Ranking Urban Areas: A Hedonic Equilibrium Approach To Quality of Life

by

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ABSTRACT

Rankings of urban areas provide useful information to planning recreational or tourism activities, making housing-locational decisions, and designing policies to attract industries. This paper illustrates how the structural approach to hedonic equilibrium models can be used to derive a quality of life based ranking of urban areas.

I. Introduction.

An interregional and/or interurban comparison is a useful information for all types of decision makers. Consumers consider amenity factors as well as employment opportunities and cost of living when they make a locational-housing decision or when they plan tourism or recreational activities. Employers consider amenity factors as assets in recruiting and maintaining an optimum workforce and a government might consider urban and regional rankings in a variety of policies, e.g., policies to attract industries. These comparisons are helpful in assessing the world and it would be useful to be able to estimate how these rankings would be altered by changes in the distribution of the amenities. The latter requires a structural analysis of the economy that is accomodated by the type of modelling that is proposed in this paper.

Interregional and interurban comparisons have been traditionally performed using quality of life indices, e.g., Liu (1976), Rosen (1979), Roback (1982) and (1988), and Blomquist et al (1985) and (1988). The contention is that the well being of economic agents depend on quality of life factors, namely, housing, neighborhood, and city characteristics, as well as income and the prices of goods that determine the cost of living. The interest in the quality of life indices arises from the fact that it is an important location factor for all economic agents.

Models of city size, e.g., Tolley (1974), can explain the positive correlation between money income and cost of living by the effect of wages on the price of local goods such as housing. However, even if high money income were not offset by high living cost, money income would be an inperfect measure of welfare for the same reason that gross national product is an imperfect measure, see Nordhaus and Tobin (1972). The previous work in the area specifies a broad based quality of life indices that assign a $ value on the set of amenities that are assumed to determine the quality of life. The price of each amenity is taken to be a function of the effect of its marginal change on prices and/or wages (see next section for details).

This paper uses a hedonic equilibrium model to illustrate an alternative method that is appropriate for addressing the issues discussed in the quality of life literature. The advantage of this alternative method is that it can be tested and address some interesting questions that a standard non-structural approach cannot. For example, it can predict the changes in urban and regional rankings that are implied by changes in exogenous factors like the distributions of housing, neighborhood, and city characteristics. The previous methods used to derive rankings of urban areas cannot predict how a ranking will be affected by changes in exogenous parameters because they cannot estimate the equilibrium hedonic price and/or wage equation; changes in exogenous parameters, e.g., the variance of the air quality distribution, will change the equilibrium price and/or wage distributions and the previous non-structural approaches cannot predict those changes.

To provide a ranking of urban areas, all approaches need to characterize a hedonic equilibrium. There are many different methods that can be used to characterize a hedonic equilibrium. One would be to empirically approximate the features of wage and/or price functions using fitting criteria to derive it. This provides more flexibility in letting the data determine the wage and/or price equations at the cost of not being able to test whether the assumed functional forms are consistent among themselves and the underlying economic structure. Another method, that is followed by this paper, makes prior assumptions about the characteristics of the economic agents interacting to form the equilibrium, uses that to derive the form of the equilibrium hedonic function(s), and then estimates only that. Imposing these prior restrictions helps through the additional theoretical information that is essential in addressing several interesting questions.

To characterize the hedonic equilibrium, this paper assumes that the utility function is quadratic and that it depends on the quality of life and on the numeraire good. The vector of attributes that describes a consumer's environment is mapped into a quality of life index (each consumer enjoys a different quality of life); where a consumer's environment is described by a vector of housing, neighborhood, and city chracteristics. Given their income, consumers make a housing-locational choice that maximizes their utility. In equilibrium, there is a quality of life distribution for each city.

In principle, the structural approach can compute the effect of changes in exogenous parameters on the wage distribution, the price distribution, and the quality of life distribution. To illustrate the latter approach, I use a hedonic equilibrium model that assumes an exogenous income distribution and exogenous housing, local, and city characteristics distributions. These assumptions can easily be relaxed using one of the models presented in Giannias (1987). To be more specific, the supply for housing characteristics can become endogenous, leisure can be introduced as an argument into the utility function, and the equilibrium wage equation can be assumed to be a function of labor characteristics (e.g., experience, education) and of city and neighborhood characteristics. Moreover, a structural approach can estimate the utility function and the equilibrium demand functions for the differentiated and the numeraire goods. This is a very useful information because the equilibrium indirect utility function can be obtained by substituting the equilibrium demand functions into the utility function. This indirect utility function can be used to compute allowances for living in cities that have a high cost of living, e.g., New York City. That would be defined to be the amount of your income that you are willing to receive (or give up) so that your utility before moving to New York City equals the utility after moving to New York City. This is another example of an interesting question that the standard method of analysis that is used in the quality of life literature cannot address.

A common characteristic of all previous work in this area is a quality of life index that researchers construct drawing inference from consumer choices over a set of amenities, wages and/or rents. These quality of life indices are used to rank urban areas and they consider only SMSA-wide amenities (if they are used to rank SMSA's) or county-wide amenities (if they are used to rank counties). In this paper, to define the quality of life, I consider the whole vector of factors that defines a consumer's environment (including housing characteristics). The idea is the following. Consider two cities with identical local and city amenities distributions, and hedonic price and wage equations that are linear in these attributes. These two cities would perform equally well on the ranking scale according to the quality of life indices used in the previous work. However, if the supply for housing characteristics of the first city is "inferior" to that of the second, the second city should be higher on the ranking scale. Unlike previous work, my analysis allows these two cities to be assigned a different quality of life index. Past work has not included housing quality variations in the index number but these variations have not been ignored either. Roback (1982) dealt with the problem by using only land prices. Blomquist et al (1988) use data that is conseptually superior to Roback's in that they have the characteristics of individual workers and the homes they live in. However, their ranking does not reflect the differences in the housing quality distributions across cities.

Section II reviews the quality of life indices used in other work. Section III introduces the theoretical model that is used to illustrate the kind of analysis that the structural approach can accomodate. Section IV applies the theory to derive quality of life indices for Chicago, Cleveland, Dallas, Houston, and Indianapolis. Concluding remarks are presented in Section V.

II. Quality of Life Indices for Ranking Urban Areas.

The quality of life indices that have been used in other studies can be defined as follows:

$$h = w\ a'$$

where h is the quality of life of an area in which a is a vector that describes the amenities of that area (e.g., climate, air quality, crime, public services), and w is a vector of weights.

An early contribution by Liu (1976) included a wide variety of nonmonetary factors into the vector of amenities, a, and specified weights using principal components. Rosen (1979) employed the same definition for the quality of life but he specified the weights to be the implicit values of the amenities. He defined the implicit value of an amenity to be the first partial of a hedonic wage equation with respect to the amenity, that is, $w_i = dw/da_i$, where w_i is the weight assigned to the ith amenity, a_i, and w is the wage. Roback (1982) defines the weight of the ith amenity, w_i, to be: $w_i = -(dw/da_i) + c\ (dr/da_i)$, where dw/da_i is defined above, dr/da_i is the first partial derivative of a hedonic land rental equation with respect to the ith amenity, and c is the amount of land consumed. Blomquist et al (1985) and (1988) define the weights in a slightly different way that is equivalent to:

$$w_i = -[E_{wi}\ m(w)\ m(H)\ m(N)\ /\ m(a_i)] + [E_{pi}\ m(p)\ 12\ /\ m(a_i)]$$

where E_{wi} is the elasticity of the average hourly earnings with respect to amenity i, m(t) is the mean of a variable t, for all t = w, a_i, H, N, p, w is the hourly earnings, a_i is the level of the ith amenity, H is hours of work, N is the number of workers per household, p is monthly housing expenditures, E_{pi} is the elasticity of monthly housing expenditure with respect to amenity i, and 12 is the number of months per years. That is, the first term on the latter specification for w_i is the implicit price from the labor market and the second term is the implicit price from the housing market.

Blomquist et al (1988) provide an improvement upon all the previously employed quality of life indices. However, all of these studies have the following features: 1) they provide rankings that do not incorporate features of differences in housing quality distributions across cities, 2) they cannot offer a method for testing whether the assumed functional forms for the hedonic price and wage equations are consistent among themselves and with the underlying economic structure, and 3) they cannot specify how the derived ranking of urban areas would be affected by changes in the exogenous parameters of the economy, e.g., a new air quality distribution, because that approach cannot estimate equilibrium hedonic price and wage distributions.

III. The Theoretical Model.

I consider a competitive economy in which individuals consume a differentiated good and the numeraire good, x. I assume that consumers use one unit of the differentiated good. The differentiated good can be accurately described by a (1xm) vector, v, of objectively measured characteristics. I assume that consumers care only about the quality index, h, of the differentiated product. The quality, h, is a scalar and a function of the vector of physical characteristics, v. I assume that h is a linear function of v, namely,

$$h = e_0 + e_1 v' \qquad (1)$$

where e_0 is a parameter, e_1 is a (1xm) vector of parameters, and v' is the transpose of v. (Hereafter, a prime " ' " will always denote the transpose of a vector or matrix). Equation (1) is a key assumption of the model. This equation is less restrictive than it might at first appear since the elements of v can be arbitrary functions of measured product characteristics.

The model lets consumers have different utility functions and income. Each consumer can be described by a [1 x (n+1)] vector z, where z = [a I], I is the income of a consumer, and a is a (1xn) vector of utility parameters that specifies the type of a consumer. z is assumed to follow a multinormal distribution. Let it be:

$$N(\ m(z),\ V(z)\ ) \tag{2}$$

where m(z) is the mean and V(z) is the variance-covariance matrix of z.

U(h,x;a) is the utility that an a-type consumer obtains from x and from the services of a differentiated good of h-quality. The utility function is assumed to be a quadratic of the following form:

$$U(h,x;a) = k + (\ k_0 + k_1\ a'\ )\ h + 0.5\ k_2\ h^2 + k_3\ x\ h + k_4\ x \tag{3}$$

where k and k_i are utility parameters, for i = 0,2,3,4, and k_1 is a (1xn) vector of utility parameters. Note that equation (1) does not imply that consumers have to agree on a ranking of housing units because they are not assumed to have identical preferences.

An a-type consumer with income I solves the following optimization problem:

max $U(h,x;a)$

with respect to h, x

subject to $I = P(h) + x$ and

$$P(h) = q_0 + q_1 h$$

where P(h) is the equilibrium price equation (it gives the price of the differentiated good as a function of the quality index, h), and q_0 and q_1 are the parameters of the equilibrium price equation.

The supply for the differentiated product is exogenously given. The vector of physical characteristics v follows an exogenously given multi-normal distribution with a mean m(v) and a variance-covariance matrix V(v). Let this distribution be:

$$N\ (\ m(v),\ V(v)\ ) \qquad (4)$$

The optimum decisions of consumers and sellers depend on the equilibrium price equation P(h). The price equation is determined so that buyers and sellers are perfecly matched. In equilibrium, no one of the economic agents can improve his position, all of their optimum decisions are feasible, and the price equation P(h) is determined by the distribution of consumer taste and income, and by the distribution of the supply for the differentiated product.

Solving the utility maximization problem to obtain the demand for h and substituting it into the equilibrium condition, namely, Aggregate Demand for h = Aggregate Supply for h for all h, it can be proved[1] that the equilibrium price equation for the economy described above is[2]:

$$P(h) = q_0 + q_1 h \quad (5)$$

where $q_1 = (k_2 + A) / (2 k_3)$ (6)

$$q_0 = [k_0 - k_4 q_1 + r m(z)' - (2 k_3 q_1 - k_2) m(h)] / k_3 \quad (7)$$

$$m(h) = e_0 + e_1 m(v)' \quad (8)$$

$$V(h) = e_1 V(v) e_1' \quad (9)$$

$$A = [r V(z) r' / V(h)]^{0.5} \quad (10)$$

$$r = [k_1 \quad k_3] \quad (11)$$

r is a [1 x (n+1)] vector of utility parameters.

The equilibrium demand for h, i.e., the demand function after substituting out P(h), is given by the following equation:

$$h = (k_0 - k_3 q_0 - k_4 q_1 + r z') / (2 k_3 q_1 - k_2) \quad (12)$$

where r is given in (11).

IV. An Application.

The model that is presented in the previous section can be used for a study of the quality of life. The empirical example that follows shows that it is feasible to estimate the complete model using cross section data and fixed effect assumptions. The model is estimated using data on Chicago (Illinois), Cleveland (Ohio), Dallas (Texas), Houston (texas), and Indianapolis

(Indiana), and the estimation results are used to provide a rank of these cities based on the quality of life distributions that each city provides to its residents.

IV.A. The Economic Model.

The quality of life, h, is assumed to be a scalar and a function of the vector [t c], where t is a vector of housing and neighborhood characteristics, and c is a vector of city-wide amenities. It is assumed that the quality of life index equation is linear in t, that is,

$$h = e_0(c) + e_1(c)\ t_1 + e_2(c)\ t_2 + e_3(c)\ t_3 \qquad (13)$$

where $e_i(c)$ is a function of c, for i = 0, 1, 2, 3. For the purpose of this illustration, it is assumed that the vector t consists of only three elements, namely, the following: t_1 = number of rooms, t_2 = air quality, and t_3 = travel time to work (measured in minutes). The air quality variable equals the inverse of the air pollution variable total suspended particulate matter (measured in microgram per cubic meter). t is assumed to follow an exogenously given multi-normal distribution.

Consumer preferences are described by utility functions. The utility function, U(h,x;a), depends on the quality of life, h, on the numeraire good, x, and on a, a vector of utility parameters that specifies the type of the consumer. The only parameters of the utility function that are different among consumers are included in a. In our application, a is assumed to be the size of the household (number of persons in a household). A consumer solves the following optimization problem:

max U(h,x;a)

with respect to h, x

subject to I = 12 P(h) + 365 x

where I is the annual income, P(h) is the gross monthly expenditure on a house that is described by a vector of characteristics [t c], 12 is the number of months in a year, and 365 is the number of days in a year. Consumers are assumed to use the services of only one house. For the empirical example of this section, it is also assumed that there is no migration across cities, that is, the vector of city characteristics, c, is exogenously given to each consumer. However, the theoretical model of section III can be applied (without any modification) to the problem studied in this section when the latter assumption is relaxed[3].

A house can be fully described by the vector [t c] that also specifies the quality of life. As a result there is a quality of life index that corresponds to each house. It is assumed that the housing price equation is a function of h. When consumers choose housing they consider the whole package [t c] that corresponds to a house. Since their utility depends on h, it makes sense within our framework to assume that in equilibrium the rental price equation is a function of h.

The utility function is given next:

$$U(h,x;a) = k + k_1\ a\ h + 0.5\ k_2\ h^2 + x\ h$$

where k, k_1, and k_2 are utility parameters. The vector [a I] is assumed to follow an exogenously given distribution that is given in (2).

The results of the the previous section and equation (12) imply that the equilibrium price equation and demand for quality of life are respectively given by the following equations:

$$P = 365\ [\ k_1\ m(a) + m(I)\ /\ 365 - A\ m(h)\ ]\ /\ 12 + 365\ (\ k_2 + A\ )\ h\ /\ 24 \qquad (14)$$

$$h = [\ m(h) - k_1\ m(a)\ /\ A - m(I)\ /\ (\ 365\ A\ )\ ] + k_1\ a\ /\ A + I\ /\ (\ 365\ A\ ) \qquad (15)$$

where A is given in (10), r is given in (11), m(a) is the mean size of the family, m(I) is the mean income, m(t) is the mean of t, V(t) is the variance-covariance matrix of t,

$$m(h) = e_0(c) + e(c)\ m(t)'$$

$$V(h) = e(c)\ V(t)\ e(c)', \text{ and}$$

$$e(c) = [\ e_1(c)\quad e_2(c)\quad e_3(c)\ ].$$

Note that in equations (14) and (15), m(a), m(I), m(h), and A should be indexed by j, where j = Houston, Chicago, Cleveland, Indianapolis, Dallas (the five cities that are considered in this cross section study). However, to simplify the notation the subscript j has been dropped.

IV.B. The Econometric Model.

Substituting equation (13) into (14), and assuming an additive error term on equations (14) and (15), equations (14) and (15) are equivalent to:

$$P = b_0 + b_1 t_1 + b_2 t_2 + b_3 t_3 + u_1 \qquad (16)$$

$$H = G - e_4 a - e_5 I + u_2 \qquad (17)$$

where u_1 and u_2 are the econometric errors of (14) and (15) respectively,

$$H = h - e_0 \qquad (18)$$

$$e_4 = - k_1 / A \qquad (19)$$

$$e_5 = - 1 / (365 A) \qquad (20)$$

$$G = g - e_0 \qquad (21)$$

$$g = m(h) + e_4 m(a) + e_5 m(I) \qquad (22)$$

$$b_0 = q_0 + q_1 e_0 \qquad (23)$$

$$q_0 = -365 A g / 12 \qquad (24)$$

$$q_1 = 365 (k_2 + A) / 24 \qquad (25)$$

$$b_i = q_1 e_i \quad \text{for } i = 1, 2, 3, \quad \text{and} \qquad (26)$$

$$e_i = e_i(c) \quad \text{for } i = 0, 1, 2, 3 \quad .$$

g, e_2, and e_0 are assumed to be the only parameters of the demand for quality of life equation and of the quality of life index equation that are different across cities. This assumption implies that b_0 and b_2 are the only parameters of the price equation that are different across cities. I make the fixed effect assumption that the following is satisfied:

$$G = G_0 + \Sigma_i G_{1i} d_i$$

$$b_0 = b_{00} + \Sigma_i b_{01i} d_i$$

$$b_2 = b_{20} + \Sigma_i b_{21i} d_i$$

where i = 1, 2, 3, 4, $d_1 = 1$ for Chicago (Illinois) and 0 else, $d_2 = 1$ for Cleveland (Ohio) and 0 else, $d_3 = 1$ for Indianapolis (Indiana) and 0 else, and $d_4 = 1$ for Dallas (Texas) and 0 else.

The econometric errors of equations (16) and (17) are assumed to satisfy: (A1) u_1 and u_2 are uncorrelated, (A2) a and I are uncorrelated to u_1 and u_2, and (A3) t_1, t_2, and t_3 are uncorrelated to u_1. These assumptions can be motivated, for example, by thinking of u_1 as a measurement error in price and u_2 as unmeasured buyer characteristics that are uncorrelated with measured buyer characteristics.

For the economy considered in Section IV, the quality of life is a latent variable. Without loss of generality the quality of life can be normalized by setting $e_1 = 1$.

IV.C. Estimation of the Reduced Form Equations.

To estimate the complete model, I apply a four step estimation procedure. This estimation method yields consistent parameter estimates and uses the restrictions that are implied by the structure of the model, namely,

$$e_2 = b_2/b_1 \quad \text{, and} \tag{27}$$

$$e_3 = b_3/b_1 \tag{28}$$

The model is estimated using (1980) census tract housing data and SAROAD based data on air quality. The model has convenient aggregation properties that allow mean values of census tract data to be used. To obtain the annual arithmetic mean of total suspended particulate for each census tract, all the monitoring stations in Chicago, Cleveland, Dallas, Houston, and Indianapolis were located according to census tract. The readings for these census tracts were used to represent pollution readings in adjacent census tracts since most cities contain a limited number of monitoring stations. If a census tract was adjacent to more than one census tract containing a monitoring station, then the average of readings was used. The estimation method follows.

STEP 1. Estimate equation (16) by ordinary least squares (which is appropriate under assumption A3). The estimation results are given in Table 1. They imply:

$$P = b_0 + 15.99\ t_1 + b_2\ t_2 - 4.69\ t_3$$

where the values of the parameters b_0 and b_2 for each city are given in Table 2.

STEP 2. Given (27) and (28) and the results of the previous step, I can obtain estimates for the parameters e_2 and e_3 of the quality of life index equation of each city. Thus, it is obtained: $H = t_1 + e_2 t_2 - 0.293 t_3$, where H is defined in (18) and the values of the parameter e_2 for each city are given in Table 2. H is a quality of life index that is appropriate only for intracity rankings of census tracts. H is not appropriate for intercity comparisons.

STEP 3. Using the estimates obtained in step 2, I can construct an estimated series for the quality index H for each census tract of my data.

STEP 4. I use the estimates for H obtained in step 3 to estimate equation (17) by ordinary least squares. Ordinary least squares is legitimate under the assumptions made about the error terms. Deviations between the actual H and its estimate are measurement errors in the dependent variable in equation (17) and hence do not affect the consistency of ordinary least squares. The estimation results are given in Table 3. They imply: $H = G - 0.196 a + 0.000255 I$, where the values of the parameter G for each city are given in Table 2.

To see if the model makes a significant contribution to explaining the data, I tested the hypothesis that all the parameters of equation (16) equal zero, that is $b_1 = b_2 = b_3 = b_{01i} = b_{21i} = 0$ for all i = 1, 2, 3, 4. An F-test implies that this hypothesis is rejected at the 1% significance level. A similar F-test rejects the hypothesis that all the parameters of equation (17) equal zero (at the 1% significance level).

The t-statistics (see Tables 1 and 3) show that the size of a house, the air quality, and the travel time to work variables (which are expected to be the main determinants of the rent), as well as the income (which is expected to be the main determinant of the equilibrium demand for quality of life) are significant at the 1% significance level. Moreover, all variables have the anticipated signs in both equations[4].

IV.D. The Quality of Life.

The parameter estimates that I obtained in Section IV.C. and (19)-(26) imply that the h-quality of life index equation is the following:

$$h = e_0 + t_1 + e_2 t_2 - 0.293 t_3 \qquad (29)$$

where the values of the parameters e_0 and e_2 for each city are given in Table 2.

Equations (29) and the distribution of the vector t give the quality of life distribution of each city which can be used for a comparison of the five cities considered. A quality of life ranking of census tracts can be obtained for the purpose of not only intra- but also inter-city comparisons.

IV.E. Ranking of Urban Areas.

The results of Section IV.D. are used to construct a quality of life based ranking of Chicago, Cleveland, Dallas, Houston, and Indianapolis. h_1 is a quality of life index that is obtained by substituting the overall five city means of t_1, t_2, and t_3 into (29). h_1 gives the quality of life that corresponds to the mean house when located in Chicago, Cleveland, Dallas, Houston, and Indianapolis. h_1 is given in Table 4 and it provides a quality of life ranking of the five cities that can be compared to the ones of the previous work because it is not affected by the differences in the housing characteristics distributions of the five cities. Table 5 gives the Blomquist et al's (1985) and (1988) and Roback's (1982) rankings for the same cities; Roback's ranking is the only one that is constructed using 1970 data. To facilitate comparisons all rankings are scaled from 0 to 100. Table 6 gives population, mean household income, and consumer price index based rankings for Chicago, Cleveland, Dallas, Houston, and Indianapolis. Tables 4 and 5 show that the h_1 ranking is the same with the Blomquist et al (1985) but different than the other rankings of Tables 5 and 6.

In equilibrium, each of the cities provides to its residents a different quality of life distribution. These distributions could considered in ranking urban areas. The quality of life index h_2 captures aspects of that. h_2 is the mean of the quality of life distribution in a city and it is obtained by substituting in (29) the mean of t_1, t_2, and t_3 for each city. Table 4 includes the ranking of the five cities that is implied by the h_2 quality of life index.

The model predicts that a 4.1% improvement in the mean air quality of Dallas would be enough to make Dallas achieve the highest h_1 and h_2 values among all five cities. In general, given equation (29), the method followed by this paper can compute the changes in the quality of life distribution of each city that are implied by changes in the supply distributions of t_1, t_2, and t_3. On the other hand, the alternative method cannot predict how a ranking will be affected by such changes because it does not provide estimates for the equilibrium hedonic price equation and the equilibrium implicit prices of amenities.

V. Conclusions.

The purpose of this paper is to illustrate an application of the structural approach to hedonic equilibrium models on a quality of life based ranking of urban areas. The restrictive assumptions of the experiment of Section IV, namely, the no migration across cities and the fixed effect assumptions, can be easily relaxed by introducing explicitly into the model all the variables that differentiate cities and census tracts across cities. Moreover, the supply for housing can become endogenous and hedonic wages can be introduced directly into the model using one of the models discussed in Giannias (1987). The latter would allow investigation of other interesting aspects of the problem that are of interest to decision makers. For example, what is the effect of changes in the distribution of consumer characteristics or technological changes on the quality of life distributions of each city.

The quality of life ranking that is proposed in Section IV, h_2, implies a ranking that is found to be different than those based on h_1, Blomquist and al (1985) and (1988), Roback (1982), population, money income, and consumer price index (see Tables 4, 5, and 6). The empirical results indicate (i) that a smaller city, e.g., Indianapolis or Dallas, is likely to achieve a higher position on the ranking scale than a larger city, e.g., Chicago, Houston, Cleveland (see Table 4), (ii) high income and low consumer price index do not necessarily imply a high quality of life index, e.g., Chicago (see Table 4), (iii) when the housing characteristics are hold constant across cities, all rankings agree that Indianapolis achieves the highest position on the ranking scale (see the first column of Table 4 and Table 5), and (iv) all the rankings that are based on 1980 data show that Cleveland holds the third position among the five cities (see Tables 4 and 5).

TABLE 1

THE PRICE EQUATION

VARIABLE	COEFFICIENT	STANDARD ERROR	T-STATISTIC
v_1	15.99276	5.763284	2.774939
v_2	6007.581	2570.596	2.337038
v_3	-4.694337	0.8765819	-5.355274
d_1 v_2	-897.9850	6549.659	-0.1371041
d_2 v_2	3125.598	4614.085	0.6774037
d_3 v_2	13869.76	7662.765	1.810021
d_4 v_2	12139.74	4171.493	2.910167
d_1	10.78907	83.59626	0.1290616
d_2	-135.7710	56.22005	-2.414993
d_3	-303.0750	101.5843	-2.983483
d_4	-257.1130	67.00254	-3.837361
INTERCEPT	202.2441	46.61379	4.338718

$R^2 = 0.58$

N = 152

NOTE: N is the number of observations

TABLE 2

VALUES OF THE PARAMETERS THAT ARE DIFFERENT ACROSS CITIES

	CHICAGO	CLEVELAND	DALLAS	HOUSTON	INDIANAPOLIS
b_0	213.03	66.47	-54.87	202.24	-100.83
b_2	5109.6	9133.18	18147.32	6007.58	19877.34
e_2	319.55	571.18	1134.92	375.71	1243.11
G	-4.19	-0.97	12.57	-1.76	11.93
e_0	-4.40	1.02	13.20	-1.85	12.53

TABLE 3

THE DEMAND FOR H EQUATION

VARIABLE	COEFFICIENT	STANDARD ERROR	T-STATISTIC
a	-0.1958743	0.2718853	-0.7204298
I	0.0002549194	0.0000413974	6.157859
d_1	-2.4297600	0.5767376	-4.212938
d_2	2.7307930	0.5955871	4.585044
d_3	13.697480	0.6445893	21.24994
d_4	14.335180	0.5395293	26.56979
INTERCEPT	-1.7629320	1.0895590	-1.618023

$R^2 = 0.89$

N = 152

TABLE 4

QUALITY OF LIFE VALUES AND RANKINGS

	h_1		h_2	
	RANK	VALUE	RANK	VALUE
CHICAGO	5	0	5	0
CLEVELAND	3	30.06	3	24.24
DALLAS	2	97.44	1	100
HOUSTON	4	11.33	4	2.59
INDIANAPOLIS	1	100	2	91.71

TABLE 5

QUALITY OF LIFE VALUES AND RANKINGS THAT ARE IMPLIED BY PREVIOUS WORK

	BLOMQUIST ET AL (1985)		BLOMQUIST ET AL (1988)		ROBACK (1982)	
	RANK	VALUE	RANK	VALUE	RANK	VALUE
CHICAGO	5	0	2	78.44	3	16.62
CLEVELAND	3	78.33	3	77.28	4	0
DALLAS	2	81.16	4	76.12	1	100
HOUSTON	4	54.83	5	0	2	20.71
INDIANAPOLIS	1	100	1	100	NA	NA

NA: Not Applicable.

TABLE 6

POPULATION, MEAN CONSUMER INCOME, AND CONSUMER PRICE INDEX BASED RANKINGS

	SMSA POPULATION RANK	MEAN CONSUMER INCOME (In $)		CONSUMER PRICE INDEX	
	RANK	RANK	VALUE	RANK	VALUE
CHICAGO	1	1	19,645	1	214.6
CLEVELAND	2	2	18,525	3	219.5
DALLAS	4	4	17,854	2	218.6
HOUSTON	3	3	17,916	4	235.7
INDIANAPOLIS	5	NA	NA	NA	NA

SOURCE: Statistical Abstracts of the United States of America 1980.

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ENDNOTES

1. The proof can be found in Giannias (1987) (see Proposition 1). The general strategy of the proof was introduced by Tinbergen (1959) and extended by Epple (1984).

2. There are two solutions that satisfy the equilibrium condition. The one of them is rejected because it does not satisfy the second order condition for utility maximization.

3. This can be easily done by introducing into the model explicitly all the elements of the vector (t c) and not making any fixed effect assumptions (see next).

4. The effect of the family size on the demand for the quality of life is insignificant and I have no a priori beliefs about the sign of the coefficient e_4.