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The Effect of Ocean and Lake Coast Amenities on Cities[1]

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This article uses census tract data to examine the importance of the role played by coastlines offering city residents recreational enjoyment. A model of an amenity coast city is developed which motivates a restructuring of the negative exponential population density function. The econometric results suggest that the standard urban model of estimating population density is inappropriate for some coastal cities. Instead, distance from census tract to the coast is necessary to attain unbiased population density gradients. © 1993 Academic Press, Inc.

INTRODUCTION

This paper focuses on an often neglected topographical feature of urban areas—ocean and lake coast lines. Most urban models are set on a flat featureless plain. The existence of a major water body with a shore line is assumed to be nothing more than a minor nuisance in analyzing the spatial structure of the city. However, a coast line has utility-bearing characteristics for residents residing near it. The natural beauty of many water bodies and their coast lines provides an aesthetically pleasing view to city dwellers. Due to the existence of sea and lake breezes, the water body often ameliorates uncomfortable variations in temperature. "In cities such as Boston, Chicago, and others, people often refer to the sea breeze bringing welcome relief from excessive heat as 'nature's air conditioner.'" (Neuberger and Cahir [12, p. 68].) Likewise, sunlight penetrates deeply into water, causing the sun's energy to be widely distributed and water

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surface temperature changes to be slow. (Landsberg [10] presents an advanced treatment of the climate of cities.) More comfortable temperatures provide residents dwelling along the coast with greater utility than those residing inland, ceteris paribus.

There are a number of notable studies on the economic value of water amenities. Interestingly, many of the empirical studies have used the city of Chicago as the focus of investigation. Pollard [14] studied the aesthetic properties of water-body amenities and their influence on the heights of buildings in Chicago. Pollard concluded that residents of a lakefront apartment were paying 26% of their housing expenditure for consumption of amenities. Diamond [4] found that living within 5 miles of Lake Michigan increased the value of a house in Chicago by $2219 (1970 dollars). Grimes [6] indicates that land price per square foot falls by an average of about 0.14% for every 1% rise in distance inland from the Lake Michigan shoreline and that the lake-distance variable alone explained 19% of the variation in land price for the sample as a whole.

Brown and Pollakowski [1] note that "economists have not yet turned their attention to the economic significance of the existence and width of the undeveloped apron offering public use and access to bodies of water in urban areas." They go on to test the significance of the width of the "setback" from the water on property values in the Seattle area. They present strong evidence that property values are positively and significantly affected by widening the setback and its attendant increase in the number of recreational visits and the number of recreational activities associated with the coast. The model in this paper assumes the width of the setback is negligible relative to city size.

There is ample evidence that coastal cities recognize the advantages of having coastal land preserved for public use. Since 1981, the city of Milwaukee has added more than 25 acres of park land at the lakeshore, increased public access to the coast, and improved the Summerfest grounds. The city of Erie has acquired Erie Sand and Gravel and the Grain Dock for waterfront development and has embarked on an aggressive marina development program. The city of Chicago has 26 miles of lakefront with 2500 acres devoted to parkland. Along its "greenbelt" are located eight recreational harbors and 21 public beaches with seven major museums.

Over the past 20 years states, too, have shown an increased interest in the preservation of their coast lines for their natural beauty and recreation. Several states have passed laws restricting industrial and commercial development of the shoreline (Hyde [8]), e.g., New Jersey's Coastal Area Facility Review Act and Delawares's Coastal Zone Act. (For a review of the literature on the recreational demand for water resources see Young and Haveman [18].)

THE MODEL

Each of the above factors—temperature, aesthetics, and recreation—influences residential location and rent. However, assume that

(1) the aesthetic and temperature effects of the water body are negligible so that the only way to consume the amenity is by traveling (incurring transport costs) to it;

(2) the income-compensated demand curve for the coastal amenity is perfectly inelastic so that no matter where the resident locates in the city, he will always consume the same number of trips to the coast.

With these assumptions, total commuting cost is equal to $tu + sy$. The variable u is radial distance to the CBD and y is the linear distance to a straight-line coast. Also, t is the cost (money and time) per unit distance to the CBD and s is the analogous cost to the coast.[2] Total commuting cost can be written as tx, where

$$x = u + (s/t)y. \tag{1}$$

Equation (1) represents a "generalized accessibility measure." The standard urban model predicts that the price of housing services, p, land rent per acre, R, and population density, D, decrease with distance to the CBD,

$$\partial p/\partial x < 0, \qquad \partial R/\partial x < 0, \quad \text{and} \quad \partial D/\partial x < 0. \tag{2}$$

Since these results apply to the more general measure of accessibility, they can be used to ascertain the impact of changes in u and y on p, R, and D. For example,

$$\partial D/\partial u = (\partial D/\partial x)(\partial x/\partial u) = (\partial D/\partial x)(1) < 0, \tag{3}$$

$$\partial D/\partial y = (\partial D/\partial x)(\partial x/\partial y) = (\partial D/\partial x)(s/t) < 0. \tag{4}$$

Likewise, similar results apply to variables p and R.

As would be expected, the shape of the city will not be semi-circular under these assumptions. The edge of the city is determined by the equation $R(\bar{x}) = R_A$, where R_A is the agricultural rent. The boundary of the city can be calculated by $x = \bar{x}$, or $\bar{x} = u + (s/t)y$. However, u can be

[2] Technically, city residents are unlikely to make the same number of trips to the amenity as the CBD and, therefore, s must reflect this.

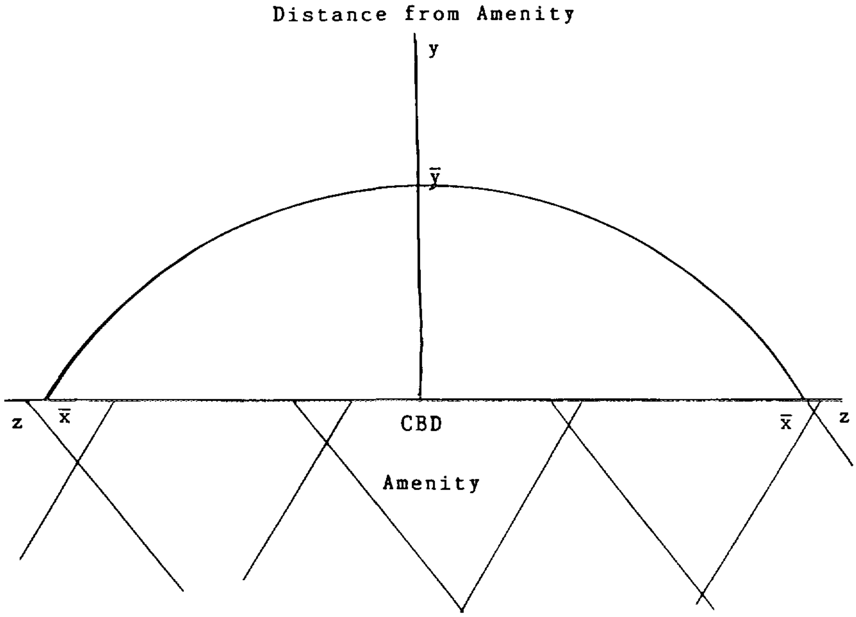

FIGURE 1

rewritten as $\sqrt{(y^2 + z^2)}$, where z is the distance along the linear coast. The equation defining the boundary of the city in z–y space is thus

$$\bar{x} = \sqrt{(y^2 + z^2)} + (s/t)y.$$

The shape of the city is represented in Fig. 1.

While restrictions (1) and (2) produce clear contours for the amenity-coast city, it should be stressed that the reality of coastal cities may be very different. First, because the visual and temperature effects of the lake or ocean diminish with distance from the water body, it is natural to suppose that the intrinsic value of the amenity diminishes with distance. Rent and population density at the coast should be stronger than is indicated by the assumptions.

Second, unlike the number of trips to work (CBD), commuting to the recreational amenity is not institutionally determined. The number of recreational visits will depend on the price of a commute (including money and time costs). If n is the number of trips to the coast, it will depend on the coastal distance, y, $n'(y) < 0$. The rent and population-density contours will still be falling away from the x axis ($du/dy < 0$) but more quickly than when city residents are not permitted to adjust the number of recreational visits based on geographic location (cost). Polinsky and Shavell [13] consider this type of case.

Third, travel to the coast—like travel to the CBD—in a straight line is not always possible nor desirable. For example, useable beaches may not be located uniformly along the coast line. For the data used below, it was always assumed that city residents traveling to the coast commuted perpendicularly thereto.

EMPIRICAL EVIDENCE

The negative exponential density function is usually used with x measuring CBD distance alone, but all the underlying theory applies to the generalized accessibility measure. The density function can be written as

$$D = b_0^* \exp(b_1 u + b_2 y). \tag{5}$$

The estimating form of (5) is found by taking the natural log of both sides,

$$D^* = b_0 + b_1 u + b_2 y + e, \tag{6}$$

where e is random disturbance with mean zero and finite variance.

All the regressions in this paper assume the negative exponential population density function. Brueckner [2] has shown that a sufficient condition for this functional specification to be valid is that the income-compensated price elasticity of demand for housing services be unitary. Citing Mayo's 1981 survey [11], Brueckner suggests that on average the income-compensated price elasticity is in the neighborhood of -0.58. He states that the "magnitude of this number suggests that any negative exponential density regression will involve specification error." Kau and Lee [9] suggest the use of the Box–Cox transformation to test the appropriateness of the negative exponential form. One limitation of the regressions below is that the negative exponential form was assumed a priori.

Equation (6) says that for a city with an amenity coast line, the logarithm of population density should decline in y and u. The usual approach in estimating population density is to estimate the equation

$$D^* = b_0' + b_1' u + e^*. \tag{7}$$

This form follows from the standard urban model in which the only relevant travel is radially from residence to CBD. The bias in the estimate of the u coefficient from (7) is given by

$$\text{bias} = b_2 \operatorname{cov}(u, y)/\operatorname{var}(u). \tag{8}$$

To remove this form of bias, the regressions below estimate Eq. (6) instead.

Data for census tracts were collected from 14 ocean and lake coast cities to test the effect of straight-line coastal distance on population density. The 1980 Census provides information on population in tracts. The Census does not estimate the geographic area of tracts and these must be estimated using a polar planimeter or obtained from city planning authorities. Straight-line distances to the CBD and the coast were ascertained using a ruler.

Since census tracts are not of equal size, estimation bias can arise. Robinson [15] suggested weighting census data by the area of the units to which they refer. Robinson *et al.* [16] called for transforming census tracts of unequal size into hexagonal districts of equal size. Frankena [5] suggested weighting census tracts in proportion to their area. The Frankena method was employed for the data in this study.

Since the data here represent virtual 100% sampling of studied cities, the possibility of spatial autocorrelation discussed by Cliff and Ord [3] was a concern. The disturbance term of a given tract may be autocorrelated with the disturbances of tracts contiguous to it; i.e., OLS yields inefficient estimates. In all cities studied, the Cliff–Ord test rejected the presence of autocorrelation.[3]

Tables 1 and 2 contain estimates of population density gradients for work and play for ocean and lake cities. In all cases, the standard urban model containing only the radial distance term, u, was run first (model a in the tables). Model b includes both CBD distance and amenity or coastal distance.

For coastal cities, 13/14 of the estimated coefficients of the amenity distance term, y, in the model were negative and statistically significant at at least the 10% level. In 64% of the cases for the coastal cities, the absolute value of the density gradient for y exceeded that of the traditional density gradient, i.e., the coefficient of u. This suggests that the draw or impact of the coast is considerable for many coastal cities.

As would be expected when an additional variable is introduced explaining the decay of population away from the CBD, the density gradient for u is smaller in absolute value for all cities except Milwaukee after y is

[3]For a more complete treatment of the econometric issues encountered in this study, see Smith [17].

TABLE 1
Regression Results for Ocean Cities

City	Model	n	Constant	Rad. Dist. (u)	Coast (y)	R^2
Los Angeles	a	1286	3.28*	−0.01		0.87
			(14.32)	(1.49)		
	b	1286	5.42	−0.05	−0.15	0.96
			(8.79)	(−2.68)	(−7.95)	
San Diego	a	363	2.87	−0.08		0.91
			(15.71)	(−11.87)		
	b	363	3.74	−0.04	−0.13	0.97
			(24.24)	(−6.24)	(−15.10)	
Portland, ME	a	53	0.41	−0.13		0.84
			(1.60)	(−5.20)		
	b	53	0.60	−0.10	−0.09	0.91
			(2.37)	(−4.20)	(−2.64)	
Boston	a	387	2.79	−0.17		0.90
			(3.58)	(−4.67)		
	b	387	3.39	−0.15	−0.11	0.98
			(4.21)	(−2.74)	(−3.56)	
Bridgeport, CT	a	105	2.04	−0.21		0.92
			(9.65)	(−7.78)		
	b	105	1.89	−0.06	−0.16	0.99
			(9.73)	(−1.42)	(−4.79)	
Corpus Christi	a	59	−1.86	−0.07		0.89
			(−3.47)	(−2.68)		
	b	59	−1.97	−0.009	−0.09	0.98
			(−3.37)	(−0.20)	(−1.96)	
Ft. Lauderdale	a	157	9.20	−0.19		0.93
			(56.97)	(−13.19)		
	b	157	9.10	−0.08	−0.12	0.99
			(62.95)	(−3.70)	(−6.41)	
Miami	a	212	8.77	−0.14		0.91
			(29.79)	(−7.25)		
	b	212	9.92	−0.09	−0.23	0.97
			(41.51)	(−5.71)	(−12.76)	

Note. n refers to sample size—number of census tracts.
*Numbers in parentheses are t statistics.

TABLE 2
Regression Results for Lake Cities

City	Model	n	Constant	Rad. Dist. (u)	Coast (y)	R^2
Chicago	a	1192	9.79*	−0.11		0.91
			(119)	(−25.5)		
	b	1192	9.77	−0.06	−0.08	0.99
			(123)	(−7.8)	(−9.2)	
Cleveland	a	373	3.16	−0.20		0.93
			(21.67)	(−15.7)		
	b	373	3.08	−0.12	−0.11	0.99
			(22.32)	(−6.92)	(−6.97)	
Duluth	a	52	−0.20	−0.18		0.86
			(−0.67)	(−9.66)		
	b	52	−0.004	−0.16	−0.05	0.93
			(−0.01)	(−8.46)	(−2.27)	
Erie, PA	a	58	0.27	−0.13		0.92
			(0.91)	(−6.9)		
	b	58	0.32	−0.10	−0.05	0.97
			(1.1)	(−4.7)	(−2.7)	
Gary, IN	a	101	2.38	−0.19		0.88
			(3.67)	(−4.56)		
	b	101	3.10	−0.13	−0.10	0.95
			(3.98)	(−3.20)	(−2.39)	
Milwaukee	a	354	10.17	−0.12		0.95
			(98.36)	(−26.22)		
	b	354	10.16	−0.12	0.01	0.96
			(98.26)	(−21.60)	(1.28)	

Note. n refers to sample size—number of census tracts.
*Numbers in parentheses are t statistics.

introduced into the model. In Cleveland, the density gradient for u falls from 0.20 to 0.12 or by 0.08. For Bridgeport the coefficient falls by 0.15 and for Ft. Lauderdale by 0.11. This suggests that without the inclusion of the y variable, population density gradients for u are biased upward.

CONCLUSION

The model and evidence presented in this article represent another contribution to the development of a more realistic urban model. For coastal cities which, based on the natural attraction of the coast, possess significant amenities, the standard urban model is inappropriate for econometric estimation. Instead, inclusion of distance from census tract to the coast in the case of population density gradients is necessary for attaining unbiased gradient estimates.

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