm are indifferent among locations. A representative worker-resident is assumed to consume land-housing services, N, and a composite commodity, C,

[1]The model presented in this section includes some, but not all, of the conceptual advances made to the Rosen/Roback structure since the mid-1980s. If data limitations prevented empirical confirmation of a recent conceptual innovation, we do not include it in the model specification below. Specifically, Hoehn, Berger, & Blomquist's (1987) endogenizing of city size and population and introduction of compensation for travel distance from the central business district are not modeled. The same holds for agglomeration effects introduced by Blomquist, Berger, & Hoehn (1988). We refer readers interested in those specific comparative statics to the two articles.

which is traded at a common price (the numeraire) across cities. Residents living in city j also consume a bundle of pure amenities A_j (e.g., good weather) and government services, G_j, that are locally produced (e.g., public safety). The amenity and service package available in city j is taken as exogenous by all potential worker-residents to that city, with the utility for representative worker-resident I living in city j given by

$$U\{C_i, N_i; A_j, G_j\}. \tag{1}$$

The gross-of-tax cost of a unit of the consumption commodity is $(1+s_j)$, where s_j is the combined state and local sales tax rate. The gross-of-tax rental rate for a unit of land-housing services is $(1+t_j)n_j$, where t_j is the local property tax rate and n_j is the local land rental rate. The worker-resident's net-of-tax wage rate is given by $(1-z_j)W_j^g$, where z_j is the combined state and local income tax rate and W_j^g is the local gross wage.[2]

Assuming that each worker-resident inelastically supplies one unit of labor, the budget constraint for the worker-resident is given by

$$(1+s_j)C_i + (1+t_j)n_jN_i \leq (1-z_j)W_j^g + I_i \quad , \tag{2}$$

where I_i represents nonwage income.[3]

Conditional on a city location, the following indirect utility function arises from the worker-resident's maximization of (1) subject to (2):

---

[2]For simplicity, all workers are treated as equally productive. Empirical applications include variables that attempt to control for productivity differences across workers.

[3]For simplicity of exposition, this specification of the budget constraint assumes that the state taxes only wages. No fundamental conclusions are altered if more complex descriptions are employed.

$$V_{ij} = V\{(1-z_j)W_i^g, (1+t_j)n_j, (1+s_j), I_i; A_j, G_j\} \quad . \tag{3}$$

Amenities enter the indirect utility function only through their impact on a worker-resident's utility. Services, in contrast, enter the indirect utility function both through their impact on a worker-resident's utility and through their associated impact on the gross- and net-of-tax prices faced by the worker-resident.

Assuming costless mobility and full information about the amenity and fiscal attributes of each city, long-run equilibrium requires that the marginal worker-resident be indifferent as to her city location,[4] with wages and land rentals adjusting so that,

$$V^* = V_{ij} \quad \text{for all j.} \tag{4}$$

Turning to the firm's location decision, profits conditional on locating in city j are given by

$$\pi_{ij} = Y_i\{A_j, G_j\} - (1+t_j)n_j N_i - W_j^g L_i - (1+s_j)M_i \ , \tag{5}$$

where Y_i is total revenues which are a function of the city's amenity and fiscal attributes through their impact on the production (and distribution) function, L_i represents the firm's labor usage,

[4] If workers are homogeneous in preferences, then the arbitrage condition implies equalizing differences which will be exact for all worker/residents. If workers are heterogeneous in preferences, then the equalizing differences will be exact only for the marginal worker. See Roback (1988).

and M_i is the firm's intermediate input usage.[5] Given a city location, the firm's maximization problem yields the following indirect profit function,

$$\Pi_{ij} = \Pi_i\{W_j^g, (1+t_j)n_j, (1+s_j); A_j, G_j\} \ . \qquad \textbf{(6)}$$

Again assuming costless mobility and full information, the long-run equilibrium requires that the marginal firm is indifferent as to its city location. This requires that wages and land rentals adjust to impose the following arbitrage condition.

$$\Pi^* = \Pi_{ij} \quad \text{for all j.} \qquad \textbf{(7)}$$

The long-run equilibrium wage and land rentals are found by solving the two arbitrage conditions as illustrated in Figure 1's familiar representation.

[5]Equal residential and commercial property tax rates are presumed in (2) and (5), but the model is unaffected if different tax rates are allowed. We also abstract from restrictive zoning that might introduce a wedge between residential and commercial rents. In this sense, the model probably is more applicable to larger, more heterogeneous cities than to smaller, relatively homogeneous suburbs.

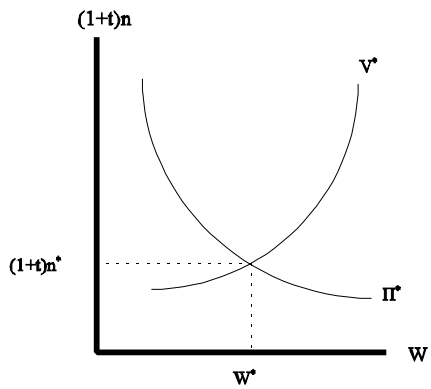

Figure 1

The reduced form wage equation is obtained by isolating the gross-of-tax land rental in (4) and (7), equating the two expressions, and solving for W_j^g so that

$$W_j^g = W\{(1+s_j), z_j, I, A_j, G_j; V^*, \Pi^*\} \ . \qquad \textbf{(8)}$$

The reduced form equation for the gross-of-tax land rental $(1+t_j)n_j$, which we denote as R_j, is obtained in a similar fashion so that

$$R_j \equiv (1+t_j)n_j = N\{(1+s_j), z_j, I, A_j, G_j; V^*, \Pi^*\} \ . \qquad \textbf{(9)}$$

The comparative statics of the model yield several insights into wage and land rental capitalization. The first implication of the model is *full* capitalization of property tax differentials

into land rentals. That is, increases in the property tax, *t*, that are not offset by added services or amenities (or other tax reductions) are fully capitalized into land prices.

$$\frac{\partial n}{\partial t}\Big|_{z,s,I,A,G} = -\frac{n}{(1-t)} < 0$$
$$\frac{\partial W}{\partial t}\Big|_{z,s,I,A,G} = 0 \quad . \tag{10}$$

Pure amenities by definition have no explicit market price. They are implicitly priced in the labor and land markets through capitalization into wages and rentals as shown in (11),

$$\frac{\partial n}{\partial A}\Big|_{t,s,z,I,G} = \frac{-\frac{V_A}{V_R} + \frac{V_W}{V_R}\frac{\Pi_A}{\Pi_W}(1-z)}{D} > 0$$
$$\frac{\partial W}{\partial A}\Big|_{t,s,z,I,G} = \frac{\frac{1}{V_W(1-z)}\left[-V_A + V_R\frac{\Pi_A}{\Pi_R}\right]}{D} \gtreqless 0 \ , \tag{11}$$

where $D = 1 - (V_W/V_R)(\Pi_R/\Pi_W)(1-z) > 0$, and V_k and Π_k are the first partials of the indirect utility and profit functions with $V_W > 0$, $V_R < 0$, $V_A > 0$, $V_G > 0$, $\Pi_W < 0$, $\Pi_R < 0$, $\Pi_A \geq 0$, and $\Pi_G \geq 0$.

These results imply that sites in cities with better amenity characteristics, *cet par*, will be rationed through higher land prices and an indeterminate shift in wages. If the amenity does not directly affect firm revenues, $\Pi_A = 0$, then wages will fall to help ration scarce sites. In this case, the amenity is capitalized in both wages and rentals (see Figure 2). If the amenity is productive, $\Pi_A > 0$, then land rentals increase by even more than in the first case, and the wage effect is

indeterminate (see Figure 3, in which the assumed shift in the firm's indirect profit curve leaves the wage unaffected). Smaller (larger) shifts in the firm's indirect profit curve would result in wages falling (rising) in response to the higher amenity level.

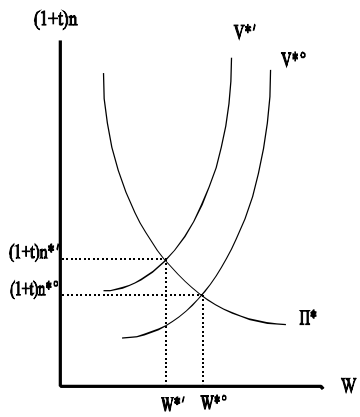

Figure 2

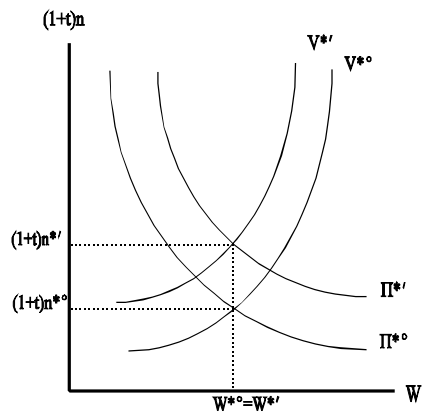

Figure 3

The analysis of government service provision parallels that for amenities because the explicit prices for government services (income, sales, and property taxes) are held constant while the level of government services varies (see equation (12)). This type of variation in the data is possible if local governments vary in their efficiency at producing services.

$$\frac{\partial n}{\partial G}\Big|_{t,s,z,I,A} = \frac{-\dfrac{V_G}{V_R} + \dfrac{V_W}{V_R}\dfrac{\Pi_G}{\Pi_W}(1-z)}{D} > 0$$

$$\frac{\partial W}{\partial G}\Big|_{t,s,z,I,A} = \frac{\dfrac{1}{V_W(1-z)}\left[-V_G + V_R\dfrac{\Pi_G}{\Pi_R}\right]}{D} \gtrless 0 \ . \qquad \textbf{(12)}$$

Two more comparative static results relate to changes in the income and sales tax rates. Higher income (z) and sales (s) tax rates, holding service levels constant, lead to lower land rentals. Since the income tax rate does not affect the firm's indirect profit function, a higher rate also leads to higher gross wages. In contrast, if firms use intermediate goods, then higher sales tax rates can lead to higher or lower gross wages. These results are summarized in equation (13).

$$\frac{\partial n}{\partial z}\Big|_{t,s,I,A,G} = \frac{\frac{V_W}{V_R}\frac{W^g}{(1+t)}}{D} < 0$$

$$\frac{\partial W}{\partial z}\Big|_{t,s,I,A,G} = \frac{\frac{W^g}{(1-z)}}{D} > 0$$

$$\frac{\partial n}{\partial s}\Big|_{t,z,I,A,G} = \frac{-\frac{V_s}{V_R} + \frac{V_W}{V_R}\frac{\Pi_s}{\Pi_W}(1-z)}{D} < 0 \qquad \textbf{(13)}$$

$$\frac{\partial W}{\partial s}\Big|_{t,z,I,A,G} = \frac{\frac{1}{V_W(1-z)}\left[-V_s + V_R\frac{\Pi_s}{\Pi_R}\right]}{D} \gtrless 0 \quad .$$

Full prices for amenities and fiscal attributes of cities are constructed from these capitalization results as follows. Define P_k as the full price for the kth city attribute, Z_k, with

$$P_k = \frac{\partial n}{\partial Z_k} - e\frac{\partial W}{\partial Z_k} \quad , \qquad \textbf{(14)}$$

where e denotes the "exposure" of the marginal household to the labor market.[6] The next step in constructing a quality of life index value is to use the equilibrium assumption to equate prices with values. In this case, the value of city j is the sum of its attributes times their full prices.

$$QOL_j = \sum_k P_k Z_{jk} \quad . \tag{15}$$

Obviously, the link between the price observed for an attribute and the value placed on the attribute is central to the QOL methodology (see Evans (1990)), and is a topic to which we return later in the end of the chapter.

III. Recent Econometric Developments in Estimating the Quality of Life

A. Specification Bias Problems and the Interpretation of Capitalization Results

All empirical work is subject to specification bias, and recent research suggests that there are special concerns in QOL analyses because of the difficulty of properly controlling for all taxes and the levels of effective service provision (Gyourko & Tracy (1989a,b; 1991)). For example, the reduced form comparative statics for government services parallel those for amenities *only* if all relevant taxes are included in the reduced form equations. In addition, public sector rent-sharing can bias the capitalization results for amenities by creating explicit prices for them if local unions appropriate some of the locational rents through the collective bargaining process via agreements that permit overstaffing or paying of wage premia.

[6] The assumption is that each household owns one residential site in the community, but may have a varying degree of exposure to the labor market. For example, a retired household would have $e = 0$, a single earner household $e = 1$, and a dual earner household $e = 2$.

Consider how the comparative statics for G would change if all taxes are not controlled for in the reduced form wage and land rental equations. To keep the analysis simple, let the locality vary only the local property tax rate in order to adjust its tax revenues. This gives rise to the following relationship between government services and the property tax rate.

$$t_j = T(G_j; B_j, \Theta_j) \ , \tag{16}$$

where B_j is the property tax base in the city and Θ_j is an efficiency parameter. While the local property tax rate depends on the level of local services, variations in rates across communities having the same level of services can exist due to differences in tax bases and efficiency levels of the governments.

Failure to control for the explicit tax price associated with a produced government service, as distinct from a non-produced amenity, generates the following capitalization results (Gyourko & Tracy (1989b, 1991)).

$$\begin{aligned} \frac{\partial n}{\partial G}\Big|_{I,A} &= \frac{\partial n}{\partial G}\Big|_{t,I,A} + \frac{\partial n}{\partial t}\Big|_{I,A,G}\frac{\partial t}{\partial G} \\ &= \frac{\partial n}{\partial G}\Big|_{t,I,A} - \frac{n}{(1-t)}\frac{\partial t}{\partial G} \\ \frac{\partial W}{\partial G}\Big|_{I,A} &= \frac{\partial W}{\partial G}\Big|_{t,I,A} + \frac{\partial W}{\partial t}\Big|_{I,A,G}\frac{\partial t}{\partial G} \\ &= \frac{\partial W}{\partial G}\Big|_{t,I,A} \ . \end{aligned} \tag{17}$$

Note that the land-rental capitalization effect now involves two terms. The first reflects the pure capitalization of the government services holding their explicit tax prices constant. The

second captures the compound effect of a pure property tax rate increase holding services constant times the increase in the property tax rate due to the higher level of services. Given the increase in property tax rates due to the higher service level, the sign of the second term is negative for land rentals and zero for wage rates (because the property tax rate effect is fully capitalized into land rentals with no spillover to local wages--see equation (10)). Thus, the second effect acts to offset the first for land rentals, lowering the observed level of capitalization. However, there is no similar affect on wage capitalization. A consequence of the failure to fully control for taxes, then, is to bias the relative capitalization effects of locally produced services toward wages.

Bias also can result from failing to control properly for all taxes when public sector unionization leads to sharing of locational rents between union members and other community residents. Assume that unions attempt to organize in areas where the potential return is the highest, so that the level of public sector unionization increases on average with the size of the locational rents. Further, let amenities comprise a significant component of locational rents. Then, as we increase the level of amenities by moving across cities, we also are increasing the level of public sector unionization, $\partial U / \partial A > 0$, where U represents the local public sector unionization rate. The measured capitalized value of amenities in this case is given in equation (18).

$$\frac{\partial n}{\partial A}\Big|_{I,G} = \frac{\partial n}{\partial A}\Big|_{t,I,G} + \left[\frac{\partial n}{\partial U}\frac{\partial U}{\partial A}\right]$$

$$\frac{\partial W}{\partial A}\Big|_{I,G} = \frac{\partial W}{\partial A}\Big|_{t,I,G} + \left[\frac{\partial W}{\partial U}\frac{\partial U}{\partial A}\right] \quad . \qquad \textbf{(18)}$$

For land rentals, the first term on the right hand side is positive and reflects the total value of the increased amenity level. However, the second term on the right hand side is negative, reflecting the combined effects of increased rent-sharing and allocative inefficiency associated with the increased union rent-seeking associated with the higher amenity level. For wages, the sign of the first term is ambiguous while the second term is positive.[7]

In the extreme, if the *entire* value of the additional amenity level is appropriated by local unions, then the capitalized value of the amenity differential is zero. In that case, collective bargaining has completely transformed the implicit price for the amenity into an explicit price because the cost of local public sector rent-sharing must be financed through a combination of higher taxes and/or lower service levels.

B. Group Effects in the Wage and Housing Data

The data used in QOL studies typically involve micro level observations on many workers and homes within a given labor or housing market area. Researchers should be cognizant of the possibility that the wage and house price hedonic regression residuals may contain city-specific error components (i.e., group effects). Ordinary least squares (OLS) estimations, which do not control for these group effects, will lead to reported standard errors of the trait prices that are biased downward (see Moulton (1986, 1987)).

Consider the following specification for wages for worker/resident *i* in city *j*,

$$\ln W_{ij} = X_i\beta_1 + Z_j\beta_2 + u_{ij}\ , \quad u_{ij} = \alpha_j + \varepsilon_i\ , \tag{19}$$

[7]See Gyourko & Tracy (1989b) for the details.

where X_i is a vector of individual worker traits and industry/occupation controls, Z_j is a vector of city amenity/fiscal characteristics, and u_{ij} is the composite error term. The composite error term is the combination of a city-specific error component, α_j, and an individual-specific error component, ε_i. The city-specific error component is common to all workers in the city, and represents systematic uncontrolled differences in worker quality across cities, systematic uncontrolled differences in amenity/fiscal characteristics across cities, and/or common demand/supply shocks to the local labor market.

Similarly, let the local land rental for household *i* in city *j* be modeled as follows,

$$\ln n_{ij} = H_i\gamma_1 + Z_j\gamma_2 + \nu_{ij}, \quad \nu_{ij} = \delta_j + \eta_i, \tag{20}$$

where H_i is a vector of individual housing structural traits and ν_{ij} is the composite error term. The composite error term again is the combination of a city-specific error component, δ_j, and a house-specific error component, η_i. The city-specific error component is common to all houses in the city, and represents systematic uncontrolled differences in house quality across cities, systematic uncontrolled differences in amenity/fiscal characteristics across cities, and/or common demand/supply shocks to the local housing market.

If $\sigma^2_\alpha > 0$ and $\sigma^2_\delta > 0$, then the composite error terms across workers and across houses within the same city are correlated, violating the OLS independence assumption. The magnitude of the bias imparted to the standard errors of the estimated trait prices when independence is violated depends on the "design effects" present in the data (Kish, 1965). The design effect for the jth city is defined as follows

$$d_j = 1 + (m_j - 1)\rho, \tag{21}$$

where m_j is the number of workers (houses) in the sample from the jth city and ρ is the common correlation coefficient between the composite errors for workers (houses) within the city. In our example, these correlations are given by the ratio of the variance of the city-specific error components to the total variance of the composite error terms.

The simplest case to analyze is where the size of each city is the same and the right hand side variables vary only between groups (i.e., there are only *Z* variables in the model). In this case, the ratio of the true variance of β_2 to the OLS variance estimate equals the design effect.[8] The presence of city-specific error components generates design effects greater than one, implying a downward bias to the OLS-based standard errors. The extent of the downward bias depends on the size of the city groups in the data and the size of ρ.[9]

A second implication of the presence of group effects is that the definition of a city's QOL becomes ambiguous. Assume that the city-specific error components represent left-out amenity/fiscal attributes of a city. If data were available on these attributes, then implicit prices could be estimated and the attributes would be included in the calculation of the QOL. In the absence of data on the attributes, their impact on a city's QOL could be determined as follows

$$QOL_j = \sum_k P_k Z_{jk} + \delta_j - e \cdot \alpha_j \ . \qquad \textbf{(22)}$$

However, if the city-specific error components represent largely uncontrolled for worker and housing quality, then they should *not* be included in the QOL calculation. Given the inherent

---

[8]See Tuenkloek (1981) for the derivation of the correct variance/covariance matrix.

[9]Generalizing the model to allow for differing city sizes and/or variables that vary within each city (*X* and *H*) still results in a downward bias in the OLS standard errors. See Scott & Holt (1981), Pfefferman & Smith (1985), and Moulton (1986).

ambiguity regarding the source of the city-specific error components, it is prudent to always examine the sensitivity of the QOL rankings to including or excluding the city-specific error components.

Testing for the presence of group effects can proceed along the lines suggested by King & Evans (1986), who proposed the following lagrange multiplier test for the null hypothesis H_0: $\sigma_\alpha^2 = 0$, versus the alternative hypothesis H_1: $\sigma_\alpha^2 > 0$,

$$\text{LM} = \frac{\sum_j (m_j \overline{u}_j)^2 - \sum_i \sum_j u_{ij}^2}{\sigma^2 \left[2\left(\sum_j m_j^2 - N \right) \right]^{1/2}} \quad , \qquad \textbf{(23)}$$

where $\sigma^2 = u'u / N$. Under the null hypothesis, the LM statistic is asymptotically distributed as a standard normal. An advantage of this test is that it only requires the OLS residuals, which makes it easy to compute as a diagnostic test.[10]

If the null hypothesis is rejected, then a random effects estimator should be used in lieu of OLS. It is important, though, following estimation of the random effects model to run a specification test for whether the city-specific error components are correlated with the right hand side variables in the model. If this is the case, then random effects will produce inconsistent coefficient estimates. The standard procedure is to carry out a Hausman test for a significant difference between the fixed and random effects coefficients on the variables that have within-

[10]If the aim of the empirical exercise is to generate consistent estimates of the coefficients on the worker and/or house quality variables and the amenity/fiscal variables are of no independent interest, then a fixed effects estimator can be used in lieu of random effects. This approach is much simpler in that no data on a location's amenity/fiscal attributes are required. See Kahn (1995).

group variation. If the test rejects the null of no correlation, then instrumental variable random effects procedures can be used (see Hausman and Taylor (1981)).

The presence of group effects has important implications for the precision of the QOL rankings. The QOL ranking for a given city is a nonlinear function of the hedonic coefficient estimates and the distribution of all city amenity/fiscal attributes. This makes simulation methods for calculating standard errors more tractable than analytic methods. The intuition for the simulation methods is as follows. The researcher would like to draw a new sample of data from the "population", and reestimate the hedonic coefficients. The new coefficient estimates can then be used to construct a new QOL ranking. Repeating this process will generate a distribution of QOL rankings for each city. A measure of the standard error of a given city's QOL ranking is the standard deviation of this empirical distribution.

This process can be approximated by simulating new draws of the hedonic coefficients based on their estimated joint distributions. In the estimation process above, we assumed a normal distribution for the composite error terms. This implies coefficient vectors that also have a normal distribution, $V(\beta)$. Rather than redrawing samples of data, one can redraw coefficient vectors from their assumed distribution. This saves considerably on computation time relative to bootstrap methods for resampling of the data.[11]

---

[11]Very briefly, since $V(\beta)$ is a positive semi-definite matrix, there exists a unique *lower* triangular matrix C such that $V(\beta) = CC'$. Let β^i denote the ith simulated coefficient vector and ξ^i a vector (with dimension matching β) of standard normals. Then β^i can be simulated as follows.

$$\beta^i = \beta + C \cdot \xi^i \quad ,$$

where β are the original hedonic coefficient estimates. The number of simulations should be increased until the implied standard errors of the QOL rankings do not change at an acceptable level of significance between separate simulation exercises.

The limited research on this issue suggests that the precision of QOL rankings is considerably less than researchers and decision-makers would like. Using 1980 *Census of Population* data on workers for 125 cities, Gyourko & Tracy's (1989) results imply that the OLS standard errors for the wage hedonic prices were biased downward by a factor of 2.4 on average. Their 1991 paper, also using 1980 *Census of Population* data, suggested that the OLS standard errors for the housing hedonic prices were biased downward by a factor of 2.8 on average.

The impact of city-specific error components on the precision of the hedonic prices, directly affects the precision of the QOL estimates derived from these prices. The average standard error of the rankings based on random effects is 16.9 versus an average of 8.6 for the rankings based on OLS. Given the 130 city sample size, this implies that it is impossible to differentiate among cities at standard confidence levels unless the comparison is between cities ranked in the top and bottom twenty of all cities.

The limitations of existing studies are further amplified when one compares the QOL rankings without and with the city-specific error components included. Assuming that the city-specific error components α_j and δ_j primarily represent systematic unobserved worker and house quality differences across cities implies that these error components should be excluded from the QOL calculation. In contrast, assuming that these error components primarily represent left-out city attributes implies that they should be included in the QOL calculation as given by equation (23). In Gyourko & Tracy (1991) the simple correlation between the two sets of rankings is 0.63. However, the mean absolute change in rankings is 27 with a standard deviation of 21. The housing and wage error components are positively correlated, $\rho = 0.14$ (0.10) when weighted by the number of housing (wage) observations. This positive correlation is consistent with the error

components reflecting primarily left-out worker and housing quality, but does not preclude the left-out amenity/fiscal variable explanation.[12]

One solution to this problem is better quality data on worker, housing, and city characteristics. The impact of the error components on the estimation results is minimized as the error components themselves are minimized. However, most QOL studies have a limited number of urban areas to work with, which places a severe constraint on the potential number of urban attributes that can be controlled for in the wage and housing specifications. Given the difficulties in improving the quality of cross-sectional data used to estimate urban QOL, an important question is the degree to which panel data could alleviate the error components problems discussed above. Unobserved workers and housing quality differences that are time invariant can be differenced out in panel data. However, the problem in QOL applications is that the urban attributes, Z_j, are differenced out as well. Moreover, there is likely to be little real variation in most urban attributes over short time periods. The measured variation in the data is likely to be heavily contaminated with measurement error. Panel data, then, does not provide a useful alternative to improved cross-sectional data.

IV. New Estimates of the Quality of Life: Results, Comparisons, and Analysis

[12]A plausible story is that workers of higher quality will demand higher quality housing. This would imply a positive correlation between the city error components. Left-out amenity/fiscal variables that are valued by workers but not firms would imply a negative correlation. However, if firms also value the amenity/fiscal variables, then the sign of the correlation is indeterminate.

Over the past decade there have been three major QOL estimation projects within the Rosen/Roback tradition that use market prices of local traits as weights in index construction: Blomquist, *et al* (1988), Gyourko & Tracy (1991), and Stover & Leven (1992). Other recent efforts to estimate compensating differentials arising from city attributes include Hoehn, Berger, & Blomquist (1987), Roback (1988), and Voith (1991). However, they are not discussed here because they did not compute a single QOL index value for each locality. In addition, research on other approaches (e.g., Cheshire & Hay (1989)) and on mobility and the QOL (e.g., Greenwood *et al* (1991)) is dealt with in Section VI. Various organizations also publish QOL rankings that use survey data or some *ad hoc* weighting scheme. Boyer's (1983) *Places Rated Almanac* and the Mobil Oil Corporation's *1989 Mobil Travel Guide* are good examples of that genre.[13]

A. Blomquist et al (1988): "New Estimates of the Quality of Life in Urban Areas"

This study spurred renewed interest into research on the urban quality of life. The empirical work is based on a large cross section of 253 counties within 185 metropolitan areas in the U.S. taken from the *1980 Census of Population and Housing*. The authors' underlying theoretical model is one in which each urban area has two counties, and they derive new and interesting comparative static results with respect to the impact of agglomeration effects associated with productivity effects of the size of the urban area. While Blomquist, *et al* report substantial intra-metropolitan area differences in the QOL for 10 of the 38 urban areas for which

[13]It should be noted that the three studies to be reviewed below all estimate reduced form wage and housing hedonic price equations. Consequently, they do not test the basic assumption of the Rosen/Roback model that labor and land markets are interrelated. Haughwout (1993) estimates structural versions of these equations using three stage least squares and finds strong evidence supporting the Rosen/Roback assumption. The elasticity (standard error) of the wage with respect to changes in housing costs is 0.59 (0.02), while the elasticity of housing costs with respect to the wage is 0.73 (0.02).

they have observations on multiple counties, it is not clear how having amenity variation both within and across urban areas impacts either the individual trait valuations or the overall QOL rankings. It would be useful to know if the price of (say) their Superfund Site trait would be substantially different if they had only used metropolitan area-level data for the 185 urban areas in their sample, and whether any such differences were large enough in aggregate to materially impact the QOL values or rankings of those metro areas.

Blomquist *et al* amassed data on thirteen local traits, which included eleven climate and environmental attributes that could be considered pure amenities and two others (a teacher-pupil ratio and violent crime rate to proxy for the quality of educational services and public safety, respectively) that are better described as locally produced characteristics. Their six environmental traits included a rich set of controls for Superfund Sites, landfills, and waste treatment and discharge sites that had not been used in previous QOL analyses.

The authors employ a Box-Cox search procedure in estimating reduced form hedonic wage and housing expenditure equations within an OLS framework. The results indicate that their thirteen local traits are jointly significant, both statistically and economically. The full range of QOL values is $5146, implying that in equilibrium the marginal household residing in the lowest rated county (St. Louis, MO) requires that amount in terms of higher wages and/or lower housing expenditures per year to be indifferent to living in the highest rated county (Pueblo, CO).

Their results for individual trait prices almost always have the correct sign in the sense that locating in an area with more of some obvious ‘bad’ is associated with compensation in the form of higher wages and/or lower land prices. Their pollution-related findings are discussed in some

detail in the next section, and we refer the readers interested in other specific trait prices in this (and the other two articles) to the papers themselves.

Blomquist *et al* also report substantial labor market capitalization of the local amenities, suggesting that firm and worker competition for scarce sites does impact both local land and labor markets. They also present the results of calculations of subindexes based on subsets of variables. Those findings strongly suggest that a top- (bottom-) ranked county need not be highly (poorly) rated on all amenity dimensions. For example, the rank correlation between the subindex based on their seven climate controls and the overall index is 0.63. The analogous correlation between their environmental subindex and the overall index is only 0.21.

B. Gyourko & Tracy (1991): "The Structure of Local Public Finance and the Quality of Life"

This paper uses the same *Census* data and many of the same climate, but not environmental, amenity variables in Blomquist *et al*. An important difference in the two studies is that the geographic unit of observation in Gyourko & Tracy is the central city of the metropolitan area. This was chosen so that a richer set of tax and service fiscal controls could be matched to a specific political jurisdiction.[14] Gyourko & Tracy also differs from Blomquist *et al* in the use of a random effects estimator to account for potential group effects in the data.

Despite these differences in data, specification, and econometric technique, the signs on the individual trait prices, especially the pure amenity variables, are almost always the same as in Blomquist *et al*. The amenities also are jointly significant in statistical and economic terms in both

[14]The material differences in fiscal conditions that existed between a central city and its typical suburb in 1980 (not to mention the extensive heterogeneity across suburbs) would have led to significant errors-in-variables problems had counties or metropolitan areas been the geographical unit of observation.

papers. And, both sets of results indicate that substantial compensation for amenity differentials occurs via wages in the labor market. The full range of QOL values across the 130 cities in Gyourko & Tracy's sample is $8227. This is larger than in Blomquist *et al*, but outliers drive that difference. The interquartile range of QOL values is only $1484.

An important contribution of this paper is its documentation that local fiscal environments also are important determinants of the QOL, suggesting that cities may have more control over their local QOL than was previously thought. Consistent with the basic theoretical prediction of the expanded model, variations in effective property tax rates appear to be fully capitalized into land prices. Except for the impact of corporate taxes, their results provide empirical support for the tax capitalization comparative statics in equations (10) and (13). The full prices estimated for police, fire, and health services each have the theoretically anticipated signs, with the police and health service proxies being statistically significant. Of the service vector variables, only the price of the student-teacher ratio has the wrong sign and its value is very low (-$27).[15] The impact of rent-sharing with successful public sector unions on the local QOL is found to be small on average, but other work suggests substantial capitalization effects into land prices for cities with very high unionization rates among their public sector employees.[16]

---

[15]Unfortunately, the different data, geographical units of observation, and specifications make it infeasible to do a simple comparison of the full prices of the two service controls common to Blomquist *et al* and Gyourko & Tracy. Such a comparison would be helpful in order to gauge whether the estimated full prices of produced services are smaller when taxes are not controlled for, as the model outlined in Section II implies should be the case.

[16]What little capitalization Gyourko & Tracy (1991) do find occurs in the land market, not the labor market. Gyourko & Tracy (1989b,c) focus solely on the impact of local public sector unionization on land values, using different metrics for identifying cities that are likely to be subject to successful rent-seeking.

Gyourko & Tracy (1989c) look at median house prices for 36 cities using *American Housing Survey* data for 1976. Rent-sharing cities are defined as those whose local public sector

The interquartile range for the aggregate contribution of the seven tax/service fiscal variables in Gyourko & Tracy is $1188, compared to $1372 for the eleven pure amenity variables. In addition, they find that fiscal differentials account for at least one-fifth of the variation in quality-adjusted housing expenditures that can be explained by all city-specific variables, and at least one-half of the variation in quality-adjusted wages that can be explained by all city-specific variables.

In an OLS regression estimation done for comparison purposes with the previous literature, they find that including the fiscal and public union controls is associated with a 16.2 mean absolute change in ranks compared to a specification that only includes pure amenities.[17] The bias, then, on the overall QOL ranking from omitting the fiscal variables is substantial.

Perhaps even more important are the findings of this paper suggesting how fragile are the QOL rankings estimates. Moving from an OLS to a random effects estimation is associated with a 10.2 mean absolute change in ranks. In QOL value terms, the mean change is $391 and the standard deviation about that mean is $320. Not only are the rankings different when group effects are controlled for, they are much less precisely estimated.

---

employees were paid wage premia in excess of one standard deviation above the mean, with the wage premia being calculated using micro data on public sector workers drawn from the May 1977 *Current Population Survey*. Median house values were found to be 28% lower in the rent-sharing cities.

Gyourko & Tracy (1989b) examined median house prices in a larger sample of 90 cities using *County & City Data Book* information for 1983. Rent-sharing cities in this study were identified as those whose public sector union organization level was at least one standard deviation above the average (i.e., above 67%). This study reports that house values were 12% lower on average in the rent-sharing cities. We interpret the findings of these three papers as indicating that relatively little rent-sharing with local public unions occurs on average (at least between 1976 and 1983), but that there are significant effects on home prices in very highly unionized towns.

[17]The standard deviation about that mean change was 15.2.

The issue of how to treat group effects increases the uncertainty regarding the reliability of the results. Gyourko & Tracy computed QOL rankings that presumed the group effects were entirely composed of omitted city characteristics. When compared to the random effects-based results that did not price out the group effects, the mean absolute change in ranks associated with fully pricing these group effects was 27, with a standard deviation of 20 about that mean change. In general, the largest decreases (increases) in a city's rank were due to observed wages being higher (lower) than predicted.

C. Stover & Leven (1992): "Methodological Issues in the Determination of the Quality of Life in Urban Areas"

Stover & Leven work within the Rosen/Roback framework to derive an alternative functional form that is used to reestimate QOLs using the Blomquist *et al* (1988) data. A key motivation of their approach is concern about the reliability of hedonic wage equation estimates due to the difficulty controlling for job and worker characteristics. Stover & Leven also believe that the dependent variable in a housing hedonic is superior because it measures the service flow from the durable good, while wages understate a worker's total compensation.

These authors assume that both land and labor markets are in equilibrium (a standard Rosen/Roback assumption) and that each market fully reflects the values of local amenities as well as conditions in the other market. This gives rise to wage and land rental specifications which take the following form: n=n{Z,W} and W=w{Z,n}. These specifications differ from the reduced form specifications described earlier in that they include the price from the other market.

Stover & Leven demonstrate that the full price for the kth city attribute, Z_k, based on their single equation housing expenditure hedonic, is given by the following expression,

$$P_k = -n_w w_n \frac{dn}{dZ_k} - n_w w_{z_k} , \qquad \textbf{(24)}$$

where the first term, - $n_w w_n dn/dZ_k$, represents the direct impact of Z_k on land rentals. The second term, - $n_w w_z$, is the indirect impact of Z_k on land rentals and reflects feedback from the labor market.[18]

In interpreting the direct impact of Z_k on land rentals, the partial derivative n_w reflects a pure income effect on the demand side because only amenities are compensating in their model. Thus, it should be greater than zero if housing is a normal commodity. The partial derivative w_n is assumed to be positive as it reflects a compensating differential for the increased cost-of-living associated with an increase in land rents. Naturally, they are interested in land rentals that rise due to a better amenity package (dn/dZ_k). In interpreting the indirect impact on land rentals reflected in the second term on the right-hand of (25), an increase in some Z_k affects wages as shown in the partial derivative w_z . This feeds back into the land market through the n_w term discussed above.

Stover & Leven actually estimate a hedonic equation in housing expenditures of the following type via OLS,

$$\ln n_{ij} = H_i\gamma_1 + Z_j\gamma_2 + L_j\gamma_3 + \upsilon_{ij}, \quad \upsilon_{ij} = \delta_j + \eta_i , \qquad \textbf{(25)}$$

where the vector H_i controls for heterogeneity in housing quality, $Z_j\gamma_2$ proxies for - $n_w w_n dn/dz$, and $L_j\gamma_3$ proxies for - $n_w w_z$. They define L_j as follows,

[18]Obviously, a single wage hedonic also could be specified, but that is not the preferred option given the authors' worries about the quality of wage data and job/worker trait controls.

$$L_j = \frac{1}{p_j} \sum_i \frac{W_{ij}}{E(W_{ij})} \ , \qquad \textbf{(26)}$$

where p_j is the number of worker observations in jurisdiction j, W_{ij} is the wage of the ith worker in community j, and $E(W_{ij})$ is the predicted wage of that same worker based *only* on worker and job traits.

While Stover & Leven estimate equation (26) using Blomquist *et al's* (1988) data for 253 counties, the two studies' reported QOL values differ dramatically. For example, the Spearman rank correlation of the two sets of rankings is essentially zero (0.004).[19] The authors interpret these results to imply that one-dimensional QOL rankings are very sensitive to model specification, and they presumably believe that their rankings based on the single equation housing expenditure hedonic are superior.

Stover & Leven's desire to reduce reliance on relatively noisy wage hedonics is understandable. Unfortunately, the estimation strategy used in this paper does not appear to be a reliable substitute for the traditional method. The reported QOL calculations still rely on imperfect worker/job controls in an underlying wage equation, still reflect the influence of uncontrolled for group effects, and may suffer from endogeneity bias problems. These points can be illustrated by

[19]Stover & Leven also estimate QOL values using a single wage hedonic (with an added control for rent premiums analogous to L). The rankings generated from that estimation are negatively correlated (Spearman rank correlation of -0.57) with those from their housing expenditure hedonic. This is troubling given that their model predicts identical rankings from the two specifications. If the problem is that hedonic wage estimates are noisy as the authors suggest, that would suggest little or no correlation between the rankings generated from the housing versus wage specifications. It does not account for the strong negative correlation between the two.

rewriting their wage premium variable (L) in terms of the components of a worker's wage as given above by equation (19),

$$
\begin{aligned}
L_i &= \frac{1}{p_j}\sum_i \left[\frac{X_i\beta_1 + Z_j\beta_2 + \alpha_j + \varepsilon_i}{X_i\beta_1}\right] \\
&= 1 + (Z_j\beta_2 + \alpha_j)\frac{1}{p_j}\sum_i \frac{1}{X_i\beta_1} + \frac{1}{p_j}\sum_i \frac{\varepsilon_i}{X_i\beta_1} \qquad \textbf{(27)} \\
&\approx 1 + (Z_j\beta_2 + \alpha_j)\frac{1}{p_j}\sum_i \frac{1}{X_i\beta_1}\ ,
\end{aligned}
$$

where the last step uses the fact that E(ε) = 0 and that ε is independent of X.

Equation (28) shows Stover & Leven's 'wage premium' variable to be a function of the wage equation group error term (α_j) and the city-specific variable effects on wages ($Z_j\beta_2$) . Note that misspecification of the wage regression through inadequate controls for worker quality will lead to a misspecification of L_j if workers sort by quality into different housing markets.[20] Further, Stover & Leven are implicitly assuming that the α's reflect left-out amenity/fiscal characteristics. If the α's arise from common demand and/or supply shocks to the local labor market or if they reflect systematic mismeasurement of worker/job quality, then L_i will not measure the pure impact of amenities on wages as assumed in their model. Finally, if the group error components from the wage and land rental regressions are correlated, then L_i is endogenous, leading to further bias in the QOL estimates.

D. Conclusions

[20]In this case, the misspecification is picked up in the error component, α_j.

Recent empirical work shows that there still is no quick technical fix to the problems of large group effects in the data or hedonic wage and housing equations estimated with imperfect worker, job, and housing quality controls. These really are data problems and probably will have to be solved by amassing higher quality data. Given the considerable effort that Blomquist *et al* (1988) and Gyourko & Tracy (1991) expended to construct their local data bases and the fact that better worker, job, or housing quality controls are not likely to be produced in an era of declining budgets at key data collection agencies, the likelihood of superior data soon appearing to solve the problem the empirical literature finds itself in seems low.

Amidst that pessimistic conclusion, we can suggest a diagnostic that should help in distinguishing whether the group effects reflect on balance unobserved heterogeneity in worker and housing quality or unmeasured city traits. Begin by using the estimated hedonic coefficients on worker and housing quality to construct an estimate of the average observed quality of workers and quality of the housing stock by jurisdiction. Next, construct a matrix of rank correlations between the predicted worker quality, the predicted housing stock quality, the local QOL, the wage group error components, and the housing group error components. If the group error components primarily reflect systematic unobserved quality effects, then we would expect them to be more correlated with the observed worker and housing quality rankings than with the QOL rankings. If the group error rankings are uncorrelated with the observed quality rankings, then it is unlikely that the group error components reflect unobserved systematic quality differences.

V. The Value of the Environment and the Urban Quality of Life--A Detailed Analysis

Modern societies' growing concerns about the environment makes research into the value of environmental attributes worthy of interest in its own right. Most important for this chapter are the important implications and insights this burgeoning literature provides for research into the urban quality of life. More varied data have been used to estimate the prices of environmental attributes. The following subsection presents a comparison of results generated from cross-city data typical of that used in QOL research with those based on within-city data. In addition, the environmental literature includes price estimates for a wider variety of attributes than have been controlled for in the QOL literature. The findings here suggest that QOL researchers should expand their list of environmental attributes to be priced. Finally, there has been greater experimentation with non-hedonic valuation methods in the environmental area. This provides the opportunity to assess the benefits and costs of valuation methodologies different from the revealed preference techniques followed in the QOL literature.

A. Environmental Hedonic Prices: Cross-City and Within-City Data and Results

Cross-city studies of the valuation of non-market environmental goods have been stimulated by the availability of microdata from the *Census of Population and Housing* and from the *Current Population Survey*, with Roback (1982), Blomquist *et al* (1988), Gyourko & Tracy (1991), and Clark & Nieves (1994) estimating house price hedonic and wage regressions where the unit of observation is a person and the geographical unit of analysis is some measure of the urban area (e.g., the central city, county, or SMSA). These studies effectively assume away local public goods measurement error because they presume that local amenities, including environmental attributes, are constant within a city. This is a strong assumption most likely to hold for climate variables but not for local air quality.

It is useful to begin with a discussion of the results for climate controls in the Blomquist *et al* (1988) and Gyourko & Tracy (1991) studies.[21] Gyourko and Tracy (1991) find that individuals are compensated for more cooling degree and heating degree days, and humidity, but pay for more sunshine. They report that rainfall lowers house price and lowers wages (the wrong sign) so that on net, rain is not capitalized because the house price and wage capitalization cancel out. In terms of dollar amounts, Gyourko & Tracy (1991) estimate that people receive $676 compensation for 1000 extra cooling degree days and $503 for 1000 extra heating degree days. Blomquist et. al. (1988) report estimates of $360 and $80 respectively. To put the magnitude of these estimates in perspective, Gyourko & Tracy (1991) report that people are compensated $82.67 for one more standard deviation of violent crimes per capita while they are compensated $567.8 for one more standard deviation of cooling degree days. This suggests that their climate estimates are very large. One possible explanation is that climate variables are proxying for costs of home heating and air conditioning that are capitalized into home prices.

In addition to climate, air pollution as proxied by ambient particulates is a common proxy in hedonic analysis. Particulates are often included in hedonic specifications because the Environmental Protection Agency has created a data base to monitor which cities are not in compliance with the Clean Air Act. In addition, there is ample epidemiological evidence documenting the morbidity and mortality risks of being exposed to high levels of this pollution (Ostro (1987), Portney and Mullahy (1990), Ranson and Pope (1995)). For particulates,

---

[21]Environmental attributes comprise roughly half of Blomquist *et al*'s location-specific public goods. They include particulates, Superfund sites, effluent discharges, landfill waste, and treatment storage and disposal sites. Of this broader set of environmental controls, Gyourko & Tracy (1991) only include a control for particulate matter. However, Gyourko & Tracy (1991) report that the remaining five Blomquist *et al* environmental variables are jointly insignificant in a random effects specification estimated on a subset of 90 cities.

Blomquist *et al* report a full price of -$0.36 per microgram per cubic meter, while the Gyourko & Tracy estimate is -$2.74.[22] In 1982, the standard deviation for particulates as measured from over 1000 county ambient monitoring stations was 14.2 Thus, these hedonic particulates estimates are very small compared to the climate estimates.

In addition to climate and air quality variables, environmental researchers have used the cross-city approach to measure the capitalization of hazardous waste sites. For example, Clark and Nieves (1994) employed the 1980 *Census of Population and Housing*, finding that proximity to a Superfund site is an positive amenity with a price of $58. Blomquist *et al* (1988) report that it is a disamenity with a price of -$107--using the same 1980 *Census* data.

In sum, these cross-city studies provide strong evidence that environmental variables are capitalized, but also suggest the price estimates are highly sensitive to specification, an issue emphasized in Graves *et. al.* (1988).[23]

The most obvious alternative to cross-city analysis is to use data for a single city. If available, the latter is attractive because the researcher typically has access to more disaggregated geographic information. For example, census tract level data allows the researcher to merge on tract-level environmental exposure, reducing the measurement error problems affecting inference

---

[22]An earlier reference point is Roback's (1982) cross-city study based on the 1973 *Current Population Survey*. Particulate levels were significantly higher in 1973 than in 1980. If people have preferences that feature diminishing marginal returns with respect to air quality, then we would expect that the hedonic price would have been higher in a study based on 1970's data than studies based on 1980's data. Roback (1982) reports OLS estimates in which particulates are significant in two out of her four specifications, but the t-statistics indicate that all four estimates would likely have been insignificant if city-specific group effects had been estimated.

[23]Rosen (1979) stressed that multicollinearity between local public goods decreases the likelihood of separating out marginal effects of individual local public goods.

from cross-city studies. Another advantage is that working within a single city controls for local business cycle effects (Topel (1986)).

One obvious disadvantage of within-city data is that only the prices of attributes that vary within the city can be identified. Another is that intra-city hedonic wage regressions cannot be estimated because detailed data on where people work within the city generally is unavailable. A third potential problem with intra-city studies is spatial sorting on unobservables. The best quality homes may be in the best city neighborhoods. The typical hedonic rental study based on *Census* data has rather crude controls for housing structure. The data do not indicate the actual square footage or condition of the unit. If suppliers build nicer units in terms of unobservables in the nicer parts of the city, then the econometrician will overestimate the value of the QOL. Moreover, low environmental quality in a neighborhood may proxy for low quality of housing structure.

A large number of within-city hedonic house price regression studies have focused on the price of particulates. Smith and Hwang (1995) use meta-analysis techniques to summarize multiple studies of housing capitalization between 1967 and 1988, with each city-specific hedonic home regression study representing a data point to explain variation in estimated prices across cities over time. Based on their sample of over 80 hedonic studies, Smith and Hwang (1995) report a median reduction in home prices of $20 and a mean reduction of $100 per microgram per cubic meter ($1980).

Hedonic home regressions also are a natural methodology for quantifying how capitalization of an attribute such as proximity to hazardous sites changes over time. This environmental attribute has been examined using both cross- and within-city data. The cross-city approach does not control for distance from the site. Instead, a count of total sites within a city's

borders is constructed. Thus, noxious sites are assumed to be a pure local public bad (e.g., Blomquist *et al* (1988) and Clark & Nieves (1994)). Kohlhase (1991), Kiel & McClain (1995), and Michaels & Smith (1990) offer intra-city studies to test this. Given the size of SMSAs, the impact of such noxious facilities seems more likely to be seen in intra-city studies.

Kohlhase (1991) is particularly instructive in this regard. She uses Houston housing data in 1976, 1980, and 1985 to explore how the coefficient on distance from a hazardous waste site changes over time as new information about the site is revealed. Using price data before and after the hazardous site has been placed on the National Priority List (NPL) in 1985, she shows that distance was not a valued amenity until after the site was placed on the NPL. After the announcement, distance became an amenity. The peak marginal price of an extra mile of distance was $2,364, which declines to zero at a distance of 6.2 miles. Her findings illustrate the importance of not simply using how many toxic sites are in a county as a proxy for toxic waste exposure--as is typically done in cross-city studies. [24]

The Kohlhase (1991), Kiel & McClain (1995), and Michaels & Smith (1990) studies employing within-city data also have made progress in investigating how "new news" about site toxicity gets capitalized differentially into housing prices at different radius distances from the site. Repeated cross-sectional regression yields insights into the speed with which the perception of environmental hazards is capitalized into price. The siting of a hazardous site can change a community's QOL, induce out-migration, and depress home prices.

---

[24]Kohlhase (1991) also reports the interesting finding that a site's rank on the NPL list is not capitalized. That is, higher ranked sites do not command a deeper discount. Kohlhase interprets this as evidence that people are not able to differentiate information. A different possible interpretation is that being ranked high on the NPL list has two offsetting effects. A high rank should indicate that your home is near a more dangerous site, but counterbalancing this is an increased likelihood that the site will be cleaned up before sites lower on the list.

Kiel & McClain (1995) study how the siting of an incinerator in North Andover, Massachusetts, affected the prices of 2,600 single family homes. They collect data on prices of homes sold in the area between 1974 and 1992. They then partition calendar years 1974 through 1992 into several sub-intervals. The first interval represents the pre-rumor (no site) stage. In the next stage, news of the proposed project leaks, so that with positive probability the incinerator will be sited in the vicinity. Next the project is constructed but is not on line. In this phase the probability of start up is one, but the exact timing is uncertain. Following this stage, the plant comes on line. The impact of each of these stages is explored by estimating a hedonic specification for each. Distance from the incinerator is statistically insignificant through the rumor stage and is insignificant at the 5% level in the construction phase. Only when the incinerator is online and ongoing is it capitalized. In addition, the authors find a larger peak impact than Kohlhase (1991) at $8,100 a mile.[25]

Only a few hedonic studies exist of compensation for water pollution, as unlike with air quality or the location of Superfund sites, no national monitoring system exists to measure water quality differentials across space.[26] Feenberg & Mills (1980) use the Harrison & Rubinfeld (1978) within-city data on the Boston area and augment their specification to include proxies for water pollution that include the water's oil level and turbidity. They find that both have a statistically significant impact on home prices. Surprisingly, Feenberg & Mills do not find strong

---

[25]Use of within-city data also permits examination of an interesting incidence question--whether proximity to a hazardous site has different effects depending on the quality of the house. In a study of the Boston real estate market, Michaels & Smith (1990) examine whether distance from a hazardous site (interacted with whether it has been placed on the NPL list) is differentially capitalized into four submarkets based on home quality.

[26]Water regulators have focused on measuring whether individual polluters are in compliance with emissions rather than with measuring spatial variation in water quality.

evidence that beach front property values decrease the most when nearby water becomes polluted. At the cross-city level, Blomquist *et al* (1988) proxied for water pollution using NPDES effluent discharges and found that it lowered rentals. Both Gyourko & Tracy (1989, 1991) and Blomquist *et al* (1988) found a large coast affect in their cross-city studies.[27]

B. Limitations of Capitalization Studies of Environmental Quality

In estimating equation (19), researchers assume that people take the stock of environment in a location as exogenously determined. For climate, this is certainly a reasonable assumption. Yet environmental quality, such as clean streets and low smog, may be produced through high expenditures on local services and resulting higher local taxes. Examples include frequent garbage collection, large expenditures for vehicle emissions testing, or transfers to high polluting junker car owners in return for scrapping the vehicle (see Hahn (1995)). Unfortunately, no QOL or other hedonic papers have explicitly modeled that environmental quality is a byproduct of economic activity, regulation and citizen actions.[28]

The implications for the QOL is that the researcher may not estimate the full value for environment if the empirical specification ignores taxes and limitations on behavior. Some

---

[27]In addition to quantifying the value of reduced air, waste and water pollution, the environmental QOL literature has also focused on the impact of low probability environmental outcomes. Interesting examples of such small probability events aare earthquakes or cancer caused by proximity to electric lines. See, for example, Brookshire *et al* (1985) for an analysis of earthquake risk premiums in San Francisco and Los Angeles.

[28]For example, changes in air quality may reflect transport regulation or the decline of manufacturing. Henderson (1996) and Kahn (1997) document the relationship between air quality levels and manufacturing activity. If industry declines over time in a major city, then air quality could increase sharply while house prices in a vicinity around these plants might decline due to the decrease in employment opportunities.

environmental attributes are produced through costly actions by local populace, with citizens paying via taxes, lost time, or lost utiles due to limitations on one's activities. If such unfunded mandates are not demanded by the local citizens, then in the extreme case, wages could be high and rents low in clean areas to compensate for the pain of achieving the standard.

In a similar vein, citizens have gained more control over their environmental consumption through the growth of explicit markets. The Clean Air Act Amendments of 1990 create a pollution permit market in sulfur dioxide. Before this market existed, real estate prices around the Adirondacks in Upstate New York might be lower because of Ohio-produced acid rain. If citizens in this area could buy pollution permits from Ohio power plants and retire them, this yearly expenditure would lead to improved acid rain levels in New York. However, rents may not rise by much because people who move there would recognize that they must pay a per-capita share for the permits. If permits expand for other environmental factors such as vehicle emissions, implicit capitalization should fall and hedonic techniques would only reveal a fraction of the full payment for environmental goods.

This discussion also highlights the limitations of hedonic prices for things such as policy analysis. Simply put, the hedonic price indicates how much one pays, conditional on a spatial distribution of environmental quality. It provides no insight as to who paid explicitly or implicitly to achieve any given spatial distribution of environmental quality. Only if the distribution of environmental quality were exogenously determined would the hedonic price would indicate total environmental payment. When environmental quality is produced through regulation, taxes, and limitations on individual behavior, or increased international trade with nations that specialize in

the polluting sector then it is quite possible that "hedonic" payments for environmental quality are dwarfed by implicit regulatory expenditures and lost quasi-rents by workers and firms.[29]

C. Econometric Issues

Recent work on hedonic econometric issues of environmental attributes has focused on the usual suspects: functional form, model specification and measurement error. For example, Stock (1991) uses non-parametric kernel estimation to study the discount in Boston home prices caused by proximity to a hazardous waste site. He finds smaller estimates of home discounts using non-parametric methods over the standard Box-Cox hedonic specifications.

On the specification front, not enough research has followed up Rosen's (1979) discussion of the problem of multicollinearity of local public goods. In cross-city studies, it is crucial that researchers attempt to estimate parsimonious specifications using random effects estimation and

---

[29]Hedonic capitalization is relevant in analyzing claims of environmental racism. Recent studies have found that minority groups are more likely to be exposed to higher levels of pollution than whites (see Hamilton (1993, 1995)). Howerver, there are two key outstanding issues in the waste siting and race literature. First, from an efficiency perspective, where is the social cost minimizing location for sites? Second, conditional on an efficient site location decision, what transfers, if any, should be made to compensate the home owners who are being exposed to increased levels of pollution? If the siting decision is reached by a majority voting process, then the political process may yield lower transfers to the affected home owners than the mythical benevolent planner would have made in achieving a Hicksian pareto improvement with compensation.

In the extreme case of no offsetting transfers, hedonic estimates of the implicit capitalization of noxious sites represent the dollar value of the environmental burden that the majority is shifting on to minority home owners. If transfers are generated by the political process, then their form will determine the impact on the measured capitalization. Lump-sum transfers to the original home owners will have no effect on capitalization, while transfers that are paid out over time will tend to mitigate the capitalization. Evidence of environmental racism requires data on *both* the extent of capitalization and the lack of initial compensating transfers to the affected community.

to study the sensitivity of the findings to specification changes. Graves *et al* (1988) provide an important specification test on hedonic regressions studying robustness of price estimates to omitted variables, function form, and outliers.

An under explored issue in hedonic regression estimation is expectations of changes in local public goods, and local taxes. Cross-city studies have implicitly assumed that migration costs are zero and that people move into a city for a single period and then re-optimize . The possibility that forward looking consumers expect that local public goods may change in the future and that this is capitalized into home prices but not rents has not been developed. For example, Blomquist *et al* (1988) and Gyourko & Tracy (1991) assume that the local public goods provision level is in steady state. Among other benefits, this assumption allows them to increase degrees of freedom by pooling renters and owners. However, there certainly are environmental amenities that will be expected to change over time (e.g., noxious facility sitings and water or air quality). Given data on rentals and home prices for the same geographical locations, future work should separately estimate rental and home price regressions and explicitly test the cross-equation restrictions that the implicit prices are equal.[30] Data sets such as the Toxic Release Inventory could be used to study how new information about exposure to environmental hazards is capitalized in the rental and housing markets.

D. Alternative Valuation Methods

The QOL approach identifies the marginal person's environmental valuation. Researchers are also interested in estimating the distribution of a population's willingness to pay for a given

[30]Abelson & Markandya's (1985) noise pollution study is a rare example of separately studying capitalization rates by tenure mode.

environmental good. Kolstad (1991) provides an excellent review of the variety of techniques for learning about environment demand. Contingent valuation is a straightforward method for learning about environmental valuation. The contingent valuation method describes a hypothetical environmental scenario and polls people on their willingness to pay for increased environmental quality. The hardest part of contingent valuation appears to be designing the actual questionnaire. A good survey must not "lead the witness" and must provide sufficient information to elicit a careful answer from a sample of respondents that is representative of the U.S. population. A key problem is that surveyed individuals do not face a binding budget constraint when stating their responses.[31]

Hedonics and contingent valuation have been jointly applied in studies comparing revealed preference data and stated preference data for the same set of respondents to study the consistency of the two samples.[32] These cross-validation studies tend to be more believable because they are studying well defined and understood environmental phenomena such as sickness from air pollution and access to water recreation.

Brookshire, Thayer, Schulze, & D'arge (1982) estimate hedonic regressions within Los Angeles using data on 684 surveyed home sales. Controlling for neighborhood effects and home characteristics, they report statistically significant impacts of nitrogen dioxide and particulates on home prices. They then survey each community to generate each community's willingness to pay for a pollution reduction. Brookshire *et al* report evidence in favor of the hypothesis that the

---

[31]Detailed discussions of its strengths and weaknesses are presented in Mitchell & Carson (1989), Cummings *et al* (1986), and Hausman (1993), with Portney (1994) providing an excellent summary of the recent debate on this methodology's merits.

[32]For an air quality example based on Israeli data, see Shecter & Kim (1991).

increase in rent that a household would face if pollution were reduced by a standard deviation is greater than a household's willingness to pay for a standard deviation reduction in pollution. This finding is consistent with economic theory because utility maximizing households (with heterogenous preferences for air quality) will sort across the equilibrium price gradient and locate to reach their highest indifference curve. At a given individual's optimal location, it must be the case that willingness to pay for a non-marginal increase in air quality is less than what one would have to pay (as indicated by the hedonic housing gradient).[33]

Another approach for valuing pollution reduction is to directly estimate its health impact and then impute a dollar value to pollution induced morbidity and mortality. This "direct" approach has been the focus of growing number of papers using micro data to estimate pollution's role in a health production function. Using micro data such as the National Health Interview Study, these studies quantify pollution's impact while controlling for personal attributes and habits such as smoking and quantify pollution's impact. (Portney and Mullahy (1986), Krupnick, Harrington, and Ostro (1990)).

Portney and Mullahy (1986) use data from the 1979 National Health Interview Survey and spatially merge ambient ozone data. This merger yields a data base that includes personal attributes such as whether one smokes, standard demographic characteristics and ambient air quality. Portney and Mullahy use as a health proxy the number of respiratory related restricted activity days (RRAD) during a two week recall period. Portney and Mullahy estimate poisson

[33]An interesting extension of this merger between stated willingness to pay through contingent valuation and hedonic estimates would be to survey how people actually vote on environmental initiatives (Deacon & Shapiro (1975), Kahn & Matsusaka (1997)). With micro data on individual voting patterns and person characteristics, a structural discrete choice model could be fitted to obtain estimates of the marginal willingness to trade off income for publicly provided environmental goods.

models of RRAD counts and find that ozone's coefficient is positive and statistically significant.[34] A 10% decline in ozone would yield 22.19 million RRAD per 110 million cases. Based on different scenarios on the health impact and the dollar damge of experiencing a RRAD, the authors estimate per person per year benefit of .04 to $4 for a 10% reduction in ozone. Due to data limitiations, this study implicitly assumes that no citizens engage in self protection against ozone exposure and that there is no migration selectivity across cities

Krupnick, Harrington and Ostro (1990) create a 1979 data base consisting of 290 families who have children in school. These families kept a diary for 182 days. The authors' goal is to quantify daily ozone's impact on the probability of having a respiratory symptom the next day. The authors aggregate 19 respiratory diseases into a single dummy variable indicator and estimating a markov transition matrix of the probability of having a respiratory condition on any day as a function of air quality, personal characteristics (such as smoking), and previous day's health, time spent inside. The authors find a small, statistically significant effect that a 1% increase in ozone raises the frequency of symptoms by .11%. In 1979, the average Los Angeles resident suffered 76 days of having some cold symptom. Their .11 elasticity indicates that if ozone levels fell by 50% between 1980 and the present, then the average Los Angeles citizen has experienced a 4.2 day reduction in respiratory symptoms. If individuals are willing to pay an average of $25 to avoid such an episode, then the per-capita yearly benefits of the reduction ozone would be $100 each. The relationship between direct health study estimates and hedonic valuation estimates would be an interesting research path.

---

[34]Portney and Mullahy (1986) report estimates of ozone's t-statistic that vary between 1.97-3.2. While apparently statistically significant, the authors are likely to have underestimated their regression's standard errors because they have not controlled for the fact that observations from the same SMSAs are likely to have correlated error terms (Moulton (1986)).

A second literature directly connecting health and pollution has studied pollution's impact on seeking medical care (Gerking and Stanley (1986), Dickie and Gerking (1991)). The authors estimate discrete choice models of whether an individual sought medical care in the last year. Controlling for demographics, pre-existing conditions and the price of health care, the authors document the positive impact of ozone on seeking medical care. Gerking and Stanley (1986) find that a bid of $24.5 to enjoy 30% reduction in ozone based on St. Louis sample. Dickie and Gerking (1991) use Los Angeles data in Glendora and Burbank to estimate a similar medical care demand probit with the econometric innovation of allowing for person specific random effects. The sample consists of full time workers who are not current smokers and oversamples people with respiratory problems. Dickie and Gerking (1991) find that reducing Glendora's ozone pollution from 117 days to 0 pphm willing to pay $170-$210 dollars a year.

While health based methods have increased our understanding of pollution valuation, they complement but should not replace the hedonic approach. Estimation of health production functions requires representative samples of the population and require information on population self protection. For example, if the econometrician does not observe that people stay inside on highly polluted days then she may conclude that ozone has very low costs for society as measured by sickness. The health production literature has not modeled individual locational choice and population sorting. Such sorting is a function of the equilibrium housing price gradient and individual preferences. A further issue with health studies is that to create a proxy for health capital (the dependent variable) is not easy. Krupnick, Harrington and Ostro (1990) aggregate over 15 different health conditions into a single health proxy. If the person specific losses from these various conditions differ, then this increases the difficulty of assigning a dollar value to the

health losses from increased pollution exposure. Given estimates of pollution's health impact, a researcher would still need to impute the value of lost time and borrow from the value of life literature to arrive at a dollar cost of pollution.

VI. The Challenge of Relaxing the Equilibrium Assumption in Quality of Life Analyses

A key feature of the QOL methodology is the assumption that measured implicit prices reflect marginal valuations for marginal worker/households in the data. This assumption hinges on the equilibrium assumption that these worker/households are indifferent to their choice of location at the current implicit prices. Given the methodological importance of this assumption, it is vital to test its validity, adjust price estimates for any possible departures from equilibrium, and explore estimation strategies that do not rely on the equilibrium assumption.

There have only been a few papers that address this issue. Cheshire & Hay (1989) propose a new methodology which does not rely on the equilibrium assumption. As in the traditional hedonic approach, their first step is to identify a set of *Z* variables that are believed to affect the QOL. Their next step then involves a significant departure from the hedonic approach in that wages and house prices are *not* used to calculate weights for the *Z* variables. Instead, a group of "experts" is selected who are asked to identify cities having the "worst" and the "best" urban environments.[35] Discriminant analysis is used to determine weights for the *Z* variables that best explains the experts' classifications. The coefficients from the discriminant analysis were then used

[35]European experts were asked to classify cities in their home country.

to create an index for *all* cities in the sample. This approach remains agnostic as to how the experts form their opinion about the cities they are asked to classify. An important issue for study is how sensitive the weights are to the particular set of experts selected, as the Cheshire & Hay methodology represents a significant departure from the original goal of Rosen and Roback to rely on market data rather than expert opinion.

Researchers' who wish to continue in the Rosen/Roback tradition will need to develop tests of the equilibrium assumption, and possibly methods for relaxing the assumption. The first step in that process involves a careful understanding of the likely implications of the equilibrium assumption, which would seem to suggest that systematic patterns of intercity migration should not appear in the data. However, the Rosen/Roback framework does not assume that households are homogeneous in their preferences and/or exposure to the labor market. Thus, the presence of substantial intercity household migration does not necessarily indicate that the key underlying equilibrium assumption is being violated.

In fact, the equilibrium price assumption is consistent with three *life-cycle* motivations for migration (see Linneman & Graves (1983)). One is that household preferences for amenities and services such as mild weather and education services likely vary over the life-cycle, so that if attribute prices remain relatively constant through time, certain households may relocate to a new city in order to achieve a more preferred local trait bundle. Changing household exposure to the labor market over the life-cycle can also be associated with equilibrium migration.[36] An incentive

[36]If all city attributes were proportionally priced in both the land and labor markets, then changing labor market exposure would change the price level but not the *relative* price levels of city attribute bundles. Households, therefore, would face no incentive to migrate. Such proportionality is unlikely to exist in practice. The basic model suggests that nonproductive (to firms) attributes will be relatively more capitalized into wages.

exists for households that are reducing their exposure to the labor market to relocate into cities with a higher mix of those attributes capitalized relatively more in the labor market. Third, capital market imperfections make it difficult for the household to perfectly smooth its consumption as its real income changes over the life cycle. Consequently, as real income rises, a household may choose to relocate in order to consume a more desired amenity/fiscal bundle.[37] An additional equilibrium explanation for migration is spatial mismatch. As individuals enter the labor market and form new households, they may find that their current location is not optimal. Given the equilibrium set of prices for amenity/fiscal attributes, a move is required to maximize their utility. An analogy in labor markets is the notion of frictional unemployment due to the spatial mismatch of currently unemployed workers and job vacancies.[38]

---

[37]Using the 1980 *Census of Population*, Graves & Waldman (1991) and Gyourko & Tracy (1991) report findings consistent with the life-cycle labor market exposure motivation for migration. Graves & Waldman regress the net inmigration (and net inmigration rate) of the elderly on the wage capitalization variable from the QOL calculation for each of the 253 counties in Blomquist *et al* (1988) and report positive and significant coefficients. When they repeat this exercise using the net inmigration of prime age households they find either insignificant or negative coefficients. Gyourko & Tracy (1991) calculate the implied net subsidy (positive or negative) to a retired household for each of 130 cities based on the assumption that retired households value the amenity/fiscal bundle in the same manner as the marginal household. They then construct the share of "retired" households for each of the cities in their sample. The simple unweighted correlation between the retirement employment share and the net subsidy is 0.15 (with a probability value of 0.08 under the null hypothesis that $\rho = 0$). Weighting cities by their total number of labor market participants increases the correlation to 0.35 (with a probability value of 0.001).

Linneman & Graves (1983) find empirical support for migration induced by likely changes in preferences for amenity/fiscal attributes and changes to real income. Their study examines the determinants of both job and geographic mobility using micro data drawn from the *Panel Study of Income Dynamics*. For the period 1971-1972, they find that 13% of households changed residences while 9% changed jobs. Roughly one-third of job changes also involved a residence change. They model the decision to change job and/or residence using a multinomial logit framework, and find significant mobility effects induced by changes in family size and real income.

[38]Linneman & Graves (1983) label this motive "residential search", and list it as a disequilibrium explanation. We prefer to include this with the other equilibrium motives since it is

The discussion in this section has so far assumed that local amenity/fiscal bundles do not change over time. This is not the case as Inman's (1995) description of the changing fiscal fortunes of the nation's 40 largest cities clearly shows. Changes in the local fiscal environment, particularly unanticipated ones, are potentially important to the task of reconciling QOL work with observed migration behavior. Consider the effect of an unexpected negative shock to a city's fiscal attributes. If the shock is common knowledge (e.g., a visible tax increase without any added services), we would expect to see land rentals and wages adjusting as described earlier. After the adjustment period, the marginal household would have no incentive to leave the city, although migration could still occur by inframarginal households if there are heterogenous preferences. On the other hand, if information problems exist and potential entrants to the city are unaware of the fiscal shock or underestimate its magnitude, then prices would not fully reflect the new fiscal bundle and residents would face gains from migration.

The conclusion that should be reached from the discussion so far is that attempts to measure the extent of disequilibrium in attribute prices by exploiting migration data must take care to distinguish equilibrium from disequilibrium reasons for migration.

Most of the migration research that involves the QOL tends to focus on another issue—namely, the importance of QOL differences in explaining migration flows.[39] Virtually no

---

consistent with equilibrium pricing in the Rosen/Roback framework.

[39]Sjaastad (1962) and Muth (1971) both argue that migration is primarily a response to economic incentives in labor markets. Migration reflects the flow of human capital across geographic boundaries as it searches out its highest valued use. More recently, Topel (1986) and Greenwood & Hunt (1989) arrive at the same basic conclusion. Berger & Blomquist (1992) argue that QOL issues matter in the choice of a destination given a move, but are secondary in the initial decision to move. Mueser & Graves (1995) argue that the relative importance of economic incentives versus QOL likely varies by time period.

work except that by Greenwood *et al* (1991) has attempted to address what we view as a critical issue of how migration data can be used to assess the reasonableness of the equilibrium assumption used to construct QOL indices. Because future research on this topic undoubtedly will build off this study, a close look at their paper is in order.

Greenwood, *et al* (1991) start with the assumption that net migration to an area is a function of the relative net present value (NPV) of labor market earnings available in the area and the relative amenity bundle.

$$nm_{jt} = h\{\,\mathrm{NPV}\left(\frac{Y_{jt}}{\overline{Y}_t}\right), \left(\frac{A_j}{\overline{A}}\right)\} \quad , \qquad \textbf{(28)}$$

where nm_{jt} is the net migration to location j in year t, Y_{jt} is potential labor market earnings in location j for a standardized unit of labor in year t, $\overline{Y}_t$ is the average potential labor market earnings in the labor market in year t, A_j is the amenity bundle in location j, and $\overline{A}$ is the average amenity bundle available in the market. Amenity and economic motivations for migration suggest that each first derivative of h is positive.

Several simplifying assumptions are made to allow estimation of this net migration equation. First, growth rates of potential incomes across areas are assumed to be equal so that all net present values can be replaced by current relative incomes. Second, a Cobb-Douglas functional form is specified for h, where the coefficient on relative amenities is assumed to equal one. Adding a stochastic error term gives the following estimating equation for the log of net migration,

$$\ln nm_{jt} = \ln\left(\frac{A_j}{\overline{A}}\right) + \lambda \ln\left(\frac{Y_{jt}}{\overline{Y}}\right) + \varepsilon_{jt} \quad . \qquad \textbf{(29)}$$

Annual data for fifty states and Washington, D.C. between 1971-1988 were used in the analysis. The net migration and relative income potential variables are constructed by the authors.[40] The relative amenity set is left to be picked up as a location fixed-effect. The coefficient λ is estimated using an instrumental variables (IV) procedure to correct for any endogeneity problems. The set of instruments is taken from a larger model presented elsewhere, and is not discussed in the paper. The IV coefficient estimate (standard error) for λ is 0.21 (0.01). This is consistent with the extensive literature finding a positive connection between migration and economic incentives in the labor market. The data also strongly reject the restriction that all states share a common intercept.

---

[40]Net migration for year *t* is defined as the sum of the "natural labor force" (NLF) in year *t*-1 plus "economic migration" in year *t* divided by NFL_{t-1}. Economic migration is defined to be the difference between the actual civilian population under the age of 65 and the estimated civilian population under the age of 65 in the absence of migration. This estimated population is calculated by using 1970 cohort counts by state extrapolated for intervening years using cohort-specific birth and death rates (adjusted so that the increments across cohorts match with gross birth and death rates by state), apportioning international migrants by state, and subtracting all military personnel and their dependents. The natural labor force is calculated by applying cohort-specific labor force participation rates (adjusted to eliminate discouraged worker effects) to cohort-specific population counts, and summing across cohorts.

The state relative income variable is constructed by deflating an estimate of the adjusted state nominal wage rate by a cost-of-living index. The state nominal wage is constructed using Bureau of Economic Analysis data on total industry wages divided by average annual employment. This nominal wage is then adjusted for any state and local income and sales taxes. If income and sales taxes are capitalized in both land and labor markets, then fully adjusting wages in the construction of the relative income measure involves an over-adjustment. The cost-of-living index is constructed by the authors and includes an adjustment for regional housing prices.

To get at the issue of disequilibrium pricing, the authors define the "equilibrium relative income" (RY^*) for a location to be the level of relative income that would imply *no* net migration for the area. The difference between RY^*s and the actual relative incomes is taken as a measure of the extent of disequilibrium in the market. Using the state fixed-effect estimates, the measured relative income for the state, and the estimate of λ, an estimate (and 90% confidence interval) for RY^* is constructed for each location. For six states and the District of Columbia, they find the actual relative income outside the 90% confidence interval for the equilibrium relative income.[41] On face, little evidence of disequilibrium pricing is suggested by the data.

It should be noted that a number of important assumptions are implicitly being made in the above formulation. First, amenities are treated as time invariant. While this is likely for true amenities such as climate, it is less likely for fiscal attributes.[42] The functional form assumptions also rule out the equilibrium life-cycle explanations for migration. Amenities enter the migration decision only as a single index, effectively ruling out equilibrium migration due to preference changes for specific amenities over the life-cycle. The Cobb-Douglas assumption further rules out any interactions between income and the demand for amenities--in particular, the potential that real income increases over the life-cycle can induce migration as households purchase a better set of amenities.[43]

---

[41]The authors do not report an overall test for disequilibrium pricing. In addition, the confidence intervals for the relative equilibrium income levels should be wider than reported by the authors due to the constructed nature of the relative income variable.

[42]It is clear from the text that the authors are thinking of "environmental" characteristics as the center of their analysis.

[43]The sample selection excludes individuals over the age of 65. This will mitigate some of the life-cycle migration effects in the data used in the estimation.

The fixed effects estimation strategy also is quite restrictive. While it obviates the need for data on specific amenities by location, it clouds the interpretation of the findings because the fixed effects estimates will pick up not only relative differences in net migration due to differences in amenity/fiscal characteristics across states, but *any* other characteristics of states that generate systematic differences in net migration that are unrelated to relative income differences. To attribute 100% of these fixed effects to amenities is speculative. The equilibrium relative income calculation, however, *directly* depends on this assumption.

These caveats aside, the basic intuition of the Greenwood *et al* study is appealing — any significant differences between actual and equilibrium prices creates incentives to relocate. Future research on this important topic should build on this underlying insight.

VII. Conclusions

Recent research clearly has enriched our knowledge of the urban QOL. Conceptual innovations have incorporated traditional concerns of urban economics such as distance from the urban core and agglomeration effects into the Rosen/Roback framework. The importance of the local fiscal conditions to the overall QOL and to specific capitalization results also has been made clear. The burgeoning field of environmental economics continues to contribute to our knowledge of the value of key local traits, in addition to yielding insights about data quality and basic strategy with respect to estimating the overall QOL.

Nevertheless, empirical research into the urban QOL stands at an important crossroads. Controlling for the large location-specific group effects in the data shows individual trait prices

and overall QOL indexes to be much less precisely estimated than suggested by OLS-based results. Dealing effectively with the challenge posed by this issue requires understanding that this primarily is a data problem. In particular, there appears to be no econometric or methodological solution on the horizon. Data on more urban areas will help, and richer databases that more fully describe local amenity, environmental, and fiscal conditions are absolutely necessary.

More technical advances are needed with respect to relaxing the key underlying equilibrium assumption in the Rosen/Roback framework. Greenwood *et al* (1991) have taken the first steps in this direction, and we believe that more fruitful progress can be made while data quality is slowly improved.

VIII. References

Abelson, P. W., and A. Markandya. "The Interpretation of Capitalized Hedonic Prices in a Dynamic Environment." *Journal of Environmental Economics and Management* 12, no. 3 (1985): 195-206.

Bartik, T.J., and Vernon K. Smith. "Urban Amenities and Public Policy." In *Handbook of Regional and Urban Economics*. Chapter 31, edited by Edwin S. Mills, 1987.

Beeson, Patricia, and R. Eberts. "Identifying Productivity and Amenity Effects in Interurban Wage Differentials." *The Review of Economics and Statistics* 71 (1989): 443-452.

Berger, Mark C., and Glenn C. Blomquist. "Mobility and Destination in Migration Decisions: The Roles of Earnings, Quality of Life, and Housing Prices." *Journal of Housing Economics* 2 (1992): 37-59.

Blomquist, Glenn C., Mark C. Berger, and John P. Hoehn. "New Estimates of Quality of Life in Urban Areas." *American Economic Review* 78 (March 1988): 89-107.

Boyer, Rick. *Places Rated Almanac*. Chicago, Rand McNally, 1983.

Brookshire, David S., Mark A. Thayer, John Tschirhard, and William Schultze. "A Test of the Expected Utility Model: Evidence from Earthquake Risks." *Journal of Political Economy* 93 (April 1985): 369-389.

Brookshire, David S., Mark A. Thayer, William D. Schultze, and Ralph C. d'Arge. "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches." *American Economic Review* 72 (March 1982): 165-177.

Cheshire, P.C., and D.G. Hay. *Urban Problems in Western Europe: An Economic Analysis*. London, Unwin Hyman, 1989.

Clark, David, and Leslie Nieves. "An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values." *Journal of Environmental Economics and Management* 27 (1994): 235-253.

Cummings, R.G., David S. Brookshire, and William D. Schulze. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method*. Totowa, NJ, Littlefield, Adams, Rowman and Allanheld, 1986.

Deacon, Robert T., and Perry Shapiro. "Private Preference for Collective Goods Revealed Through Voting on Referenda." *American Economic Review* 65 (December 1975): 943-955.

Dickie, Mark and Shelby Gerking. "Willingness to Pay for Ozone Control: Inferences from the Demand for Medical Care". *Journal of Environmental Economics and Management* 21; 1-16 1991

Ehrenberg, Ronald, and Joshua Schwarz. "Public Sector Labor Markets." In *The Handbook of Labor Economics*, edited by Orley Ashenfelter and Richard Layard. Amsterdam, North-Holland, 1986.

Epple, Dennis, and Allan Zelenitz. "The Implications of Competition Among Jurisdictions: Does Tiebout Need Politics?" *Journal of Political Economy* 89 (1981): 1197-1217.

Epple, Dennis, Allan Zelenitz, and Michael Visscher. "A Search for Testable Implications of the Tiebout Hypothesis." *Journal of Political Economy* 86 (June 1978): 405-425.

Evans, Alan W. "The Assumption of Equilibrium in the Analysis of Migration and Interregional Differences: A Review of Some Recent Research." *Journal of Regional Science* 30 (November 1990): 515-531.

Feenberg, Daniel, and Edwin Mills. *Measuring the Benefits of Water Pollution Abatement*. Studies in Urban Economics. New York, Academic Press, 1980.

Freeman, Richard. "Unionism Comes to the Public Sector." *Journal of Economic Literature* 24 (March 1986): 41-86.

Garen, John. "Compensating Wage Differentials and the Endogeneity of Job Riskiness." *Review of Economics and Statistics* 70, no. 1 (1988): 9-16.

Gerking, Shelby, and Linda Stanley. "An Economic Analysis of Air Pollution and Health: The Case of St. Louis." *Review of Economics and Statistics* 68 (1986): 115-121.

Graves, Philip E., and Donald M. Waldman. "Multimarket Amenity Compensation and the Behavior of the Elderly." *American Economic Review* 81 (December 1991): 1374-1381.

Graves, Philip, James Murdoch, Mark Thayer, and Don Waldman. "The Robustness of Hedonic Price Estimation: Urban Air Quality." *Land Economics* 64 (August 1988): 220-242.

Greenwood, Michael J., and Gary L. Hunt. "Jobs versus Amenities in the Analysis of Metropolitan Migration." *Journal of Urban Economics* 25 (1989): 1-16.

Greenwood, Michael J., Gary L. Hunt, Dan S. Rickman, and George I. Treyz. "Migration, Regional Equilibrium, and the Estimation of Compensating Differentials." *American Economic Review* 81 (December 1991): 1382-1390.

Gyourko, Joseph, and Joseph Tracy. "The Importance of Local Fiscal Conditions in Analyzing Local Labor Markets." *Journal of Political Economy* 97 (1989a): 1208-1231.

Gyourko, Joseph, and Joseph Tracy. "Local Public Sector Rent-Seeking and Its Impact on Local Land Values." *Regional Science and Urban Economics* 19 (1989b): 493-516.

Gyourko, Joseph, and Joseph Tracy. "On the Political Economy of Land Value Capitalization and Local Public Sector Rent Seeking in a Tiebout Model." *Journal of Urban Economics* 26 (1989c): 152-173.

Gyourko, Joseph, and Joseph Tracy. "Public Sector Bargaining and the Local Budetary Process." *Research in Labor Economics* 12 (1991): 117-136.

Gyourko, Joseph, and Joseph Tracy. "The Structure of Local Public Finance and the Quality of Life." *Journal of Political Economy* 99 (August 1991): 774-806.

Hamilton, James. "Politics and Social Costs. Estimating the Impact of Collective Action on Hazardous Waste Facilities." *Rand Journal of Economics* 24 (Spring 1993): 101-121.

Hamilton, James. "Testing for Environmental Racism, Prejudice, Profits, Political Power?" *Journal of Policy Analysis and Management* 14, no. 1 (1995): 107-132.

Harrison, David, and Daniel Rubinefeld. "Household Prices and Demand for Clean Air." *Journal of Environmental Economics and Management* 5 (March 1978): 81-102.

Haughwout, Andrew F. "Measuring the Impact of Fiscal Policy: A Theoretical and Empirical Examination." Working Paper, Princeton University, 1993.

Hausman, Jerry A., and William E. Taylor. "Panel Data and Unobservable Individual Effects." *Econometrica* 49 (November 1981): 1377-1398.

Hausman, Jerry. "Contingent Valuation: A Critical Assessment," 1993. North Holland Press.

Henderson, J. Vernon. "The Tiebout Model: Bring Back the Entrepreneurs." *Journal of Political Economy* 93 (April 1985): 248-264.

Henderson, J. Vernon. "The Effects of Air Quality Regulation." *American Economic Review* (September 1996)

Hoehn, John P., Mark C. Berger, and Glenn C. Blomquist. "A Hedonic Model of Interregional Wages, Rents, and Amenity Values." *Journal of Regional Science* 27, no. 4 (1987): 605-620.

Inman, Robert. "Do You Know How Much Money Is In Your Public Purse?" Federal Reserve Bank of Philadelphia. *Business Review*, July/August 1995, 19-30.

Kahn, Matthew. "A Revealed Preference Approach to Ranking City Quality of Life". *Journal of Urban Economics.* 38, 221-235 (1995)

Kahn, Matthew. "Particulate Pollution Trends in the United States". *Regional Science and Urban Economics;* (February 1997).

Kahn, Matthew, and John Matsusaka. "Who Votes for the Environment? Evidence from California Voter Initiatives." *Journal of Law & Economics*, (April 1997)

Kiel, Katherine, and Katherine McClain. "House Prices During Siting Decision Stages: The Case of an Incinerator from Rumor Through Operation." *Journal of Environmental Economics and Management* 28 (March 1995): 241-255.

King, M.L, and M.A. Evans. "Testing for Block Effects in Regression Models Based on Survey Data." *Journal of the American Statistical Association* 81 (September 1986): 677-679.

Kish, Leslie. *Survey Sampling*. New York, John Wiley, 1965.

Kohlhase, Janet E. "The Impact of Toxic Waste Sites on Housing Values." *Journal of Urban Economics* 30, no. 1 (1991): 1-26.

Kolstad, Charles (editor). Measuring the Demand for Environmental Quality. North Holland Press 1991

Krupnick, Alan, Winston Harrington, and Bart Ostro. "Ambient Ozone and Acute Health Effects: Evidence from Daily Data." *Journal of Environmental Economics and Management* 18 (1990): 1-18.

Linneman, Peter, and Philip E. Graves. "Migration and Job Change: A Multinomial Logit Approach." *Journal of Urban Economics* 14 (1983): 263-279.

Michaels, R. and V. Kerry Smith. "Market Segmentation and Valuing Amenities with Hedonic Methods: The Case of Hazardous Waste Sites." *Journal of Urban Economics* ? (1990): 223-242.

Mitchell, Robert C., and Richard T. Carson. "Using Surveys to Value Public Goods: The Contingent Valuation Method." Washington, DC: Resources for the Future, 1989.

Moulton, Brent R. "Random Group Effects and the Precision of Regression Estimates." *Journal of Econometrics* 32 (1986): 385-397.

Moulton, Brent R. "Diagnostics for Group Effects in Regression Analysis." *Journal of Business and Economic Statistics* 5 (1987): 275-282.

Muesser, Peter R., and Philip E. Graves. "Examining the Role of Economic Opportunity and Amenities in Explaining Population Redistribution." *Journal of Urban Economics* 37 (March 1995): 176-200.

Muth, Richard F. "Migration: Chicken or Egg?" *Southern Economic Journal* 37 (1971): 295-306.

Ostro, Bart D. "Air Pollution and Morbidity Revisited: A Specification Test." *Journal of Environmental Economics and Management* 14 (March 1987): 87-98.

Pfefferman, D., and T.M.F Smith. "Regression Models for Grouped Populations in Cross-Section Surveys." *International Statistical Review* 53 (1985): 37-59.

Portney, Paul R. "The Contingent Valuation Debate: Why Economists Should Care." *Journal of Economic Perspectives* 8 (Fall 1994): 3-17.

Portney, Paul R., and John Mullahy. "Urban Air Quality and Acute Respiratory Illness." *Journal of Urban Economics* 20 (July 1986): 21-38.

Ranson, Mike, and C. Pope. "External Health Costs of a Steel Mill." *Contemporary Economic Policy*, April 1995, 86-101.

Roback, Jennifer. "The Value of Local Urban Amenities: Theory and Measurement." Ph.D. dissertation. University of Rochester, 1980.

Roback, Jennifer. "Wages, Rents, and the Quality of Life." *Journal of Political Economy* 90 (1982): 1257-1278.

Roback, Jennifer. "Wages, Rents, and Amenities: Differences Among Workers and Regions." *Economic Inquiry* 26 (January 1988): 23-41.

Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy* 82 (January/February 1974): 34-55.

Rosen, Sherwin. "Wage-based Indexes of Urban Quality of Life." In *Current Issues in Urban Economics*, edited by Peter Mieszkowski and Mahlon Straszheim. Baltimore, Johns Hopkins University Press, 1979.

Scott, A.J, and D Holt. "The Effect of Two-Stage Sampling on Ordinary Least Squares Methods." *Journal of the American Statistical Association* 77 (1982): 848-854.

Sjaastad, Larry A. "The Costs and Returns of Human Migration." *Journal of Political Economy* 70 (1962): 80-93.

Smith, V. Kerry, and Ju Chin Huang. "Can Hedonic Models Value Air Quality? A Meta-Analysis." *Journal of Political Economy* 103 (February 1995): 209-227.

Stock, James. "Nonparametric Policy Analysis: An Application to Estimating Hazardous Waste Cleanup Benefits." In *Nonparametric and Semiparametric Methods in Economics and Statistics*, edited by Powell Barnett, 1991.

Stover, Mark E., and Charles L Leven. "Methodological Issues in the Determination of the Quality of Life in Urban Areas." *Urban Studies* 29, no. 5 (1992): 737-754.

Topel, Robert H. "Local Labor Markets." *Journal of Political Economy* 94, no. 3, pt. 2 (1986): S111-S144.

Voith, Richard. "Capitalization of Local and Regional Attributes into Wages and Rents: Differences Across Residential, Commercial and Mixed-Use Communities." *Journal of Regional Science* 31, no. 2 (1991): 127-145.