NEW ESTIMATES OF THE DEMAND FOR URBAN GREEN SPACE: IMPLICATIONS FOR VALUING THE ENVIRONMENTAL BENEFITS OF BOSTON'S BIG DIG PROJECT

KAYO TAJIMA
Tufts University

ABSTRACT: *Parks and open spaces enhance the quality of life in urban areas. Over the last 15 years, the city of Boston has sponsored the most expensive urban infrastructure project in history. This project relocates an elevated highway underground and creates urban parks, increasing the city's green space. The study estimates the economic benefits of proximity to parks in Boston, Massachusetts, based on hedonic pricing methods. Using Boston's land use and assessed property price data, it is determined that proximity to urban open space has positive impacts on property values, while proximity to highways has negative impacts on property prices. Based on this observation, it is expected that the spatial alteration will cause a significant increase in nearby property prices.*

Urban planners and urban park advocates have long debated the importance and value of city parks (Jacobs, 1961; Trust for Public Land, 1999). Although many agree that open urban spaces are important, the degree of importance is difficult to determine. Especially in city centers where demand for land is high, open spaces are often subject to development pressures. Green spaces in city centers can also characterize and enhance the image of the cities: Central Park in New York, Royal Parks in London, and Red Square in Moscow. Boston, the focus of this study, has a reputation for its historic parks and open spaces. In 1634, Boston built the first public park in America, the Boston Common. It was also in Boston that Frederick Law Olmsted designed the park and drainage masterpiece known as the Emerald Necklace in the late nineteenth century.

Such urban amenities as open space matter now more than ever as major cities compete for skilled workers. Glaeser, Kolko, and Saiz (2001) reported that more cities recognize the strategic advantage in providing urban amenities to attract skilled workers and firms. In the decades of suburbanization, rich and well-educated people fled to the urban periphery seeking open space and better public schools while the poor were left in inner

Direct correspondence to: Kayo Tajima, Graduate School of Arts and Sciences, Tufts University, 97 Talbot Ave., Medford, MA 02155. E-mail: kayo.tajima@tufts.edu

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cities (Glaeser, Kahn, & Rappaport, 2000; Kahn, 2000; Margulis, 2002). Consequently, urban politicians face the challenge of bringing middle and upper class residents back to the city through various public projects including affordable housing (Steinacker, 2003). While they recognize that reducing crime and improving public schools make cities more livable, another policy lever they control is the improvement of urban environmental amenities through provision of public goods such as urban green spaces (Warner & Hefetz, 2002).

This study focuses on the benefits of parks in urban centers. City centers rarely have the green space of suburban areas; therefore, additional parks are important assets. Also, because the city centers draw more people, parks in such areas benefit more people—residents, commuters, weekend visitors, and tourists.

The mega-scale urban construction project popularly called "the Big Dig" is currently underway in Boston, bringing 30 acres of new open space in the very middle of the city. The project is unprecedented both in the amount of open space it will create in an existing urban center and its price. The highway project is spending a $14.6 billion in tax dollars. Because of its scale and impacts, the Big Dig has been a major issue in urban politics for more than two decades. Therefore, it is of particular interest to estimate the benefits of the new open spaces and examine the distribution of the benefits among urban stakeholders.

This article reports new empirical estimates of the value of open spaces in the city center of Boston, Massachusetts, building on previous real estate research and using a Geographic Information System dataset. The next section provides background on the Big Dig project and is followed by a qualitative assessment of the spatial alterations involved from highway to green spaces. Based on a brief review of literature measuring the benefits of urban green space, an empirical analysis based on a hedonic pricing model is presented. These models can help answer the question "If the typical downtown condo were 50% closer to green space, how much more expensive would its selling price be?" These predictions are used to estimate the potential aggregate benefit to Boston property owners from the new green space. The final section discusses policy implications.

THE BIG DIG IN BOSTON, MASSACHUSETTS

In Boston, Massachusetts, the Central Artery/Tunnel (CA/T) project, popularly called the Big Dig, is presently underway. At the center of Boston, an elevated highway, the Central Artery (Interstate 93 or I-93) will be moved underground. As a consequence, 40 acres of land will be created on the surface. The city of Boston, in collaboration with the community, decided in 1991 to preserve 75% of the parcel (30 acres) as open space (to be named the Rose Kennedy Greenway) and to allow 25% (10 acres) to be developed. The Greenway will lie in the center of downtown Boston, connecting North Station to South Station. It will bring an attractive new character to downtown Boston with scenic views and symbolic green space, as well as recreational opportunities and improved pedestrian access between east and west. After a yearlong process of public involvement, the CA/T project issued the Central Artery Corridor Master Plan in May 2001. Design specifics have yet to be determined.

Two somewhat similar examples can be seen in Seattle, Washington and San Francisco, California. When I-5 opened in 1965, it split downtown Seattle in half, separating the central business district from nearby commercial and institutional activity. Public officials rejoined the areas by building a park on top by purchasing the air rights of the sunken highway (Garvin, 1997). In San Francisco, after the 1989 Loma Prieta earthquake destroyed the elevated Embarcadero Freeway, the city decided not to rebuild it and instead created an at-grade boulevard that includes a palm-lined tramway and a 25-foot-wide pedestrian promenade (Fader, 1997).

The CA/T project is funded as a highway project with the primary purpose being to improve Boston traffic conditions. The construction started in 1991 after an extensive environmental impact review process at both the federal and state levels. A new airport tunnel opened for public use in 1998 and a new I-93 highway that crossed the Charles River was completed in 2001. Eight to 10 lanes of underground expressway will replace the present elevated Central Artery (I-93), leaving 40 acres of newly created parcels on the surface. The whole project is scheduled for completion in May 2005 at a total estimated cost of 14.6 billion dollars (Massachusetts Turnpike Authority, 2003).

QUALITATIVE ASSESSMENT OF THE BENEFITS CREATED BY THE SPATIAL ALTERATION

While the CA/T project is a combination of transportation and urban projects, this article focuses solely on the end result. When the construction is complete a rusting highway that has long blighted the landscape will have been razed and new parks connecting the city with the Boston Harbor will be open. The most outstanding characteristics of this project are: 1) the demolition of the existing elevated highway, and 2) the creation of new green space in the center of a densely populated historic city. This section offers a qualitative assessment of the benefits created by this spatial alteration on the Central Artery Corridor.

The demolition of the existing Central Artery will remove two prodigious effects on the city's appearance: 1) a source of noise, air pollution, and an eyesore; and 2) a physical and symbolic barrier that has separated harbor-front parcels from the rest of the city.

The Central Artery was built in the late 1950s, the period characterized by the urban redevelopment movement (Krieger, 1999) and the Great Mega-Project era supported by federal financing (Altshuler & Luberoff, 2003). The Central Artery has cut through old neighborhoods, mostly occupied by Italian and Asian immigrants. A large number of residents, as well as shops and businesses for the communities, were displaced through eminent domain. The idea of "slum clearance" was the basis of such decision, and the most common victims of mega-projects from this period were the low-income and minority residents of older neighborhoods (Altshuler & Luberoff, 2003). After the Central Artery was built, the city developed within the constraints that the neighborhoods had been separated by the existence of the elevated freeway (Lynch, 1960).

In the current context, urban planners who were working on the Central Artery Corridor Master Plan found the impact of the demolition unprecedented. In an informal conversation after a public meeting, a planner described the impact of his work: "It will change everything—at the same time . . . People had a sense that the waterfront is separated from the rest of the city. No one can easily imagine what's going to happen when the Artery is gone" (E. S. Rose, personal communication, April 3, 2001).

The creation of new urban open spaces will not only knit together the urban fabric that was torn apart by the construction of the Central Artery in the 1950s, but also add a new character to central Boston. The importance of the new urban open space is evident in the stories told by the media. Most newspaper articles address the prime real estate, the number of people working there, how many tourists would respond to the change, and so on. As explained by one reporter, "but only lately has the extraordinary prospect that this old, dense city will suddenly gain a 30-acre swath of green land smack in its center begun to seem dauntingly, thrillingly real" (Goldberg, 2000, p. A22). Another local observer commented, "No other city has a facility like that right smack in the middle of its urban center, said society president John Peterson, calling it a new crown jewel for a city already renowned for its history" ("At the Statehouse," 2000, p. 5C). As the project approaches completion, the future open spaces are becoming a reality to people in the city.

ESTIMATION OF THE ENVIRONMENTAL BENEFITS OF GREEN SPACE

Quantifying the economic value of an urban park is not an easy task, and has a history as long as urban planning itself. Leinberger and Berens (1997) cite a nineteenth century study by landscape architect Frederic Law Olmsted, planner of Central Park in New York City and the Emerald Necklace in Boston. While planning and constructing Central Park in New York City, Olmsted tracked the value of the surrounding real estate.

> He found that by 1864, when the park was only half-finished, it had begun generating net revenue of $55,880. He also charted the average increase in property value in the three wards surrounding the park and in the city's other wards. If the three wards around the park had increased in value 100 percent between 1856 and 1873, as did other wards throughout the city, in 1873 their appraised value would have been $53 million; instead, it was $236 million. Although Olmsted's analysis was simple, the difference was striking (Leinberger & Berens, 1997, pp. 27–28).

Whether he knew it or not, Olmsted conducted a hedonic real estate exercise in calculating a local project's impact on nearby real estate prices. Today, these hedonic techniques are widely used in urban and environmental economics to measure the price difference of homes located in nicer, safer, cleaner communities relative to similar homes located in less desirable communities. These price differentials provide an estimate of the value placed on local amenities. While the hedonic approach requires several assumptions and has weaknesses, it offers the best opportunity to measure the benefits of open space improvements relative to alternative valuation methods. This method measures the value of a non-market good by utilizing the value of a market good. Many studies have used property prices of single-family housing close to a park to value local amenities (Geoghegan, 2002; Hammer, Coughlin, & Horn, 1974; More, Stevens, & Allen, 1988; Tyrvainen, 1997, 2000). The willingness to pay for a park is expressed in terms of how much property owners would pay for a view of or access to the park. Although this method is superior in the sense it is based on observed economic choices, shortcomings include: 1) the requirement of an observed economic behavior means that the hedonic pricing method cannot be directly applied to evaluate hypothetical projects, and 2) the compensation differentials observed in nearby property prices only capture the value of a green space for residents who live close, but do not reveal its value for people who may or may not visit the park from other areas.

Two possible alternatives to the hedonic pricing method are the travel cost method and the contingent valuation method. Travel cost methods are used to determine the economic value of recreation resources. The costs of consuming the services of the environmental asset are used as a proxy for price. These consumption costs will include travel costs, entry fees, on-site expenditures, and outlay on capital equipment necessary for consumption (Hanley & Spash, 1993). This method has been widely used to evaluate national parks and other large recreational facilities (Dwyer, Peterson, & Darragh, 1983). At least two issues arise when we apply this method to valuing the Rose Kennedy Greenway. First, there is too little price variation in travel cost to trace a representative demand curve. When there is little variation in travel costs (as would be the case for a neighborhood park), the model may be unsuitable (More, et al., 1988). Another limitation of this model is that most visitors have several reasons for coming to the city, not just to visit the park. In such cases it is extremely difficult to isolate the costs of a park visit (Hanley & Spash, 1993)

Contingent valuation is a method for evaluating a public good by asking people directly how much they are willing to pay for the good. This is useful when we want to estimate values associated with hypothetical scenarios. Because there are no observed economic activities for imaginary scenarios, an evaluation has to be based on a survey (Fuguitt & Wilcox, 1999). The strength of contingent valuation is that it can evaluate any goods or functions by informing people about the goods through the survey. The weaknesses are associated with people's inability to express an exact value. Also, when survey respondents know that they are not actually required to pay, their answers may be based upon inflated valuations.

DATA

Hedonic pricing requires actual property data. The city of Boston's assessing department began publishing property parcel data with housing attribute information in 2000. These data are updated annually each February and are based on the recent resale prices in nearby areas. These data can be located on digitized maps using GIS software. With GIS information about open spaces and other urban facilities, it is possible to attach location (distance) variables to the property database and determine the impact of location attributes of housing units on their property values.

A small percentage (approximately 300 observations out of 16,000) of property data were dropped from the sample because they were not linked to the GIS database, thus missing location variables. It should be noted that the assessed price is a proxy indicator of sales value of real estate with possible measurement errors. In this study the assessed value was used as a dependent variable. Therefore, the possible measurement error should be minimal as long as a consistent assessment method is used for the entire sample.

To evaluate the economic effects of Rose Kennedy Greenway, we need comparable samples that vary in their proximity to parks. Because the spatial change consists both of the demolition of the elevated Central Artery and the creation of green spaces, distances both to parks and highways should be primary variables in the hedonic model to estimate marginal willingness-to-pay for proximity to these facilities. One hypothesis is that the farther from a highway, the higher the housing price, and the farther from a park, the lower the cost of housing. If the price differentials on these location values are significant, they imply that a highway is an undesirable environmental public good, while a park is a desirable good. While in suburban residential areas (where automobile transportation is necessary and the cost of parking is low) the proximity to a highway is often desired, the visibility and audibility of the highway may appear as an undesired factor in the city center where access to a highway is not a problem.

In order to estimate the appropriate willingness-to-pay for the Central Artery case under existence of market segmentation (Michaels & Smith, 1990), sub-market and data samples should represent the characteristics of Boston's downtown area. To focus on the housing market in Boston's city center, I used property data of all condominium units in nine zip codes in Boston: 01208, 02109, 02110, 02111, 02113, 02114, 02115, 02116, and 02118. For the property prices and other housing attributes, I used property parcel data obtained from the city of Boston Assessing Department (2000).

Condominium units are used as a sample of residential properties because they dominate the housing stock in downtown Boston and have the most uniform variables among the different property types. Based on the discussion about market segmentation, I use only condominium units in downtown Boston (defined as nine zip codes) as the sample for the hedonic regression. Descriptions of variables used are shown in Table 1, and the descriptive statistics are shown in Table 2. Location of each property is also available from the assessing department as a digitized map. Using GIS software, variables indexing location attributes of properties such as the distances to major urban facilities and respective zip code were added to the database.

Compared to hedonic studies on hazardous waste sites or incinerators (Kiel & McClain, 1995; Kohlhase, 1991), the impact of proximity to parks on property prices is expected to appear at shorter distances (Hendon, 1973). A challenge is that the facilities of interest—parks and opens space—are not defined as points in geographical space. There a number of parks in the sample area in the form of any shapes. Therefore, the "distance from a park" needs to be defined in a reasonable way. I define the distance from park as the distance from an edge of the closest park. By using this method, I use GIS software to yield the distance for a larger number of property units and parks.

The Open Space Geographic Information System 2000, compiled by the Policy and Resource Development Unit of Parks and Recreation Department, contains geographic coverage, site name, acreage, type, ownership, and facility codes of all open spaces in the city. The coverage includes privately owned urban wilds, athletic fields, and other open spaces as well as open spaces owned and managed by the city, state agencies, and the

Table 1

Variable Descriptions

Variables	Description (unit)
Dependent Variable:	
Price	Assessed value of condominium unit (dollar)
Explanatory Variables:	
Area	Total finished living area (square foot)
Rooms	Total number of rooms in condo unit
Bathrooms	Total number of full bathrooms in condo unit
Dummy Variables for Housing Attributes:	
owner-occupied	1 if occupied by owner, 0 if not
parking	1 if off-street parking is included, 0 if not
fireplace	1 if equipped with a fireplace, 0 if not
Building Age	Years since the condominium building was constructed
Residential Units	Total number of residential units in condo building
Distance from*:	
large park	The closest open space larger than or equal to one acre
small park	The closest open space smaller than one acre
Charles River	The Charles River (the Espalanade and the Storrow Drive)
harbor	Surrounding water except the Charles River
highway	The closest highway except the Storrow Drive
subway	The closest subway station
Dummy Variables for Each Zipcode:	
02108, 02109, 02110, 02111, 02113, 02114, 02115, 02116, 02118	1 if the zipcode corresponds to each of them, 0 if not

*All distance variables measured in meters.

Table 2

Descriptive Statistics

Variable	Mean	Standard Deviation	Min	Max
Price	255,248.70	233,786.90	8,800	4,625,500
Area	941.12	519.12	154	7,554
Rooms	3.72	1.40	1	22
Bathrooms	1.24	0.48	1	5
Dummy Variables				
Owner-occupancy	0.51	0.50	0	1
Parking	0.19	0.39	0	1
Fireplace	0.27	0.44	0	1
Building age	90.35	37.79	3	209
Residential Units	52.57	90.60	1	373
Distance from:				
Large park	257.07	188.72	60	900
Small park	248.46	170.29	60	700
Charles River	837.96	576.08	100	2,500
Harbor	1,430.23	770.47	60	3,000
Highway	601.48	275.67	60	1,300
Subway	449.06	183.99	100	1,500
Dummy = 1 if zip code is				
02108	0.0541	0.2262	0	1
02109	0.0696	0.2545	0	1
02110	0.0510	0.2201	0	1
02111	0.0390	0.1935	0	1
02113	0.0449	0.2072	0	1
02114	0.1521	0.3591	0	1
02115	0.1404	0.3474	0	1
02116	0.3175	0.4655	0	1
02118	0.1314	0.3378	0	2
$N = 16{,}044$				

National Park Service. There are almost 300 urban parks covered in the database. In this study, parks within one kilometer from the sample housing unit area are used to yield distance variables. Although there are many types of open space, few show significant differences in impacts on property prices in preliminary regressions. Therefore, open spaces are divided into two types: 1) large parks that have the area of more than or equal to one acre (4,047 m^2), and 2) small parks with smaller areas. We expect to find different levels of impact on property prices for large and small parks.

Proximity to water may also be an important factor of environmental value. The Charles River, Boston Harbor, and the Fort Point Channel all surround Boston's city center. A potential problem is the multi-collinearity among the open spaces, highway, and the water on the Charles River. The Charles River (water), the Esplanade (open space), and Storrow Drive (highway) run parallel to each other for more than two miles. Therefore, the property samples in this area have distances to these facilities strongly correlated to each other. To address this potential problem, we treat Storrow Drive, the Esplanade, and the Charles River as one combined feature—*Charles*. We then refer to the remainder of the water as *harbor*. The coefficient on the *Charles* variable should reflect the combined effects of proximity to the river and the green space (the Esplanade) across a busy highway.

Data for highway routes were obtained from the Boston Redevelopment Authority. In the sample area, there are three major highways: I-93 (The Central Artery), I-90, and Storrow Drive. Because Storrow Drive is parallel to the Charles River and is treated as a part of the variable Charles, the highway variable describes the distances from I-90 or I-93.

Locations of subway stations are available in the Boston Redevelopment Authority database. In this data, stations of MBTA subway lines are located as points. Distances from the points are used as the distance to subway station variable. While the variable *distances to work* (Central Business District) is potentially important, it is not controlled because all sample properties are either part of, or within a few miles to, the CBD. Therefore, we could only observe a small differential.

Community attributes such as local public school quality and crime rates influence the quality of life. Therefore, people pay more to locate in a better community (DiPasquale & Kahn, 1999). Because data on neighborhood attributes are not available, dummy variables for each zip code are used to control for general neighborhood desirability such as crime rate and the quality of public schools. Any premium for being located in a prestigious address, such as Beacon Hill or Back Bay, is captured by these dummy variables. Thus, desirable neighborhoods are expected to have larger (positive) coefficients, while less desired neighborhoods are expected to have smaller (negative) coefficients.

Hedonic empirical model

The following form of hedonic pricing equation is employed.

$$P_{ij} = e^{\alpha} X_{1i}^{\beta_1} X_{2j}^{\beta_2} X_{3j}^{\beta_3} e^{u_{ij}}$$

This equation can be transformed into a linear equation by taking the natural logs of both sides:

$$\ln P_{ij} = \alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2j} + \beta_3 \ln X_{3j} + u_{ij}$$

Where,
i - indexes the condominium unit
j - indexes the condominium building
P - represents the assessed value of each condominium unit
X_1 - a vector of physical characteristics of each condominium unit
X_2 - a vector of location attributes for condominium buildings including distances to parks, subway stops, and highways
X_3 - a vector of community attributes denoted by dummy variables for zip codes
β_i - a vector of price elasticity with respect to each estimator
u_{ij} - error term

For variables for which a larger value is desirable, such as square footage of living area, total number of bathrooms, and distance to highway, coefficients are expected to have positive values. Estimators for which a smaller value is desirable, such as age of buildings or distances to parks or subway stations, negative coefficients are expected (DiPasquale & Wheaton, 1996).

Whether property price changes when a plan to build a park is announced, or when the park is actually built is an empirical question (Kiel & McClain, 1995). Although construction is still underway and expected to be completed in 2004, it is possible that property prices in the abutting neighborhoods have already begun to adjust to planned future land use. The Big Dig had been under construction for more than 10 years and the land use plan was publicly available in 1991. Despite the financial crisis of the Big Dig, few people believed that the project would actually stop because it was near completion. The plan of open space, however, still had certain problems in 2000. Discussion of the Corridor Master Plan was just beginning. Business communities showed interest in developing the parcels. The development option was widely discussed on public media as a way to get additional revenue to pay for the project debt. Considering these facts, we suspect that property prices in 2000 had already adjusted to the highway demolition but not to the new open spaces.

RESULTS AND DISCUSSIONS

The key coefficients of the hedonic regression are those on the distances to parks and to highways. Table 3 shows the results of two separate regressions: Model I entails location variables with current land use (before the Big Dig); and Model II entails the highway variable that represents the distance from the highways left above ground after the Big Dig. As expected, it is shown that distances from both large and small parks have negative coefficients, and the distance from the highway has a positive coefficient on the property price of condominium units in both models. Therefore, it is desirable to be located close to a park, and it is not desirable to be located close to a highway. Distances to large parks, small parks, and subway stations are all statistically significant. This model assumes constant elasticity at every point. When distance to the nearest large park doubles, the coefficient of –.085 implies that property price is expected to decrease by 6%. ($2^{-.085} - 1 = -.057$). For the highway, the effect is in the opposite direction. When distance to the nearest highway doubles, the coefficient of .064 means that property price will increase by 5% ($2^{.064} - 1 = 0.045$). Estimated prices of condominium units at the mean in relation to the distances to parks and highway, holding all other location and property attributes constant at the sample means, are shown in Figures 1 and 2.

When the Big Dig is complete, the Central Artery will be relocated underground and several new parks will be created. As shown in the hedonic results in the previous section, a highway has a negative impact and open spaces have a positive impact on property prices. Therefore, the highway demolition and open space creation should create new economic values for the adjacent properties.

If we assume the same impact of proximity to parks for all types of properties, the demolition of the highway should result in \$732 million increase in property values, and the new parks should increase property values by at least \$252 million. The increase is heavily concentrated in the properties adjacent to the construction site. To estimate the value of the new open spaces created on the Central Artery Corridor, the hedonic estimation results were applied to calculate the total increase of the property values.

Drawing upon the property price adaptation argument, it is assumed that (1) the property price in the year 2000 already reflects the effect of highway demolition, but will reflect the effect of open space creation in future. Therefore the hedonic gradient from the Model II in Table 3 is applied to all types of properties. It is further assumed that: (2) the same elasticity coefficients estimated in Model II can be applied for all property types, and (3) these coefficients do not change radically before and after the Big Dig.

While these are all necessary assumptions to calculate the aggregated value change, it needs to be remembered that they are highly restrictive. Regarding the first point, there is

TABLE 3

Hedonic Regressions: Highway Variables Before and After the Big Dig

	Model I		Model II	
Variables	Coefficient	Standard Error	Coefficient	Standard Error
ln(area)	0.979	0.009*	0.973	0.009*
ln(rooms)	0.068	0.009*	0.073	0.009*
ln(bath rooms)	0.102	0.010*	0.104	0.010*
Dummy = 1 if:				
Owner-occupied	0.039	0.005*	0.039	0.005*
with parking	0.136	0.006*	0.136	0.006*
with a fire place	0.091	0.006*	0.091	0.006*
ln(building age)	−0.063	0.005*	−0.064	0.005*
ln(residential units)	−0.053	0.003*	−0.054	0.003*
ln (Distance) from:				
large park	−0.085	0.004*	−0.085	0.004*
small park	−0.046	0.005*	−0.043	0.005*
Charles River	−0.165	0.005*	−0.165	0.005*
harbor	−0.031	0.009*	−0.051	0.009*
highway (before the Big Dig)	0.064	0.006*		
highway (after the Big Dig)			0.080	0.007*
Subway	−0.103	0.008*	−0.098	0.008*
Dummy = 1 if zip code is:				
02108	0.228	0.014*	0.223	0.014*
02109	0.108	0.023*	0.027	0.024
02110	0.478	0.029*	0.314	0.031*
02111	0.082	0.018*	0.080	0.018*
02113	−0.136	0.021*	−0.186	0.020*
02114	−0.004	0.014	−0.008	0.014
02115	−0.035	0.013*	−0.014	0.014
02116	0.187	0.011*	0.201	0.012*
Constant	7.959	0.144*	7.987	0.142*
Adjusted R-squared	0.823		0.823	
Number of observations	16,044		16,044	

Note. Summary statistics of highway after the Big Dig: mean = 685.64, std. dev. = 290.57, min = 60, and max = 1300.
The dependent variable is natural log of the assessed value of condominium unit (in dollars).
The omitted zip code is “02118.”
*$p < .01$.
Source: City of Boston, Property Assessing Data, 2000.

little empirical evidence showing that the assessed price in 2000 was based upon changes that would presumably take place in the future. As for the second point, the appreciation for a park could be different depending on the use of the properties involved. Some commercial uses (e.g., hotels) may be willing to pay more for closer park proximity than residential properties. However, for uses such as manufacturing, close proximity to a park may not be particularly valuable. Regarding the third, Sieg, Smith, Banzhaf, and Walsh (2000) suggest that a major shock to a local housing market, such as the Clean Air Act drastically reducing smog in Los Angeles might make a significant change in the housing market. If this is the case, an assumption of fixed mean and differential in price may have led an overestimation of the change in housing values. Above all, it needs to be remembered that hedonic pricing does not account for the existing value of the local public goods for people who do not live nearby.

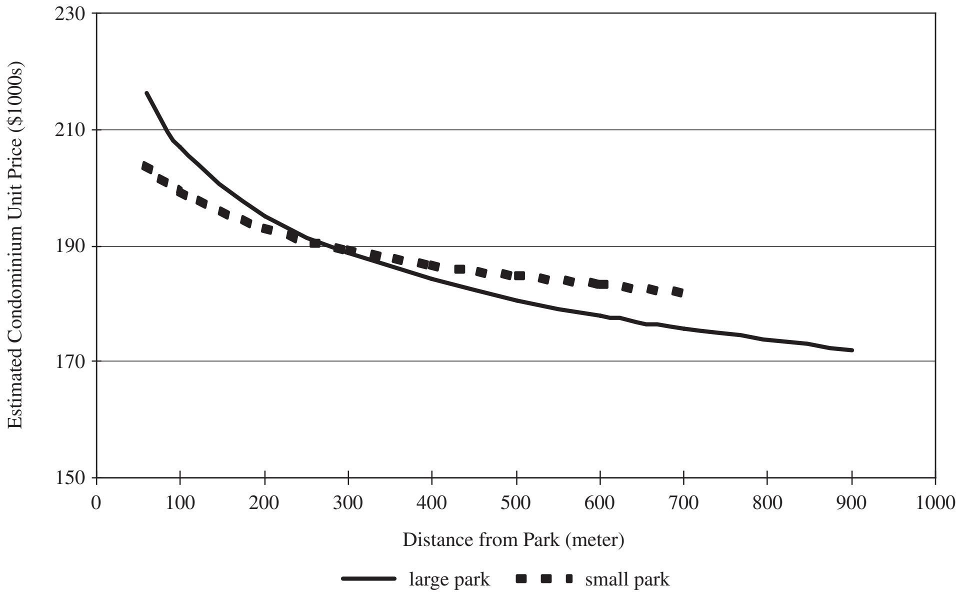

FIGURE 1

Estimated Condominium Unit Price and Distance from Urban Parks

POLICY IMPLICATIONS

Through the empirical analysis using the hedonic pricing method, we have seen that people are willing to pay higher prices to live near a park. Demand for a property apparently increases with the creation of a new park nearby. If this is the case, what are

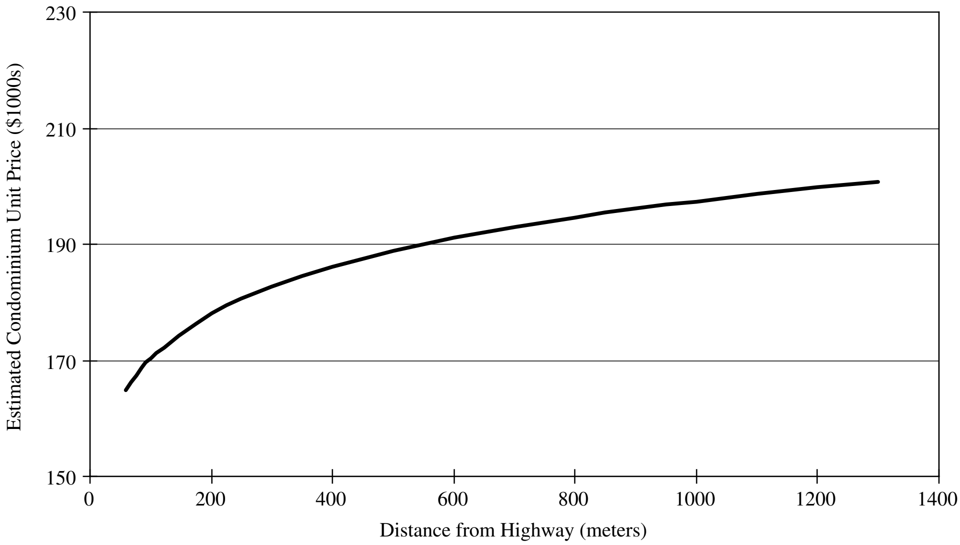

FIGURE 2

Estimated Condominium Unit Price and Distance from Highway

the impacts of the Big Dig (improvement of local environment by demolishing the highway and creating additional parks) on neighboring communities?

In the urban United States where ethnic segregation has always been prevalent, there will be winners and losers depending on which socio-economic groups benefit from the windfalls. In mega-projects in the 1950s and 1960s, the losers were poor urban minorities who lost their residences as a result of slum clearance (Altshuler & Luberoff, 2003; Tsipis, 2001). In new-era mega-projects such as the Big Dig, the picture can be far more complicated. When a property price increases as a result of environmental improvement, property owners enjoy the windfalls through the capitalization effects. On the other hand, tenants may be required to pay more rent to keep up with the housing market as urban amenities attract high-income population groups (Leichenko, Coulson, & Listoken, 2001). In that case, low-income minorities who rent apartments in the inner city could be worse off. As their rent rise, they may not be able to continue to live in their current residence.

Table 4 shows the housing units and population tabulated by race and housing tenure from the area used in the hedonic regressions based on 1990 decennial Census data. There were over 30 census tracts in the area used in the hedonic regression. The two columns on the left-hand side show the data from all census tracts. The right two columns show the same data from the nine census tracts directly adjacent to the Central Artery Corridor. In these adjacent tracts, the housing market will be more severely affected by the Big Dig than other tracts. Additionally, the percentages of white and Asian and Pacific Islanders population (77.5% and 18.5%, respectively) are substantially higher and the percentage of black is much lower than the whole sample area. The large Asian population is explained by the fact that the Central Artery cuts through Boston's Chinatown where large numbers of Asian immigrants live in a high density commercial and residential mix.

The percentages of renter-occupied units account for more than 78% of total occupied units in both samples, reflecting the fact that the area is in the central city. A tabulation of owner-occupied housing units by the race of the owners indicates that the percentage of whites among all owner-occupied housing units is higher than the percentage of white population, and the percentage of blacks and Asian and Pacific Islanders among all owner-occupied housing units is lower than the ratio of these ethnic groups in the population. These numbers suggest the fact that the home-ownership rate is higher in white population. Although there is a high percentage of Asian population in the tracts adjacent to the Central Corridor (18.5%), the percentage of Asian-owned housing units out of the total owner-occupied units is only 3.8% (100 home owners), reflecting disproportionately low home-ownership among Asian residents.

The data suggest that the increase in property price caused by the environmental quality improvement by the Big Dig may negatively impact low-income minority groups who live in rental housing units in the neighborhood. However, it may benefit the owners of the properties in the form of capital gains and by attracting a wealthier population. In order to make proper assessments of the impacts of the Big Dig on community demography, further investigation is needed.

CONCLUSION

Parks and open spaces in a central city have an important role in enhancing the local environment. They provide recreational opportunities and improve the natural environment, thereby raising the quality of urban life. In urban centers where the population is large and land scarce, open spaces are expected to play an even larger role. The Big Dig project in Boston, Massachusetts exemplifies the creation of new green spaces in central

TABLE 4

Tabulation of Housing Units and Population in Affected Neighborhoods

	31 Census Tracts in Central Boston		9 Census Tracts Adjacent to the Big Dig	
	Count	Percentage	Count	Percentage
Number of Persons:	95,335	100.0	22,075	100.0
White	65,636	68.8	17,109	77.5
Black	15,201	15.9	707	3.2
Asian and Pacific Islanders	10,392	10.9	4,076	18.5
Chinese	8,066	8.5	3,659	16.6
Housing Units:	51,027	100.0	13,585	100.0
Occupied	45,225	88.6	12,025	88.5
Owner occupied	9,735	19.1	2,614	19.2
Renter occupied	35,490	69.6	9,411	69.3
Vacant	5,802	11.4	1,560	11.5
Owner-Occupied Housing Units:	9,735	100.0	2,614	100.0
White owner	8,923	91.7	2,490	95.3
Black owner	365	3.7	18	0.7
Asian and Pacific Islander owner	400	4.1	100	3.8
Renter-Occupied Housing Units:	35,490	100.0	9,411	100.0
White renter	24,625	69.4	7,649	81.3
Black renter	6,163	17.4	219	2.3
Asian and Pacific Islander renter	3,395	9.6	1,488	15.8

Note. 31 Census tracts in the sample area includes the following tracts: 101.01, 103, 104.01, 104.02, 105, 106, 107, 108, 201, 203, 301, 302, 303, 304, 305, 305.99, 701, 702, 703, 704, 705, 706, 707, 708, 710, 711, 712, 801, 804, 805, and 806.
The nine census tracts adjacent to the Central Artery Corridor include tracts: 203, 301, 302, 303, 304, 305, 305.99, 701, and 702.
Source. U.S. Census Bureau, 1990 Decennial Census, Summary Tape File 1, 1990.

city through an urban mega-project. To show the environmental benefits of this project, the impact of proximity to parks on housing values in Boston was estimated based on the hedonic pricing method. Assessed values of condominium units in nine zip codes of central Boston are used to estimate the implicit prices for their location attributes that were added to the property database using the Geographic Information Systems (GIS). In order to estimate the effects of demolishing the elevated highway, the effect of proximity to highways on housing prices is simultaneously estimated.

The empirical analysis using the hedonic pricing method showed the following: 1) Based on the current land use and observed property values of condominium units, shorter distances to urban open space in central Boston have positive impacts on property prices. The benefits of parks enjoyed by city visitors, however, cannot be measured by the hedonic pricing method. And, 2) Shorter distances to a highway have negative impacts on property prices. Combined with the impact of proximity to parks, it is expected that the highway demolition and creation of open spaces on the Central Artery Corridor will cause significant increases in prices of neighborhood properties.

When a property price increases as a result of environmental improvement, property owners enjoy the effect through capitalization. On the other hand, renters may be displaced from the current residence because of the increased rent. In the neighborhood near the Big Dig where large numbers of minority residents live in rental units, it is possible that the increase in property price by the Big Dig will negatively impact the low-income minority groups.

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REFERENCES

Altshuler, A. A., & Luberoff, D. (2003). *Mega-projects: The changing politics of urban public investment*. Washington, DC: Brookings Institution Press.

At the statehouse—vision for big dig park unveiled. (2000, December 15). *The Providence Journal*, p. 5C.

City of Boston. (2000). *Property parcel data*. (CD-ROM version). Boston, MA: City of Boston, Assessing Department.

DiPasquale, D., & Kahn, M. E. (1999). Measuring neighborhood investments: An examination of community choice. *Real Estate Economics*, *27*(3), 389–424.

DiPasquale, D., & Wheaton, W. (1996). *Urban economics and real estate markets*. New Jersey: Prentice Hall.

Dwyer, J. F., Peterson, G. L., & Darragh, A. J. (1983). Estimating the value of urban forests using the travel cost method. *Journal of Arboriculture*, *9*(7), 183–185.

Fader, S. (1997). Embarcadero promenade. In A. Garvin & G. Berens (Eds.), *Urban parks and open space* (pp. 90–95). Washington DC: Urban Land Institute.

Fuguitt, D., & Wilcox, S. J. (1999). *Cost-benefit analysis for public sector decision makers*. Westport, CT: Quorum Books.

Garvin, A. (1997). Enhancing the public realm. In A. Garvin & G. Berens (Eds.), *Urban parks and open space* (pp. 25–42). Washington, DC: Urban Land Institute.

Geoghegan, J. (2002). The value of open spaces in residential land use. *Land Use Policy*, *19*, 91–98.

Glaeser, E. L., Kahn, M. E., & Rappaport, J. (2000). *Why do the poor live in cities?* National Bureau of Economic Research, Working Paper No. w7636. Available: http://papers.nber.org/papers/W7636 [September 2003]. Cambridge, MA: National Bureau of Economic Research.

Glaeser, E. L., Kolko, J., & Saiz, A. (2001). Consumer city. *Journal of Economic Geography*, *1*, 27–50.

Goldberg, C. (2000, December 21). Boston's digging produces a green jewel. *The New York Times*, p. A22.

Hammer, T. R., Coughlin, R. E., & Horn, E. T., IV. (1974). The effect of a large urban park on real estate value. *Journal of American Institute of Planners*, *40*, 274–277.

Hanley, N., & Spash, C. L. (1993). *Cost-benefit analysis and the environment*. Northampton, MA: Edward Elgar.

Hendon, W. S. (1973). Property values, schools, and park-school combinations. *Land Economics*, *49*(2), 216–18.

Jacobs, J. (1961). *The death and life of great American cities*. New York: Random House.

Kahn, M. E. (2000). The environmental impact of suburbanization. *Journal of Policy Analysis and Management*, *19*, 569–586.

Kiel, K. A., & McClain, K. T. (1995). House price during siting decision stages: The case of an incinerator from rumor through operation. *Journal of Environmental Economics and Management*, *28*, 241–255.

Kohlhase, J. E. (1991). The impact of toxic waste sites on housing values. *Journal of Urban Economics*, *30*, 1–26.

Krieger, A. (1999). Experiencing Boston: Encounters with the places on the maps. In A. Krieger, D. Cobb, & A. Turner (Eds.), *Mapping Boston* (pp. 146–172). Cambridge, MA: MIT Press.

Leichenko, R. M., Coulson, N. E., & Listokin, D. (2001). Historic preservation and residential property values: An analysis on Texas cities. *Urban Studies*, *38*, 1973–1988.

Leinberger, C. B., & Berens, G. (1997). Executive summary: Creating better urban parks and open space. In A. Garvin & G. Berens (Eds.), *Urban Parks and Open Space* (pp. 25–42). Washington, DC: Urban Land Institute.

Lynch, K. (1960). *Image of the city*. Cambridge, MA: MIT Press.

Margulis, H. L. (2002). Suburban housing resale prices and housing market restructuring. *Journal of Urban Affairs*, *24*, 461–477.

Massachusetts Turnpike Authority. (2003, October). *Central artery/tunnel project: Finance plan*. Available: *http://www.bigdig.com/thtml/pdf/fin_10–01–03.pdf* [October, 2003].

Michaels, R. G., & Smith, V. K. (1990). Market segmentation and valuing amenities with hedonic models: The case of hazardous waste sites. *Journal of Urban Economics*, *28*, 223–242.

More, T. A., Stevens, T., & Allen, P. G. (1988). Valuation of urban parks. *Landscape and Urban Planning*, *15*, 139–152.

Sieg, H., Smith, V. K., Banzhaf, H. S., & Walsh, R. (2000). *Estimating the general equilibrium benefits of large policy changes: The clean air act revisited*. National Bureau of Economic Research, Working Paper No. w7744. Available: http://papers.nber.org/papers/W7744 [September 2003]. Cambridge, MA: National Bureau of Economic Research.

Steinacker, A. (2003). Infill development and affordable housing patterns from 1996 to 2000. *Urban Affairs Review*, *38*, 492–509.

Trust for Public Land. (1999). *The economic benefits of parks and open space*. Available: *http://www.tpl.org/tier3_cdl.cfm?content_item_id=1145&folder_id=727* [February 2002].

Tsipis, Y. (2001). *Boston's central artery*. Charleston, SC: Arcadia Publishing.

Tyrvainen, L. (1997). The amenity value of the urban forest: An application of the hedonic pricing method. *Landscape and Urban Planning*, *37*, 211–222.

Tyrvainen, L. (2000). Property prices and urban forest amenities. *Journal of Environmental Economics and Management*, *39*, 205–223.

Warner, M., & Hefetz, A. (2002). The uneven distribution of market solutions for public goods. *Journal of Urban Affairs*, *24*, 445–459.