JOURNAL OF REGIONAL SCIENCE, VOL. 21, NO. 3, 1981

THE VALUE OF URBAN AMENITIES*

M. L. Cropper†

1. INTRODUCTION

Beginning with Tobin and Nordhaus [12], economists have tried to estimate the value of urban amenities by regressing wages on city size, population density, and other amenity measures. In some cases (Izraeli [7], Rosen [10], Getz and Huang [1]) these results have been used to value particular amenities such as air pollution and crime. More often the object has been to see whether the externalities associated with city size—greater variety of goods and services, air pollution, congestion—are, on net, valued positively or negatively. The general finding (Tobin and Nordhaus [12], Hoch [6], Meyer and Leone [8]) has been that the net value of urban growth is negative, implying that persons must be compensated with higher incomes to live in large cities. One implication of this (Tobin and Nordhaus [12]) is that increases in output are poor indicators of improvements in welfare unless they are adjusted to reflect urban growth. A second implication is that cities are larger than they should optimally be.[1]

In spite of the importance of these conclusions there have been few attempts to justify rigorously the use of wage-amenity regressions.[2] One question which remains unanswered is whether wage differentials capture all of the compensation for living in cities when prices also adjust to equalize amenity differences. A more fundamental question is whether the coefficients of amenities in the wage-amenity regression yield unbiased estimates of marginal amenity values. One reason for believing that they do not is that within-city variation in air pollution and crime is ignored in wage-amenity regressions.

The question addressed in this paper is under what assumptions the value of urban amenities can be inferred from a regression of wages on amenity values. To answer the question Section 2 develops a model of a system of cities. Each city is characterized by a distribution of amenities and by a vector of wages and prices.

---

*This research was supported by USEPA Grant No. #R805059010. The author would like to thank Allen Kneese, Sherwin Rosen, and an anonymous referee for helpful comments on an earlier version of the paper.

†Assistant Professor of Economics, University of Maryland.

[1]If the net value of urban growth is negative, then adding another person to a city imposes a cost on society which the individual ignores. Even though wages in equilibrium will rise to compensate for the disutility of increased population, the fact that potential entrants ignore their marginal social cost causes cities to deviate from optimum size.

[2]Rosen [10] justifies wage-amenity regressions using the theory of hedonic prices. His model, however, ignores the spatial organization of cities, which has important implications for wage-amenity regressions.

Date received: October, 1979; revised, June, 1980.

With this information workers select the city in which they live and their location within the city. Equilibrium conditions on the consumer side of the model yield a labor supply function which expresses the real acceptance wage as a function of population, city area, and site-specific amenities. It is shown, under specific assumptions on preferences and amenities, that coefficients of the labor supply function can be used to value urban externalities. The model thus demonstrates that wage differentials do not understate amenity values, provided that they are computed from the coefficients of the labor supply function.

The labor supply function derived from the model is not, however, the equation estimated in the literature. The conventional wage-amenity equation assumes that all persons in a city are exposed to the same levels of crime and air pollution. The model, however, indicates that the dispersion of amenities within each city explains some of the variation in wages. Since the dispersion of amenities is very likely greater in large cities, it can be approximated by including city area in the regression.

The more important implication of the model is that the coefficients of the labor supply function do not represent marginal amenity values. Equilibrium conditions in the land market indicate that an increase in population raises land prices throughout a city. This implies that the coefficient of population includes compensation for higher land prices as well as compensation for urban disamenities. Unfortunately, conditions for land market equilibrium also cause other amenity coefficients to overstate marginal willingness to pay.

This suggests that conventional wage-amenity regressions, which interpret coefficients as marginal amenity values, overstate the disutility of large cities. This question is examined in Section 3 by comparing estimates of the value of city size using a conventional wage-amenity regression with estimates derived from the model of Section 2. When compared to estimates from the model, conventional estimates overstate the disutility of city size and indicate that cities yield net disamenities when they in fact yield net amenities. The implications of these results are discussed in Section 3.

2. AN EQUILIBRIUM MODEL OF URBAN LOCATION[3]

The model presented in this section provides the theoretical justification for estimating amenity values from cross-sectional wage data. Justification for wage-amenity regressions has also been provided by Rosen [10], who has developed a model of interurban migration using the theory of hedonic prices. According to Rosen's model the coefficients of amenities in the wage-amenity equation can be interpreted as marginal amenity values. Rosen's theory of interurban location, however, ignores the distribution of amenities within cities and conditions for intraurban housing market equilibrium. This section incorporates these features into a model of interurban migration and examines their implications for the valuation of amenities.

[3]The model developed in Section 2 is similar to urban location models developed by Henderson [4], Polinsky and Rubinfeld [9] and Solow [11].

The Spatial Organization of Cities

The model consists of a large number of cities, each one of which contains a business district (CBD) surrounded by residential areas. Below, it is assumed that each city is circular with the business district at the city center; however, the results hold as long as all industry is concentrated in a single area. Since the size of the CBD is small relative to total city size, the CBD is treated as a point whose land sells at a single price. Residential areas are indexed by their distance from the CBD, and the price of land at distance k is denoted $r_i(k)$.

An important feature of the model is the distribution of amenities within each city. It is assumed that the value of amenity A at location k is the product of the amenity in the CBD, A_i, and a dispersion function $a(k)$

$$A_i(k) = A_i a(k) \tag{1}$$

This is a strong assumption as it implies that the distribution of each amenity is symmetric with respect to the CBD and similar in all cities. It is, however, an improvement over existing work, which assumes that all persons are exposed to the same level of amenities. For crime and air pollution the assumption is perhaps defensible since these disamenities usually vary with distance from the CBD.

In addition, it is assumed that the city boundary is fixed and equal to $\bar{k}_i$. What is analyzed is thus a short-run situation where the period of analysis is long enough to allow workers to move from one city to another but not long enough to allow city boundaries to adjust to this migration. This short-run equilibrium persists until each city rezones agricultural areas as residential districts and provides them with public services. Although this assumption would be restrictive in a purely theoretical context, it seems appropriate for empirical work since real-world data are unlikely to reflect a long-run equilibrium.

Assumptions Regarding Workers

Within each city live workers who can costlessly migrate from one city to another but who must work in the city in which they live. Initially all workers are assumed to be identical and to work a fixed number of hours in the CBD at a wage of w_i per period. (The case of different occupations is treated in Appendix A.) In urban location models it is customary to assume that the cost of commuting from the residence to the CBD is an increasing function of distance travel but does not depend on income. This assumption, however, is incompatible with the utility function employed below, and transportation is therefore treated as another good which the individual purchases. The disutility associated with commuting is captured instead by including the term $k^{-\xi}$ in the utility function.

In deciding where to live the worker considers not only commuting distance but site-specific amenities and the value of purchased goods. Formally, suppose each worker receives utility from his residential site, q, from local goods, x, and from imports, y. Utility also depends on city size, N_i, on amenities in the CBD, A_i, and on amenities at home, $A_i a(k)$

$$U_i = Bq^{\beta} x^{\alpha_1} y^{\alpha_2} N_i^{\gamma} A_i^{\eta} [A_i a(k)]^{\delta} k^{-\xi} \qquad (\alpha_1 + \alpha_2 + \beta = 1) \tag{2}$$

(For simplicity, only a single local amenity is included in the utility function.)

Since the individual takes amenities and prices as given, utility varies according to the city and neighborhood in which he lives. To find the location with the highest utility the individual maximizes (2) subject to the budget constraint

$$w_i = r_i(k)q + p_{1i}x + p_{2i}y \tag{3}$$

for each (i, k).[4] The resulting demand functions can be substituted into (2) to yield the indirect utility function

$$V_i(k) = Cw_i r_i(k)^{-\beta} p_{1i}^{-\alpha_1} p_{2i}^{-\alpha_2} N_i^{\gamma} A_i^{\eta+\delta} a(k)^{\delta} k^{-\xi} \qquad (C = B\beta^{\beta}\alpha_1^{\alpha_1}\alpha_2^{\alpha_2}) \tag{4}$$

which gives utility in each neighborhood of each city as a function of site-specific amenities, income, and prices.

If each individual chooses the location with highest utility, and if all persons are identical, utility in equilibrium must be identical in all locations. Furthermore, if city i is small relative to the country, $V_i(k)$ may be regarded as exogenously determined and, hence, $V_i(k) = V^*$ for all i and k. Worker mobility thus implies that rents, wages, and the prices of local goods adjust to compensate for differences in amenities. The question is whether this information can be used to estimate amenity values.

To define the marginal value of an amenity consider a small change in N or an equiproportionate change in A throughout the city. The individual's willingness to pay for this change may be defined as the largest amount of income one can take away from him without altering his utility. If the change in A is so small that its effect on prices can be ignored, then differentiation of (4) yields

$$d(\ln w_i)/d(\ln A_i) = \eta + \delta \Longleftrightarrow dw_i = w_i(\eta + \delta)\frac{dA_i}{A_i} \tag{5}$$

The value of an amenity thus depends only on its coefficient in the utility function.

One way to estimate this coefficient would be to solve the locational equilibrium condition for w

$$w_i = (V^*/C)r_i(k)^{\beta} p_{1i}^{\alpha_1} p_{2i}^{\alpha_2} N_i^{-\gamma} A_i^{-\eta}[A_i a(k)]^{-\delta} k^{\xi} \tag{6}$$

and estimate the resulting equation using data across cities. This, however, would require data on property values and amenities by census tract for a large number of cities. The effort involved in obtaining such a data set would be considerable,[5] and it is this cost which motivates the use of the labor supply function.

To obtain the labor supply function, (4) may be solved explicitly for $r_i(k)$ to give each individual's maximum willingness to pay for land at location k,

$$r_i(k) = (C/V^*)^{1/\beta} w_i^{1/\beta} p_{1i}^{-\alpha_1/\beta} p_{2i}^{-\alpha_2/\beta} N_i^{\gamma/\beta} A_i^{(\eta+\delta)/\beta} a(k)^{\delta/\beta} k^{-\xi/\beta} \tag{7}$$

[4]Since x represents local goods, the price of x will vary from city to city. Exports, y, are assumed to sell in a national market at a single price; however, the delivered cost of y will vary according to the distance of city i from the national market. Both p_1 and p_2, therefore, bear the subscript i.

[5]Harrison and Rubinfeld's [3] study of property values in the Boston area illustrates the difficulty encountered in obtaining amenity data by census tract. Since disaggregated pollution data were unavailable in the Boston area, a model had to be built to simulate the interaction of emissions and weather conditions. A similar undertaking would be required for all cities used in the estimation of (6).

Since land is sold to the highest bidder, (7) also represents the equilibrium rent function in city i. Now for the land market to be in equilibrium the population (labor force) in city i must be such that the demand for land at distance k from the CBD equals the supply. Equivalently, if $2\pi k dk$ is the fixed supply of land at distance k, then the number of persons living in ring k, $n(k)$, must equal total land available divided by land per person

$$(8) \qquad n(k) = \frac{2\pi k dk r_i(k)}{\beta w_i}$$

Substituting for $r_i(k)$ from (7) and integrating from $k = 0$ to $k = \bar{k}_i$, the fixed boundary of the city, yields the number of workers as a function of amenity levels and the wage

$$(9) \qquad N_i = \int_0^{\bar{k}_i} n(k)dk = Mw_i^{(1-\beta)/\beta} p_{1i}^{-\alpha_1/\beta} p_{2i}^{-\alpha_2/\beta} N_i^{\gamma/\beta} A_i^{(\eta+\delta)/\beta} f(\bar{k}_i)$$

where $M = 2\pi\beta^{-1}(C/V^*)^{1/\beta}$ and $f(\bar{k}_i) = \int_0^{\bar{k}_i} k^{1-(\xi/\beta)} a(k)^{\delta/\beta} dk$. Equation (9), the supply function of labor in city i, may also be written with the real acceptance wage expressed as a function of population and amenities

$$(10) \quad \ln(w_i/P_i) = c + \frac{\beta - \gamma}{1-\beta} \ln N_i - \frac{\eta + \delta}{1-\beta} \ln A_i - \ln f(\bar{k}_i), \; P_i \equiv p_{1i}^{\alpha_1/(1-\beta)} p_{2i}^{\alpha_2/(1-\beta)}$$

It is now possible to answer the question posed in the Introduction, "Can amenity values be inferred from cross-sectional wage data if prices also adjust to compensate for amenity differences?" The answer is yes, provided that one estimates Equation (10), and provided that one obtains an independent estimate of β, the proportion of income spent on the housing site. Given $\hat{\beta}$ and estimates of the coefficients of population ($\hat{\beta}_1$) and amenities ($\hat{\beta}_2$), the marginal value of population and amenities can be obtained from the equations

$$(11a) \qquad \hat{\gamma} = \hat{\beta} - \hat{\beta}_1(1 - \hat{\beta})$$

$$(11b) \qquad \widehat{\eta + \delta} = \hat{\beta}_2(1 - \hat{\beta})$$

Equation (10), however, is not the equation estimated in the literature. The equation estimated by Rosen [10], for example, is[6]

$$(12) \qquad \ln[w_i/(r_i^{-\beta} p_{1i}^{-\alpha_1} p_{2i}^{-\alpha_2})] = c' - \gamma \ln N_i - (\eta + \delta) \ln A_i$$

This may be derived from the locational equilibrium condition by setting $a(k) = k = 1$ and solving for the real wage. A comparison of Equations (10) and (12) indicates the importance of considering the spatial distribution of amenities and conditions for land market equilibrium in each city.

The fact that amenities do vary spatially implies that wage differentials can be explained by variation in amenities within, as well as across, cities. Within-city variation, which is ignored in (12), is captured in (10) by the term $\ln f(\bar{k}_i)$. Since within-city variation in amenities is greater in large cities, $\ln f(\bar{k}_i)$ can in practice

[6]Rosen also includes human capital variables in the hedonic price equation to control for this source of variation in the wage.

be approximated by some function of city area. Failure to include this term will bias amenity coefficients.

Equations (10) and (12) also differ in their dependent variable. In the hedonic price equation, (12), the wage is deflated by a price index which includes the price of housing. Housing prices do not enter the price index in Equation (10), however, because (10) is derived from conditions for land market equilibrium. In equilibrium the rent gradient in city i is an increasing function of the number of persons in the city and the level of amenities. This implies that individuals must be compensated for higher land prices in cities with large values of N and A, and this compensation is reflected in the coefficients of N and A in Equation (10).

Since the coefficient of population reflects compensation for higher land prices as well as for the disamenities of urban life, this coefficient can no longer be interpreted as the marginal value of urban disamenities.[7] This is also true of the coefficient of amenities, which reflects compensation for higher land prices as well. Land market equilibrium thus implies that regression coefficients overstate marginal willingness to pay and must be adjusted downward. In the case of city size this adjustment is likely to be substantial. Estimates of the coefficient of $\ln N_i$ in literature are in the range of 0.02 to 0.07. Since this is the same order of magnitude as β, adjusting the coefficient for the effects of land prices may even change the sign of γ from negative, indicating a disamenity, to positive.

This strongly suggests that existing estimates of willingness to pay overstate the true disutility of city size. This is not certain, however, since the estimated regression coefficients in (10) and (12) will likely differ. To see whether (10) yields lower estimates of willingness to pay than the conventional approach, estimates of (10) and (12) are contrasted in Section 3.

Assumptions Regarding Firms

To properly estimate (10) and (12) we must briefly discuss the production decisions of firms and equilibrium conditions in product and factor markets.

In each city there is assumed to be a production function for industry X and industry Y. The Y production function in city i may be written as

$$(13) \qquad Y_i = D_2 N_{2i}^a L_{2i}^b K_{2i}^c S_{2i}^d E_{2i}^f \qquad (a + b + c + d < 1)$$

where N_{2i} denotes labor inputs, L_{2i}, land and raw material inputs, K_{2i}, capital goods, S_{2i}, pollution generated by the industry, and E_{2i}, environmental goods such as climate. Population may also enter the production function as a proxy for agglomeration economies. It is assumed that both industries behave as price-takers in all markets. Thus, given output price, input price, and a tax on effluents, each industry determines profit maximizing levels of inputs, L, N, and K and a level of emissions, S.[8]

---

[7]Goldfarb and Yezer [2] recognize that the coefficient of city size reflects both compensation for amenities and compensation for higher living costs; however, they do not separate the two components of the coefficient.

[8]A necessary condition for each industry to operate in city i is that it earn nonnegative profits. The industry may earn positive profits, and these may vary in amount from city to city. This is compatible with locational equilibrium since the size of the industry will also differ from city to city.

Although each industry regards input and output prices as exogenous, the wage, land price in the CBD, and the price of local goods are determined by equilibrium conditions in product and factor markets. Equating the aggregate demand for land to the size of the CBD, the aggregate demand for labor to the right-hand side of (9) and the supply of X to the aggregate demand for X yields three equations which may be solved for the land price, the wage, and the price of X. The equilibrium level of employment is found by substituting the equilibrium wage into (9) and the quantity of local goods produced obtained by substituting p_{1i} into the aggregate demand function for X. Environmental goods which depend on output or on population are also determined by market equilibrium conditions.

The foregoing emphasizes the need to estimate (10) and (12) as part of a simultaneous equation system in which N, and any amenities which depend on N, are treated as endogenous. While perhaps obvious, this has rarely been observed in the literature. To identify the labor supply function, the remaining parameters of the model can be regarded as exogenous to city i. These include the prices of exports and raw materials, which are sold in national markets, and the size of the CBD, which may be regarded as exogenous in the short run.

3. EMPIRICAL IMPLICATIONS OF THE MODEL

Section 2 indicates that conditions for intraurban equilibrium alter the specification and interpretation of the wage-amenity equation. Specifically, the coefficient of population in the equation reflects compensation for higher land prices as well as compensation for external diseconomies of urban scale. If interpreted as marginal willingness to pay, the coefficient of population, therefore, overstates the disutility of large cities. Whether previous studies have overestimated urban disamenities is not clear, however, because the equation estimated in the literature differs from the wage-amenity locus of our model.

To examine the consequences of Section 2 for the valuation of amenities we estimate the labor supply function (10) and contrast the results with estimates of the conventional wage-amenity locus (12). In both equations the variables chosen are representative of those used in previous studies. The sample of cities (see Appendix B) and wage data are also identical to those used elsewhere (Getz and Huang [1], Meyer and Leone [8]). This allows us to focus on the effect of including city area in the regression and on the consequences of interpreting regression coefficients as indicated in Section 2.

Specification of the Wage-Amenity Relationship

Equations (10) and (12) are estimated using wage data for one-digit occupations from the 1970 Census of Population (U.S. Bureau of the Census [17]). The dependent variable in each equation is the median earnings of men who worked 50–52 weeks, deflated by the appropriate price index. In Equation (12) earnings are deflated by the BLS Intermediate Budget Cost-of-Living Index (U.S. Bureau of Labor Statistics [14]). According to Section 2 the price of housing should not enter the price index in the labor supply function; hence, housing has been omitted from the BLS Index in Equation (10).[9]

[9]The adjusted BLS Index was computed by adding expenditures for all items except housing, dividing this figure by average expenditures across the U.S., and multiplying the quotient by 100.

The dependent variable in (10) and (12) has also been adjusted for the effects of unions. Since it is widely believed that unions are able to affect wages, and since the proportion of workers covered by union contracts varies from city to city, failure to control for differences in union strength may cause the effect of unions to be attributed to urban amenities.[10] For occupations with a significant proportion of union members the earnings variable is adjusted using the formula[11]

$$w_{\text{observed}} = (1 - a)w_{\text{nonunion}} + aw_{\text{union}} \tag{14}$$

where a represents the percent of workers in unions (U.S. Bureau of Labor Statistics [13]). Earnings in each equation thus represent nonunion earnings.

In Table 1, the main variable of interest, scale amenities, is represented solely by population. An alternative approach would be to measure individual amenities such as sports franchises, museums, and air quality. These, however, are highly correlated and each must be treated as endogenous. To solve this problem Getz and Huang [1] use the first principal component of scale amenities; however, the latter is difficult to interpret. Another approach is to use both population and population density, as have Tobin and Nordhaus [12], Meyer and Leone [8], and Rosen [10]. This cannot be done here; however, since if all right-hand variables are in log form, ln (population density) will be an exact linear function of ln (population) and ln (area). This suggests that one may interpret the real wage as a function of either population and population density or population and area. Both interpretations are given below.

So that N remains an unambiguous amenity measure, the remaining variables in the equation are chosen to be uncorrelated with population.[12] Two of these require further explanation. The ratio of females to males employed in city i is used as a measure of employment opportunities for women, following Getz and Huang [1]. The anticipated sign of this coefficient is negative since men should be willing to accept lower wages in exchange for employment opportunities for their wives.[13] Net migration is included to correct for labor market disequilibrium. A positive coefficient indicates that workers are still entering (leaving) a city in response to an increase (decrease) in the wage.

In Table 1, (10) and (12) are estimated for nine one-digit occupations using earnings data from the 1970 Census of Population (U.S. Bureau of the Census [17]). Estimating equations for separate occupations helps control for variation in the skill mix across cities and also allows tastes to differ among workers. Since it is

---

[10]This assumes that the percentage of the workforce in unions is independent of the level of urban amenities. If there are no barriers to union membership, then workers may be more likely to join unions in cities with large disamenities so as to receive compensation for these disamenities.

[11]This formula is valid only if the w's are sample averages. Since our data pertain to median earnings, (14) holds only approximately.

[12]It might appear that crime would be excluded from the regression on the grounds that crime rates increase with city size. The correlation between crime and population in our sample, however, is only 0.19. Results obtained by Hoch [5] support the idea that crime varies more with race and region than with city size.

[13]A referee points out that this variable may also measure competition from women in the labor market and may have a negative sign for this reason.

not clear that (10) or (12) applies in the disaggregated case, the model of Section 2 is generalized in Appendix A. The resulting labor supply function is

$$\ln (w_{ij}/P_{ij}) = c_j + \frac{\beta_j - \gamma_j}{1 - \beta_j} \ln N_i - \frac{\eta_j + \delta_j}{1 - \beta_j} \ln A_i - \ln f_j(\bar{k}_i) \tag{10'}$$

As indicated in Appendix A, employment in occupation j should appear in (10′) together with population; however, in practice the two are so highly correlated that only population is used. The corresponding version of (12), Equation (12′), is

$$\ln [(w_{ij}/r_i)^{-\beta_j} p_{1i}^{-\alpha_{1j}} p_{2i}^{-\alpha_{2j}}] = c_j' - \gamma_j \ln N_i - (\eta_j + \delta_j) \ln A_i \tag{12'}$$

The estimation of (10′) and (12′) is based on the model in Section 2. Both equations are estimated by 2SLS with employment treated as endogenous. Factors affecting the demand for labor serve as excluded exogenous variables. These include proximity to output markets and availability of cheap transportation, both of which raise the net price of exports, and proximity to raw materials, which lowers the delivered cost of inputs.[14] In other studies human capital variables and race are included in the wage-amenity regression to control for this source of variation in the wage rate. In the context of the model, however, these variables should be treated as factors which are perceived to affect productivity and, hence, enter the demand function for labor. Accordingly, average age of the workforce and percent nonwhite are used as excluded exogenous variables.[15] The sample of cities used in the regressions appears in Appendix B.[16]

Results

In comparing the two sets of regressions the important question is what each implies about the disutility of urbanization. The conventional wage-amenity regressions indicate that city size is a net disamenity for all occupations. The marginal value of city size (γ) ranges from -0.02 to -0.08, implying that an individual earning \$10,000 would pay between \$20 and \$80 per year for a 10 percent decrease in population. Although these values depend on the specification

[14]These variables are measured as follows: proximity to output markets by the percent of exports (by weight) shipped at least 500 miles from each city (U.S. Bureau of the Census [18]); and availability of transportation by a dummy variable equal to one for port cities. To indicate accessibility of natural resources acres of commercial timberland (U.S. Bureau of the Census [21]), value added in mining (U.S. Bureau of the Census [16]), and value of farm products (U.S. Bureau of the Census [15]) are measured for the state containing city i.

[15]To test the significance of human capital variables, money earnings in each occupation (adjusted for union membership) were regressed on average age of workers in the occupation, on percent nonwhite in the occupation and on average school years of all men. In each case years of schooling (unavailable by occupation) was insignificant. Average age of the workforce, however, was positive and significant for all but two occupations. For laborers and service workers percent nonwhite was significant, with the expected negative sign. The latter variables were used as excluded exogenous variables in occupations for which they appeared significant.

[16]The BLS Cost of Living Index is computed for 39 cities; however, earnings and employment data are available by one-digit occupation for only 34 of them. Lack of amenity data further reduces the sample to 30 cities when net migration is excluded from the equation, and 28 cities when it is included.

TABLE 1: Wage-Amenity Equations, One-Digit Occupations[a]

	All Earners		Professional Workers		Nonfarm Managers		Sales Workers		Clerical Workers	
	(10′)	(12′)	(10′)	(12′)	(10′)	(12′)	(10′)	(12′)	(10′)	(12′)
Constant	4.9943***	4.8422**	3.3743**	3.2128**	4.5923***	4.4508***	2.9739*	2.7936*	3.4220**	3.4552**
	(1.2895)	(1.3211)	(1.3841)	(1.4537)	(1.3434)	(1.4800)	(1.9282)	(1.9677)	(1.5740)	(1.5700)
Population	0.0641***	0.0437***	0.0573***	0.0406**	0.0713***	0.0596***	0.0783***	0.0613***	0.0383**	0.0426**
	(0.0164)	(0.0131)	(0.0181)	(0.0151)	(0.0176)	(0.0159)	(0.0241)	(0.0194)	(0.0203)	(0.0155)
Area	−0.0325*		−0.0395**		−0.0414**		−0.0480*		0.0055	
	(0.0192)		(0.0209)		(0.0203)		(0.0286)		(0.0236)	
July	−0.4574***	−0.4555***	−0.0328	−0.0340	−0.1058	−0.1114	0.0172	0.0132	−0.2893**	−0.2908**
Temperature	(0.1148)	(0.1179)	(0.1232)	(0.1298)	(0.1196)	(0.1319)	(0.1716)	(0.1756)	(0.1401)	(0.1401)
Wind	−0.0815*	−0.0827*	−0.1092**	−0.1130**	−0.1165**	−0.1233**	−0.0494	−0.0556	−0.0642	−0.0648
Velocity	(0.0527)	(0.0541)	(0.0565)	(0.0596)	(0.0549)	(0.0606)	(0.0788)	(0.0806)	(0.0643)	(0.0643)
Doctors/	−0.1742**	−0.1362**	−0.1244*	−0.0901	−0.1160*	−0.0938	−0.0547	−0.0209	−0.1115*	−0.1216*
100,000	(0.0681)	(0.0662)	(0.0737)	(0.0737)	(0.0716)	(0.0756)	(0.1013)	(0.0985)	(0.0835)	(0.0786)
Hospital Beds/	0.0458*	−0.0472*	−0.0249	−0.0233	−0.0185	−0.0131	−0.0513	−0.0472	−0.0381	−0.0368
100,000	(0.0323)	(0.0332)	(0.0347)	(0.0367)	(0.0337)	(0.0374)	(0.0483)	(0.0495)	(0.0395)	(0.0395)
Crimes/	0.0549**	0.0608**	0.0686**	0.0766**	0.0414	0.0506*	0.0252	0.0353	0.0375	0.0368
100,000	(0.0302)	(0.0308)	(0.0324)	(0.0339)	(0.0315)	(0.0345)	(0.0452)	(0.0459)	(0.0369)	(0.0366)
Female/Male	−0.2126**	0.2011*	−0.1904*	−0.1730	−0.0756	−0.0534	−0.1511	−0.1277	−0.2880**	−0.2889**
Employment	(0.1196)	(0.1226)	(0.1283)	(0.1350)	(0.1246)	(0.1372)	(0.1788)	(0.1826)	(0.1460)	(0.1457)
Coastal	−0.0732***	−0.0800***	−0.0351*	−0.0458**	−0.0851***	0.0992***	−0.1015***	−0.1162***	−0.0759***	−0.0755***
Dummy[c]	(0.0219)	(0.0222)	(0.0236)	(0.0245)	(0.0229)	(0.0250)	(0.0328)	(0.0331)	(0.0268)	(0.0264)
Net	0.0024**	0.0017*	0.0041***	0.0033**	0.0034***	0.0027**	0.0480**	0.0025*	0.0017	0.0019
Migration	(0.0011)	(0.0010)	(0.0012)	(0.0011)	(0.0011)	(0.0012)	(0.0016)	(0.0015)	(0.0013)	(0.0012)
R^2	.8099	.7877	.7497	.7061	.7595	.6903	.5955	.5519	.6120	.5894
n	28	28	28	28	28	28	28	28	28	28

[a]All variables except net migration are in natural logarithms; *** (**) (*) denotes coefficients asymptotically significant at the .01 (.05) (.10) level, one-tailed test.
[b]Includes transport and nontransport operatives.
[c]Equal to 1 for coastal cities.
Source: Data for the explanatory variables in Table 1 were taken from U.S. Bureau of the Census [17, 19, 22] and U.S. Dept. of Health, Education, and Welfare [23].

TABLE 1. (Continued)

	Craftsmen		Operatives[b]		Nonfarm Laborers		Service Workers	
	(10′)	(12′)	(10′)	(12′)	(10′)	(12′)	(10′)	(12′)
Constant	3.2527**	2.9829*	2.1248	2.0568	5.1381***	5.1681***	7.3107***	7.1373***
	(1.6390)	(1.7602)	(1.6638)	(1.6233)	(1.4248)	(1.3812)	(2.4263)	(2.2764)
Population	0.0899***	0.0614***	0.0265*	0.0169	0.0613***	0.0644***	0.1027***	0.0845***
	(0.0213)	(0.0189)	(0.0196)	(0.0156)	(0.0170)	(0.0137)	(0.0289)	(0.0215)
Area	−0.0645***		−0.0106		0.0074		−0.0417	
	(0.0247)		(0.0241)		(0.0207)		(0.0353)	
July Temperature	−0.4578***	−0.4589***	−0.4243***	−0.4209***	−0.8204***	−0.8201***	−0.9305***	−0.9314***
	(0.1459)	(0.1571)	(0.1481)	(0.1445)	(0.1268)	(0.1233)	(0.2160)	(0.2031)
Wind Velocity	−0.0721	−0.0777	−0.0499	−0.0484	0.0146	0.0154	0.0105	0.0068
	(0.0670)	(0.0722)	(0.0680)	(0.0665)	(0.0582)	(0.0566)	(0.0991)	(0.0932)
Doctors/ 100,000	−0.2056**	−0.1464*	−0.0584	−0.0368	−0.1538**	−0.1601**	−0.3016**	−0.2639**
	(0.0872)	(0.0899)	(0.0860)	(0.0808)	(0.0738)	(0.0692)	(0.1258)	(0.1128)
Hospital Beds/ 100,000	−0.0285	−0.0268	−0.0922**	−0.0952**	0.0215	0.0212	−0.0076	−0.0063
	(0.0411)	(0.0445)	(0.0416)	(0.0407)	(0.0356)	(0.0347)	(0.0607)	(0.0571)
Crimes/ 100,000	0.0331	0.0459	−0.0051	−0.0037	0.0408	0.0393	0.0398	0.0481
	(0.0384)	(0.0411)	(0.0390)	(0.0379)	(0.0334)	(0.0322)	(0.0569)	(0.0531)
Female/Male Employment	−0.4620***	−0.4344***	−0.5831***	−0.5820***	−0.2562**	−0.2595**	−0.1222	−0.1042
	(0.1520)	(0.1634)	(0.1544)	(0.1507)	(0.1322)	(0.1283)	(0.2251)	(0.2113)
Coastal Dummy[c]	−0.0826***	−0.0994***	−0.0480*	−0.0483**	−0.0333*	−0.0314*	−0.0313	−0.0423
	(0.0279)	(0.0298)	(0.0283)	(0.0272)	(0.0242)	(0.0232)	(0.0413)	(0.0381)
Net Migration	0.0021*	0.0008	0.0000	−0.0003	−0.0012	−0.0010	0.0019	0.0010
	(0.0014)	(0.0014)	(0.0014)	(0.0013)	(0.0012)	(0.0011)	(0.0020)	(0.0018)
R^2	.7903	.7427	.7955	.7930	.8994	.8994	.7235	.7412
n	28	28	28	28	28	28	28	28

of the wage-amenity relation, they are consistent with results reported in the literature.[17]

The labor supply functions, by contrast, indicate that city size yields greater utility than the conventional estimates suggest. This is not immediate from Table 1 since the coefficients of N are usually higher in (10′) than in (12′). For reasonable values of β, however, urbanization appears to be an amenity rather than a disamenity. Recall that β represents the fraction of income spent on the residential housing site. Figures reported by the U.S. Bureau of the Census [20, p. 10] indicate that the median ratio of capitalized housing rent to income (housing price/income) is 2.2. For interest rates of 8 to 12 percent this implies that the ratio of rent to income is between 0.18 and 0.26.[18] If one-third of the rental price represents the value of land then β should lie between 0.06 and 0.09. For values of β in this range, estimates of γ are computed in Table 2.

Table 2 indicates that for β as low as 0.08, city size is a net amenity for six out of eight occupations. For lower values of β urbanization may yield disamenities, but these are in every case less than those implied by (12′). If one focuses on the value of city size in the aggregate labor supply equation then in no case does city size yield net disamenities.

One might criticize these results on the grounds that we have ignored the effects of population density and may be attributing some of the benefits of densely populated areas to population. Rosen [10], for example, finds that population density has a consistently negative sign in the wage-amenity regression, whereas the sign of population is consistently positive.

Equation (10), however, may be written as a function of population density and population

$$\ln(w_{ij}/P_{ij}) = \alpha_0 + \alpha_1[\ln N_i - \ln(\text{area}_i)] + \alpha_2 \ln N_i + \alpha_3 \ln A_i \tag{15}$$

By comparison with (10′) it is clear that

$$\alpha_2 = \beta_1 + \beta_3 \qquad \text{and} \qquad \alpha_1 = -\beta_3 \tag{16}$$

where β_1 is the coefficient of $\ln N_i$ in (10′) and β_3 is the coefficient of ln (area).[19] Table 1, therefore, implies that population density is viewed as a disamenity, as is population. When the effect of population density is held constant, however, population appears to be less of a disamenity than in Equation (10′). Allowing for the effects of population density therefore strengthens our results.

---

[17]In a log-linear regression of income on population, population density and other amenities, Tobin and Nordhaus [12, p. 50] find that the combined population coefficients range from 0.006 to 0.064. Meyer and Leone, repeating the Tobin-Nordhaus regression with wage data, obtain a combined population coefficient of 0.07 [8, p. 87].

[18]This is computed from the formula, rent/income = (housing price/income) × (interest rate) which assumes an infinite-lived housing stock. The percentage of income spent on housing cannot be computed from published figures on housing expenses since the latter include expenditures on insurance and utilities and exclude that portion of rent not reflected in mortgage payments.

[19]For this reinterpretation to be valid, area must be treated as an exogenous variable in Equation (15) as well as in Equation (10).

TABLE 2: Estimates of the Value of Urban Amenities

	All Earners	Professional Workers	Nonfarm Managers	Sales Workers	Clerical Workers	Craftsmen	Nonfarm Laborers	Service Workers
Equation (10′)	.000	.006	−.007	−.014	.024	−.025	.002	−.037
$\beta = .06$ Equation (10′)	.021	.027	.014	.008	.045	−.003	.024	−.014
$\beta = .08$ Equation (10′)	.042	.048	.036	.030	.066	.019	.045	.008
$\beta = .10$ Equation (12′)	−.044	−.041	−.060	−.061	−.043	−.061	−.064	−.085

Source: Table 1. Estimates in the first three rows are computed from the formula $\gamma = \beta - \hat{\beta}_1(1 - \beta)$, where $\hat{\beta}_1$ is the coefficient of employment. Estimates of γ are presented only for those occupations for which $\hat{\beta}_1$ is significant at conventional levels.

4. CONCLUSIONS

The model developed in Section 2 shows that the value of urban amenities can be identified from cross-sectional wage data under two key assumptions. These are that city boundaries are fixed and that the spatial distribution of amenities is similar in all cities. The first assumption seems appropriate for empirical work since real-world data more likely describe a short-run than a long-run equilibrium in the land market. The second assumption is more difficult to defend but is satisfied for amenities such as air pollution which are generated in the CBD and spread outward to the rest of the city.

Under these assumptions the labor supply function, which relates the real acceptance wage to city size, site-specific amenities, and city area, can be used to estimate the marginal value of urban amenities. The labor supply function, however, differs in two respects from the wage-amenity equation in the literature. The conventional wage-amenity equation ignores variation in amenities within cities. The dispersion of amenities within each city, however, explains some of the variation in wages and should be included in the regression equation. Since the dispersion of amenities is greater in large cities, it can be approximated by city area. Secondly, the model indicates that the coefficients of amenities in the labor supply function do not represent marginal amenity values. In the case of population, the regression coefficient includes compensation for higher land prices since increases in population raise rents and thus the wage necessary to attract workers. This compensation must be subtracted from the population coefficient to determine the value of urban disamenities per se.

This suggests that conventional wage-amenity regressions, which interpret coefficients as marginal amenity values, overstate the compensation required for living in large cities. Section 3, in comparing estimates of the disutility of city size obtained from the model with those obtained by the conventional approach, tends to confirm this result. The conventional wage-amenity regressions indicate that cities yield net disamenities for all occupations whereas estimates based on the model indicate (for $\beta > 0.08$) that cities yield net amenities. Although the regressions in Section 3 are subject to many of the same limitations as previous studies, e.g., small sample size, they suggest that these studies overestimate the disutility of city bigness.

This result has two important implications. First, it suggests that adjustments to GNP for the disamenities of urbanization are unwarranted. Tobin and Nordhaus [12, p. 10] estimate that GNP must be reduced by approximately 5 percent ($40.6 billion in 1970) to compensate for urban externalities. Meyer and Leone's figures, while lower ($15.6 billion), also indicate that a substantial welfare adjustment is required. Section 3, by contrast, suggests that GNP should actually be increased to reflect the net gain in utility which accrues from consumption externalities.

An estimate of $\gamma = 0.02$, for example, implies that GNP should be increased by $10.4 billion for 1970.[20] Secondly, since consumption externalities are positive, it is unlikely that they limit city size, as has traditionally been assumed (Hoch [6]). This suggests that urban growth may end because external economies in production have been exhausted. To investigate this, one could expand the production side of the model and estimate the coefficient of population in the aggregate production function.

Finally, although the paper has focused on the value of city size, the model could be used to value specific disamenities such as air pollution and crime. The value of these disamenities has traditionally been estimated using property value data; however, residential property values cannot capture the utility which consumers attach to clean air and safety at work. The advantage of the present approach is that estimates based on wage data capture the value of amenities at the work site as well as at home.

REFERENCES

[1] Getz, Malcolm and Yuh-ching Huang. "Consumer Revealed Preference for Environmental Goods," *Review of Economics and Statistics*, 60 (1978), 449–458.

[2] Goldfarb, Robert S. and Anthony M. J. Yezer. "Evaluating Alternative Theories of Intercity and Interregional Wage Differentials," *Journal of Regional Science*, 16 (1976), 345–363.

[3] Harrison, David and Daniel L. Rubinfeld. "Hedonic Housing Prices and the Demand for Clean Air," *Journal of Environmental Economics and Management*, 5 (1978), 81–102.

[4] Henderson, J. Vernon. *Economic Theory and the Cities*. New York: Academic Press, 1977.

[5] Hoch, Irving. "Factors in Urban Crime," *Journal of Urban Economics*, 1 (1974), 184–229.

[6] ———. "Variations in the Quality of Urban Life Among Cities and Regions," in L. Wingo and A. Evans (eds.), *Public Economics and the Quality of Life*. Baltimore: Johns Hopkins Press, 1977.

[7] Izraeli, Oded. "Differentials in Nominal Wages and Prices Between Cities," Ph.D. Dissertation, University of Chicago, 1973.

[8] Meyer, John R. and Robert A. Leone. "The Urban Disamenity Revisited," in L. Wingo and A. Evans (eds.), *Public Economics and the Quality of Life*. Baltimore: Johns Hopkins Press, 1977.

[20] The computation, which is intended solely as an illustration, follows Tobin and Nordhaus [12, pp. 50–51]. Tobin and Nordhaus define the urban disamenity per household as the value of a 1 million person change in population multiplied by the population of the U.S. in millions: disamenity/household = $(dw/dN)\,N = \gamma\,(w/N)\,N$ where w is measured in 1958 dollars. For $\gamma = 0.02$ and a median income (in 1958 dollars) of $8172.90, this comes to $163.46 for the year 1970. Multiplying this by the number of households in the U.S. gives $10.4 billion, the value of urban amenities.

[9] Polinsky, A. Mitchell and Daniel L. Rubinfeld. "The Long-Run Effects of a Residential Property Tax and Local Public Services," *Journal of Urban Economics*, 5 (1978), 241–262.
[10] Rosen, Sherwin. "Wage-Based Indexes of Urban Quality of Life," in P. Mieszkowski and M. Straszheim (eds.), *Current Issues in Urban Economics*. Baltimore: Johns Hopkins Press, 1979.
[11] Solow, Robert M. "On Equilibrium Models of Urban Location," in M. Parkin and A. R. Nobay (eds.), *Essays in Modern Economics*. London: Longman, 1973.
[12] Tobin, James and William Nordhaus. *Economic Growth, N.B.E.R. Fiftieth Anniversary Colloquium*, Vol. V. New York: Columbia University Press, 1970.
[13] U.S. Bureau of Labor Statistics. *Selected Earnings and Demographic Characteristics of Union Members, 1970*, Report 417, Table 11. Washington, D.C.: U.S. Government Printing Office, 1972.
[14] ———. *Three Standards of Living for an Urban Family of Four Persons, 1969–70*, Supplement to Bulletin no. 1570-5, Table B-1. Washington, D.C.: U.S. Government Printing Office, 1972.
[15] U.S. Bureau of the Census. *Census of Agriculture, 1969*, Vol. I, Highlights of the State's Agriculture. Washington, D.C.: U.S. Government Printing Office, 1972.
[16] ———. *Census of Mineral Industries, 1967*, Area Statistics, Table I. Washington, D.C.: U.S. Government Printing Office, 1971.
[17] ———. *Census of Population, 1970*, Vol. I, Part 1, Table 35; Parts 2–51, Tables 174–176. Washington, D.C.: U.S. Government Printing Office, 1972.
[18] ———. *Census of Transportation, 1972*, Commodity Transportation Survey, Summary of Shipments: 1967 and 1972. Washington, D.C.: U.S. Government Printing Office, 1976.
[19] ———. *County and City Data Book, 1972*, Table 3, Item 6; Table 6, Items 489, 494. Washington, D.C.: U.S. Government Printing Office, 1973.
[20] ———. *Current Housing Reports*, Series H-150-76, General Housing Characteristics for the United States and Regions: 1976, Table A-2. Washington, D.C.: U.S. Government Printing Office, 1978.
[21] ———. *Statistical Abstract, 1970*. Washington, D.C.: U.S. Government Printing Office, 1971.
[22] U.S. Department of Health, Education and Welfare. *Decennial Census Data for Selected Health Occupations, United States, 1970*. Washington, D.C.: U.S. Government Printing Office, 1975.
[23] U.S. Federal Bureau of Investigation. *Uniform Crime Reports, 1970*, Table 5. Washington, D.C.: U.S. Government Printing Office, 1971.

APPENDIX A

The purpose of this appendix is to derive counterparts of (10) and (12) when individuals work in different occupations and tastes may differ among occupational groups. We assume that members of each occupation are identical and solve the utility maximization problem given by (2) and (3). The indirect utility function for members of group j is

$$V_{ij}(k) = C_j w_{ij} r_i(k)^{-\beta_j} p_{1i}^{-\alpha_{1j}} p_{2i}^{-\alpha_{2j}} N_i^{\gamma_j} A_i^{\eta_j+\delta_j} a(k)^{\delta_j} k^{-\xi_j} \tag{A.1}$$

where parameters are subscripted to allow for differences in tastes.

As above, the conventional wage-amenity equation may be derived from locational equilibrium conditions. In equilibrium all members of each occupation must enjoy the same utility regardless of where they live. Thus V_{ij} must be equal to V_j^* for all i and k. (If each city is small and open, then V_j^* can be considered exogenous to the city.) Solving the locational equilibrium condition for w_{ij} and setting $a(k) = k = 1$, yields Equation (12′) in the text.

Deriving the labor supply function is more complicated. By solving the equilibrium condition $V_{ij} = V_j^*$ for $r_{ij}(k)$, one obtains group j's maximum willingness to pay for land at each location. Since in equilibrium land is sold to the highest bidder, members of group j will reside at those k where

(A.2)
$$r_{ij}(k) = \max_{j} r_{ij}(k)$$

Summing the number of persons in ring k, $n(k)$, across all k at which group j resides (K_{ij}) yields group j's supply function of labor,

(A.3)
$$N_{ij} = M_j w_{ij}^{(1-\beta_j)/\beta_j} p_{1i}^{-\alpha_{1j}/\beta_j} p_{2i}^{-\alpha_{2j}/\beta_j} N_i^{\gamma_j/\beta_j} A_i^{(\eta_j+\delta_j)/\beta_j} \int_{k \in K_{ij}} k^{1-(\xi_j/\beta_j)} a(k)^{\delta_j/\beta_j} dj$$

Unfortunately, this cannot readily be solved for the acceptance wage since the limits of integration in (A.3) depend on the w_{ij}'s. If, however, neighborhoods are not in long-run equilibrium, neighborhood boundaries will depend on past rather than on current wages. In this case the limits of integration in (A.3) are exogenous and the last term will be positively correlated with city area. The labor supply function can therefore be written

(A.4)
$$\ln(w_{ij}/P_{ij}) = c_j + \frac{\beta_j - \gamma_j}{1 - \beta_j} \ln N_i - \frac{\eta_j + \delta_j}{1 - \beta_j} \ln A_i - \ln f_j(\bar{k}_i)$$

where N_{ij} has been replaced by N_i due to the high correlation between employment and population.

APPENDIX B

SMSA's in Sample

1. Buffalo
2. New York
3. Philadelphia
4. Pittsburgh
5. Chicago
6. Cincinnati
7. Cleveland
8. Dayton
9. Detroit
10. Indianapolis
11. Kansas City
12. Milwaukee
13. Minneapolis-St. Paul
14. St. Louis
15. Wichita
16. Atlanta
17. Austin
18. Baltimore
19. Baton Rouge
20. Dallas
21. Houston
22. Nashville
23. Washington, D.C.
24. Denver
25. Los Angeles
26. San Diego
27. San Francisco
28. Seattle