Assessing the Economic Impact of Sports Facilities on Residential Property Values: A Spatial Hedonic Approach

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Abstract

This paper estimates the intangible benefits of a two sports facilities in Columbus, Ohio on residential property values. We estimate a spatial hedonic model that avoids biased and inconsistent estimates in the presence of uncorrected spatial autocorrelation. The results suggest that the presence of sports facilities in Columbus have a significant positive distance-decaying effect on surrounding house values, supporting the idea that professional sports facilities generate important intangible benefits in the local economy. OLS overestimates the hedonic model parameters compared with Maximum Likelihood and Spatial Two Stage-Least-Squares.

Keywords: Economic Impact, Residential Property Values, Sports Facilities, Hedonic Model, Spatial Dependence, Spatial Hedonic Model

JEL Codes: I180, L830

Introduction

In the past two decades, the Untied States experienced a boom in construction of sports stadiums and arenas. Sixty-four major league sports stadiums and arenas were built for the four major professional sports from 1991 to 2006. This trend shows no sign of stopping; in fact, the subsidies appear to be growing (Zimbalist and Grant-Long, 2007). Cities continue to compete to construct new facilities to attract new teams or renovate old ones to retain their current teams by subsidizing the cost of construction. These subsidies raise an important question: why do cities subsidize sports facility construction?

The answers to this question vary widely. Proponents of subsidies claim that sports facilities and teams generate substantial economic impact, in terms of income increases, job creation, and tax revenue increases, because outside visitors who attend games spend money at the facility and on many other related and unrelated goods and services, injecting new spending to the local economy. Moreover, proponents of subsidies claim, this new spending generates substantial multiplier effects on sports related industries. These claims are typically supported by economic impact studies performed by consulting firms (ERA, 2004). A substantial body of empirical research, based on

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retrospective econometric evidence, shows that professional sports facilities and teams have little or no significant positive impacts, or even negative impacts, on the local economy (Baade and Dye, 1990; Baade, 1996; Coates and Humphreys, 1999, 2003a; Siegfried and Zimbalist, 2000; Nelson, 2001). Explanations for the lack of positive economic impact include compensating differentials generated by sports facilities and teams, substitution effects among consumers and across industry sectors, ignored opportunity costs of stadium construction and location of stadiums. The academic literature also points out the frequent misapplication of regional I-O multipliers in most promotional economic impact studies (Siegfried and Zimbalist, 2000, Crompton, 1995).

The overwhelming academic evidence against tangible positive economic impacts of professional sports and the continued subsidization of sport facility construction and renovation generates considerable tension in the literature. The continuing subsidization of sports facility construction suggests that professional sports might generate other intangible benefits that most retrospective econometric research ignores. At minimum, the debate clearly calls for more studies on the economic impacts of sports facilities, including research that examines the intangible benefits beyond income, jobs, and taxes, generated by professional sports. To date very few studies have examined this issue empirically.

This paper examines the economic impact of sports facilities on residential housing values. We use a spatial hedonic approach to assess the impact of two professional sports facilities, Nationwide Arena, home of the Blue Jackets of the NHL, and Crew Stadium, home of the Columbus Crew of MLS, in Columbus Ohio, on surrounding residential property values. This research makes a contribution to the small, growing literature focusing on the impacts of sports facilities on property values. Two recent, similar studies (Tu, 2005; Dehring et al. 2007) examine the effects of NFL stadiums on property values with quite different results. Tu (2005) found a positive effect on housing values within three miles of the FedEx Field; Dehring et al. found a negative aggregate impact of three stadium location announcements on property values in Arlington, Texas. This study contributes to this literature by providing new evidence based on data from a different location and from different sports. We also use an estimator with spatial autocorrelation incorporated, an important aspect in examining the housing values previously ignored in this literature, and in many other hedonic housing studies. We combine a spatial autoregressive model with an hedonic approach to estimate the effect of sports facilities on surrounding housing values.

Professional Sports Facilities and Housing Values

Most economic impact studies, both promotional studies and empirical academic research, focus on the effect of sports facilities on income, jobs, and tax revenues (Baade and Dye, 1990; and among the others). The literature has generally ignored the impact of sports stadiums and teams on a community's "quality of life," the intangible utility and satisfaction that residents derive from enjoying various community attributes and amenities. Quality of life depends on many factors including climate, public safety, medical facilities, sports and other recreational facilities, and cultural activities. Quality of life, or related concepts like cultural importance, civic pride, city image, and community visibility, have been mentioned and discussed frequently in the literature (Crompton, 2004; Noll and Zimbalist, 1997; Rappaport and Wilkerson, 2001; Siegfried and Zimbalist, 2000). The proponents of sports facility construction also claim the improved quality of life or the intangible benefits to justify the public subsidies. However, the discussion of the effect of sports on local quality of life is typically descriptive, because it is very hard to measure and quantify intangible benefits (Noll and Zimbalist, 1997).

Despite the difficulty in quantifying the intangible and non-pecuniary benefits to residents, economists have made efforts in this direction. The series of papers by Johnson and Whitehead (2000), Johnson, Groothuis, and Whitehead (2001), and Johnson, Mondello, and Whitehead (2005) measured the intangible benefits by people's WTP for sports facilities using the Contingent Valuation Method (CVM) approach. Another approach utilizes a standard hedonic housing model to estimate the intangible benefits of sports facilities (Carlino and Coulson, 2004; Tu, 2005; Dehring et al. 2007, Ahlfeldt and Maennig, 2007)). The underlying idea in these papers is that a house is a differentiated good, and the price of a house is determined by a combination of its own characteristics and intangible characteristics associated with the house, including public amenities near where the house is located. This approach has also been used to estimate the prices and demand for environmental amenities. In the context of this paper, the presence of a sports facility in a neighborhood is viewed as an intangible characteristic and the presence of a sports facility would be capitalized into housing prices.

The papers mentioned above all contain evidence that sports facilities affect property values in cities. Carlino and Coulson (2004) used data from 53 of the 60 largest metropolitan statistical areas from 1993 and 1999 and found that non-economic impacts, what they called social benefits and compensating differentials, flow from NFL franchises to central cities and their associated metropolitan areas. According to this story, cities that gained an NFL team had higher quality of life than other cities, which translates into higher housing values or rents or lower wage rates. Their results indicate that the presence of an NFL franchise raised housing rents by approximately 8 percent in central cities.

Tu (2005) investigated the impact of FedEx Field, home of the NFL's Washington Redskins, on housing values for houses in Price George's County, Maryland. A difference-in-difference approach showed that the value of a house inside the impact area was lower than that of a comparable house outside the area before the site was selected for this stadium. However, by comparing the price differentials between houses in and out of the impact area across the pre-development, development, and post-development periods, Tu (2005) showed that the price differentials were narrowed after the announcement of site selection and further reduced after the stadium was completed. This indicated that the construction of the stadium actually improved the housing price in the surrounding area and the impact was minimal when the house was more than 2.5 miles away from the stadium.

Dehring et al. (2007) investigated two sets of stadium announcements concerning a new stadium for the NFL's Dallas Cowboys. One was a proposal to build a new stadium in Dallas Fair Park which was ultimately abandoned. The other was a proposal to build a stadium in Arlington that was confirmed. For the Dallas Fair Park case, they found that property values increased near Dallas Fair Park after the announcement of the new stadium proposal. However, in Dallas County, which would have paid for the stadium with increased sales taxed with rate increased by 0.5 percent, residential property values decreased after the announcement. These patterns reversed when the proposal was abandoned. Subsequently, the aggregate impact of the three announcements concerning the stadium proposal in Arlington was negative and statistically significant. The accumulated net impact corresponded to an approximate 1.5% decline in property values in Arlington, which is almost equal to the anticipated household sales tax burden. Their results differ from Tu (2005) who found a positive amenity effect for properties located within 3 miles of FedEx Field.

Alfeldt and Maennig (2007) estimate the effect of three multipurpose sports facilities in Berlin on surrounding land values. All three facilities were designed to revitalize the surrounding neighborhoods. The paper estimates a spatial hedonic land price model that accounts for spatial dependence. The sports facilities are found to have a positive effect on land values within about 3000 meters of the facility, although the effect varies with specific design features.

With the exception of the paper by Alfeldt and Maennig (2007), these papers ignore spatial effects, especially spatial autocorrelation. There are two broad types of spatial effects: spatial autocorrelation (or spatial dependence) and spatial heterogeneity. The former is best known and most often acknowledged. Spatial autocorrelation can be loosely defined as the coincidence of value similarity with location similarity; similar values for a given random variable tend to cluster in space (a case of positive spatial autocorrelation), or dissimilar values tend to cluster in space (negative spatial autocorrelation). Spatial autocorrelation exists in some cross-sectional data because variables we examine share the same locational characteristics. Housing prices are spatially correlated because of the same reason. Ignoring these spatial effects in econometric modeling will lead to model misspecification and biased estimates (Anselin, 1988). Despite the recent advances in spatial data analysis and spatial econometrics (Anselin, 1988, 2003a; Anselin, et al., 2004) and for all of its importance, spatial autocorrelation is not considered in the current hedonic housing studies in measuring the impacts of sports facilities. So the existing evidence about the effects of sports facilities on housing values may be based on misspecified models due to uncorrected spatial autocorrelation in the individual housing data, thus their estimates may be biased. In this paper we explicitly account for the presence of spatial dependence in the data, using standard spatial autoregressive models to assess the impact of sports facilities on housing values, the spatial hedonic approach (Kim, et al. 2003).

A Spatial Lag Hedonic Housing Price Model

Housing prices tend to be spatially correlated because houses in the same community share neighborhood characteristics and the externalities generated from the neighborhood characteristics, positive or negative, will be reflected in housing prices. Besides neighborhood effects, Can (1992) suggested a second source of effects that will lead housing prices to be spatially dependant, the absolute spatial spill-over effects, i.e., the impact of the prices of adjacent structures on housing prices. These two different effects can be classified as reaction effects and interaction effects. Reaction effects mean observations of the dependant variable respond to the underlying common factors. Interaction effects mean observations affect each other. Both effects imply that spatial autocorrelation needs to be carefully incorporated in hedonic price models. Recent advances in spatial econometrics (Anselin, 1988, 2003a; Anselin et al., 2004) provide a range of spatial econometric model specifications, testing, and estimation. Researchers have demonstrated the importance of incorporating spatial dependence in hedonic studies (Can, 1992; Basu and Thibodeau, 1998; Kim, et al., 2003). Basically, spatial dependence can be incorporated in two different ways: spatial autoregressive lags and spatial autoregressive errors (Anselin, 1988).

The most commonly used spatial model specification is the spatial autoregressive model in the dependant variable. Anselin (1988) develops a spatial lag hedonic model, or spatial autoregressive (SAR) lag model that combines the features of a standard hedonic housing price model with a correction for spatial dependence. This spatial lag hedonic model is

$$y = \rho W y X \beta + \varepsilon \tag{1}$$

where y is an $n \times 1$ vector of observations on the dependent variable, in this case either housing prices or the log of housing prices, X is an $n \times k$ matrix of observations of the explanatory variables which include housing structural attributes, neighborhood characteristics, and sports facility related variables, and are assumed to be uncorrelated with the error term, β is a $k \times 1$ vector of unknown coefficients, and ε is a random error term. ρ is the spatial autoregressive parameter and W is an $n \times n$ row-standardized spatial weights matrix that represents the neighbor structure in the data. The spatial lag term Wy links each observation of the dependent variable to all other observations and can be thought of as a weighted average of neighboring values. After some algebraic manipulation, the reduced form of the spatial lag model can be derived

$$y = (I - \rho W y)^{-1} X\beta + (I - \rho W y)^{-1}\varepsilon \tag{2}$$

there i is the identity matrix. The "Leontief Inverse" $(I - \rho W y)^{-1}$ links the dependent variable y_i to all the x_i in the system through a spatial multiplier. Expanding the "Leontief Inverse," under the assumption that $|\rho| < 1$ gives an expression

$$(I - \rho W y)^{-1} = I + \rho W + \rho^2 W^2 + \dots \tag{3}$$

which links each observation of the dependent variable is linked to all observations of the explanatory variables through a spatial multiplier. Equation (3) shows how the dependent variable y at location i relates to the error terms at all locations in the system through the same spatial multiplier in the SAR process. The SAR process generates a global range of spillovers, which is a type of global autocorrelation since it relates all the locations in the system to each other (Anselin, 2003b). This SAR process captures important features of housing markets in that there are neighboring spillover effects among houses due to shared neighborhood amenities. The price of each house affects all the other houses in the neighborhood and the effect diminishes with distance. This dependence leads to simultaneity due to the two-way spatial interaction, and makes the spatial lag Wy endogenous. This makes OLS estimators biased and inconsistent in the presence of spatial dependence and requires specialized estimation methods like maximum likelihood or instrumental variables approaches (Anselin, 1988) to correct for it.

Data Description and Context

We analyze the values of residential dwellings around two professional sports facilities: Nationwide Arena, home of the NHL's Columbus Blue Jackets, and Crew Stadium, home of the MLS's Columbus Crew, in Columbus, Ohio. Nationwide Arena, located on the corner of Nationwide Boulevard and Front Street in Columbus, opened in 2000. The $150 million arena was designed as a mixed-use facility integrated into the downtown surroundings and serves as the center of a planned entertainment district, the Arena District, an urban village of housing, retail, and office space surrounding the arena. Crew Stadium, a $25 million soccer-only facility, opened in 1999. Seating just over 25,000 spectators, Crew Stadium is the largest soccer-only facility in the United States.

The location of Nationwide arena presents some problems for the spatial analysis of property values. The facility is located in downtown Columbus; in fact, it is in one of the two Census tracts identified in 1983 as the "Central Business District" of Columbus. Because of the location of Nationwide Arena, any empirical estimate of the effect of the facility on property values will be confounded by the effect of the proximity to the downtown area of Columbus. We expect that the estimated effect of proximity to Nationwide Arena will be biased up by this. However, the other sports facility in Columbus, Crew Stadium, is about four miles north of Nationwide Arena, and not located in the center of Columbus. Estimates of the effect of proximity to Crew Stadium should not be affected to the same extent as estimates of the proximity to Nationwide Arena by the "downtown" effect.

Unlike most professional sports facilities in North America, the construction of Nationwide Arena was privately financed by Nationwide Insurance as part of along-term naming rights deal. Similarly, the construction of Crew Stadium was financed by team owner Lamar Hunt. However, the local amenity value generated by a sports facility should not depend on the financing of the construction. We do not think that the financing details will affect the results in this paper.

The data analyzed are transactions data for the year 2000 in Columbus, Ohio. These data were used in Brasington (2007), Brasington and Haurin (2006), and Brasington and Hite (2006). The data set contains observations on 9,504 single-family housing units which were transacted in the year 2000. We include only transactions with a value above $30,000 to eliminate non-market transactions and transactions involving uninhabitable dwellings. The data set includes detailed housing characteristics such as lot size, building square footage, number of stories, number of bedrooms, number of bathrooms, number of fireplaces, central air conditioning, and other variables. It also contains variables capturing neighborhood characteristics such as school quality, environmental quality, and crime data which are matched with School District, Census Block Group, and Police District data, respectively.

The distance between each house and the two facilities was calculated based on the latitude and longitude of each facility and each dwelling in the sample. Given the assumption that the presence of a sports facility improves the quality of life in the community, it is hypothesized that the presence of these facilities generate positive impacts on the values of houses in the surrounding area. Moreover, the impacts are assumed to be distance decaying: the economic impact on housing values would be higher near the facilities than farther from them, and decline as the distance from the facility increases, other things equal. There is also a large Division I-A football stadium, Ohio Stadium, on the nearby Ohio State University campus, which is near both facilities. However, the Ohio State University Campus is large, and the presence of student housing near the campus may confound the effect of this facility on nearby housing values. To control for the effects of Ohio Stadium, a dummy variable equal to 1 if the house is within 3 miles of Ohio Stadium, was created. Figure 1 shows the location of each house in the sample and the location of the three sports facilities in Columbus.

As to the neighborhood characteristics, it is important to control for transportation accessibility in a hedonic housing price model. Usually, the distance to the CBD and/or to major highways proxy for transportation accessability. We include distance to the CBD and distance to the nearest highway interchange in the model.

As the study examines the effect of proximity to a sports facility on residential housing prices, the observed effect of this proximity could work through the effect of the sports facilities on business location and through the effect of business location on residential properties. If bars, restaurants, and retail establishments open near a sports facility, this can increase the demand for land in these areas and therefore drive up existing property values. To control for the effects of businesses on housing values, we augmented the housing and neighborhood characteristic data set with variables from County Business Patterns for the number of commercial establishments in each dwelling's ZIP Code. By controlling for the number of commercial establishments in the neighborhood, we hope to isolate, as much as possible, the effects of proximity to Nationwide Arena on hoising values. Also, since Nationwide Arena is located adjacent to the Central Business District (CBD) in Columbus, based on the 1983 definition, making it necessary to control for spillover effects from the CBD to the values of surrounding houses. The business variables can be expected to capture some of these effects, in addition to a variable showing .

Table 1 contains summary statistics of the variables in the empirical model. The average house sold in Columbus in 2000 was a one story house with three bedrooms and about one and a half bathrooms on a 9,300 square foot lot. The average house was about five and a half miles from each of the two professional sports facilities in Columbus; only 16% of the houses in the sample were located near Ohio Stadium, on the campus of the Ohio State university. The average house sold in 2000 was 1.28 miles from the nearest interstate interchange and the median household income in the neighborhood was $47,693. The average house was located in a below average school district (average school district rating 2.2 out of 5).

Table 1: Variable Descriptions and Summary Statistics

Variable	Definition	Mean	Std. Dev.
Hsvl	House transaction amount, 2000 dollars	126780	87389
Onestory	Dummy for one-story house	0.47	0.5
Brick	Dummy for brick house	0.44	0.5
Finbase	Dummy for finished basement	0.09	0.28
Garage	Dummy for garage	0.51	0.5
Air	Dummy for air conditioning	0.72	0.45
Fire	Dummy for fireplace	0.48	0.6
Bedrooms	Count of bedrooms	3.05	0.69
Fullbath	Count of full bathrooms	1.43	0.57
Partbath	Count of partial bathrooms	0.46	0.53
Agehouse	Age of house	41.59	30.72
Lotsize	Square feet of lot	9338	13877
Pool	Dummy if house has a pool	0.01	0.1
prtax	Property tax rate by school district, 1998	33.58	3.05
sdrating	School district rating (5=excellent)	2.22	1.52
dpld	Disposal to land on site by census block group, lbs.	1840	35833
pm10	Particulate matter, diameter <10 micrometers, 1999	0.28	2.4
pbk	% of population in block group black, non-hispanic	19.58	24.93
phs	% of persons in block group with HS diploma	28.64	12.67
pba	% of persons in block group with college degree	19.24	13.2
mhe	Median household income in block group	47693	19507
offe	Number of criminal offenses per 1000 residents, 1996	112.61	66.27
DNHL	Distance between each house and Nationwide Arena	5.59	2.42
DMLS	Distance between each house and Crew Stadium	5.49	2.78
DIV1	Dummy for houses within 3 miles of Ohio Stadium	0.16	0.37
DI	Distance from each house and nearest highway interchange	1.28	0.86
Retail	Number of retail trade establishments in ZIP Code	125.64	68.57
Finance	Number of finance/insurance establishments in ZIP Code	51.34	38.97
Food	Number of accommodation/food establishments in ZIP Code	66.55	35.42
Service	Number of services establishments in ZIP Code	77.18	31.08

Model Specification

A crucial issue in spatial autocorrelation modeling is defining the locations for which the values of the random variable are correlated, i.e., neighbors. A spatial weights matrix is an $n \times n$ positive and symmetric matrix, W, which specifies a "neighborhood set" for each observation as nonzero elements. Each row of the spatial weights matrix, indexed by i, contains elements w_{ij} and nonzero elements define column j as a neighbor of i. So $w_{ij} = 1$ when i and j are neighbors, and $w_{ij} = 0$ otherwise. Conventionally, the diagonal elements of the weights matrix are set to zero, i.e., $w_{ii} = 0$. Usually the weights matrix is row standardized such that the weights of each row sum to one. The row standardized weights matrix makes the spatial lag term an average of neighboring values and thus allows for spatial smoothing of the neighboring values. It also ensures that the spatial parameters in many spatial stochastic processes are comparable between models.

The specification of neighborhood sets, in other words, is important because it captures all spatial interaction in the data. In the case of housing market, nonzero elements in the weights matrix would represent the range of spillover effects from each house on its neighboring houses. Due to the features of both housing markets and individual housing data, the specification of the neighborhood set for each house, in other words, the definition of the spatial weights matrix W, is especially important. A wide range of methods have been suggested to specify neighborhoods and define the spatial weights matrix. It can be a traditional approach which relies on geographic structure or spatial arrangement of the observations. In this approach, areal units are defined as "neighbors" if they share a common border, called first-order rook contiguity. Alternatively, "neighbors" can be identified based on distance. In this case $w_{ij} = 1$ for $d_{ij} < t$, where d_{ij} is the distance between observations i and j, and t is a distance cut-off value. In GeoDa (Anselin, 2003a), software developed by Anselin (2003a) designed to implement exploratory spatial data analysis techniques in lattice data (points and polygons), a spatial weights matrix can be constructed based on border contiguity, distance contiguity, and k-nearest neighbors. For the border contiguity, GeoDa can create first-order and higher-order weights matrices based on rook contiguity (common boundaries) and queen contiguity (both common boundaries and common vertices).

Each of these three approaches to constructing a weights matrix has advantages and disadvantages. For example, when there is a high degree of heterogeneity in the spatial distribution of areal units, a distance based spatial weights matrix might generate a non-constant number of neighbors for each observation. One way to solve this heterogeneity problem is to constrain the neighbor structure to the k-nearest neighbors which will generate constant number of neighbors, k. However, a spatial weights matrix based on k-nearest neighbors is not symmetric. Non-symmetric weights matrices do not capture the two-way interaction among observations because non-symmetry implies subject i is a neighbor of subject j but not vice versa. In some rare cases, spatial effects might be one-way and irreversible, but in most cases, including housing values, the spatial effects are a two-way interaction and the spatial weights matrix, therefore, should be symmetric. So a k-nearest neighbor weights matrix is not appropriate in this setting.

As there is no formal test to decide the choice of a spatial weights matrix, selecting an appropriate spatial weights matrix is more of an art than a science. It has to be based on the features of data. In the case of housing markets, if the houses are in rural areas, a spatial weights matrix based on contiguity may not be appropriate because houses in rural areas may be far apart each other and be separated by some geographic features so that they are not contiguous. A spatial weights matrix based on the contiguity thus may include houses with no neighbors, or "islands." The disadvantages of distance-based spatial weights matrix discussed above applies to the housing market in rural areas too. However, in the case of urban areas like downtown Columbus Ohio, houses tend to be more contiguous than those in rural areas, and lot sizes do not vary as much as

Table 2: Characteristics of Spaital Weights Matrices

	Rook	2nd-Order Rook	Queen	Distance
% Nonzero Weights	0.063	0.217	0.063	2.428
Average No. of Links	6.0	20.6	6.0	230.8
No. of Least Connected	1 (with 2 links)	1 (with 7 links)	1 (with 2 links)	1 (with 1 link)
No. of Most Connected	2 (with 17 links)	1 (with 67 links)	2 (with 17 links)	2 (with 526 links)

in rural areas. So both contiguity and distance based spatial weights matrices are feasible in this setting. Since housing observations are point data, a point shape file was created and transformed into a Thiessen polygon shape file in GeoDa in order to construct a spatial weights matrix based on common boundaries. This study first uses four types of spatial weights: rook, second-order rook, queen and distance-based. The cut-off distance to create distance-based spatial weights matrix was 0.019 miles. This is the smallest distance that ensures that each house has at least one neighbor so that no "islands" exist. The basic characteristics of each spatial weights matrix are illustrated in Table 2.

All the weights are row-standardized. The percentage of nonzero cells indicates the sparseness of the weights matrix. This percentage increases with less strict definitions of neighbors, for example, from first-order rook to second-order rook contiguity. Note that the spatial weights based on rook and queen contiguity are the same in this sample. Also, the weights matrix based on distance has a very wide range of number of links, i.e., the number of neighbors varies substantially, with one least connected region with one neighbor and two most connected regions with 526 neighbors. The average number of neighbors is about 231. As discussed, this varying number of neighbors will lead to heterogeneity in the data. The weights matrix used in this case is the queen, which is the same as the rook in this sample.

The standard hedonic housing price model relates the market value, usually measured by the sales price, to a set of measures of dwelling-specific attributes and neighborhood amenities that affect the property's value. One important element of the process is to determine the best fitting functional form. The the hedonic housing price literature contains three alternative functional forms: linear (Palmquist, 1984), semi-log (Carlino and Coulson, 2004; among others), and log-log (Basu and Thibodeau, 1998). Each of the three functional forms has its advantages. Both the log-linear and log-log forms allow the marginal implicit price of a particular attribute to vary across observations. The linear form forces a constant effect across observations which has less theoretic support. The advantage of the linear form is that it is intuitive and provides a direct estimate of the marginal implicit price of an attribute. There is little guidance on selecting the appropriate functional form for a hedonic price function. Typically, ad hoc decisions or some model "goodness-of-fit" criteria are used to select the functional form. Rosen's (1974) hedonic model featured nonlinear price functions, motivating the semi-log and log-log forms.

We estimate a log-log version of equation (2). The Moran's I statistic, based on a OLS residuals from a standard log-log hedonic model under the null hypothesis of no spatial autocorrelation, indicates significant and strong positive spatial autocorrelation in the housing values. While Moran's I has strong power against the null hypothesis of no spatial autocorrelation, it does not identify the proper alternative hypothesis. An LM test and a robust LM test suggested that the spatial lag model best describes the spatial pattern in the housing values in this case. Accordingly, we estimate a log-log specification of equation (2) with a spatial lags using a queen weights matrix. The parameters of this model are estimated using both maximum likelihood (ML) and a spatial two-stage least squares robust estimator (S-2SLS Robust). We also report OLS estimates of the hedonic housing price model with no spatial lags for comparison. ML estimation requires normality of the errors, which may not be appropriate in this case since the Jarque-Bera statistic for the OLS regression indicates a violation of normality. The spatial two-stage least squares robust estimator uses spatially lagged explanatory variables (WX) as instruments. This estimator is robust to non-normality and produces consistent estimates. Also the Breusch-Pagan test suggests heteroskedasticity in the error term, and this spatial two-stage least squares robust estimator corrects for heteroskedasticity when present.

Results and Discussion

The estimates of the unknown parameters in the spatial lag model using Maximum Likelihood and the robust S2SLS estimator are shown on Table 3. Parameter estimates from the hedonic housing price model with no correction for spatial dependence generated by OLS are also shown for comparison. All distances are expressed in logs in these models. The OLS parameter estimates are generally larger than the ML and S2SLS parameter estimates. The larger OLS parameter estimates may be due to bias from uncorrected spatial autocorrelation in the data. A Likelihood Ratio (LR) test for spatial dependence is significant and confirms the results of other spatial dependence diagnostics discussed above.

The primary variable used to evaluate the effects of sports facilities on surrounding housing values is the distance between each house and the sports facility. In these models, the parameter estimate on the log distance variable can be interpreted as the elasticity of housing values with respect to changes in distance. The parameter on the distance from Nationwide Arena and distance from Crew Stadium variables are both negative and significant for both the ML and S2SLS estimators. This implies that presence of sports facilities in Columbus has positive effects on housing values, and that the effect diminishes as the houses get farther from the facilities. The estimate on the distance to nationwide Arena variable for the OLS model can also be interpreted as an elasticity, and indicates that for each 1% increase in distance from the arena, house values fall by 0.14%.

The interpretation of the parameters from the two models with spatial lags differs from the OLS parameter estimates. To get the exact effect on housing values for each explanatory variable we need to use the reduced form of equation (2). In this case, the estimated elasticity should be multiplied by $1/(1-\hat{\rho})$. So for the S2SLS estimates on Table 3, the coefficient on the distance to Nationwide Arena variable is -0.084. This means that, at the average, all else equal, for each 1% decrease in the distance to the arena is associated with a 0.175% [0.175=1/(1-0.519)*0.084] increase in the price of the average house. Proximity to Crew Stadium also increases housing values, but the estimated elasticity is much smaller for the soccer stadium. Again, the larger estimated effect of proximity to Nationwide Arena can be attributed to the fact that the arena is located in downtown Columbus. The effect of proximity to Crew Stadium, which is located several miles north of Nationwide Arena, may not be biased up by the unobservable "downtown" effect on property values. The difference could also be due in part to differences in usage patterns for the two facilities, or reflect the relatively higher profile of the NHA and larger attendance at NHL games. The result that property values are higher in proximity to sports facilities is consistent with some recent empirical evidence which suggests that the non-pecuniary impact of professional sports teams and facilities varies across space. By analyzing voting on subsidies for professional sports facilities in two cities, Houston, Texas and Green Bay, Wisconsin, Coates and Humphreys (2005) found that voters living in close proximity to facilities tend to favor subsidies more than voters living farther from the facilities.

Table 3: Model Estimation Results

	OLS		ML		S2SLS	
Variable	Parameter	SE	Parameter	SE	Parameter	SE
Spatial Lag			0.496**	0.011	0.519**	0.020
Distance to Nationwide	-0.135**	0.011	-0.096**	0.010	-0.084**	0.011
Distance to Crew Stadium	-.383	0.700	-0.013*	0.006	-0.011**	0.006
One Story	-0.042**	0.007	-0.043**	0.006	-0.041**	0.007
Brick	0.053**	0.007	0.033**	0.006	0.031**	0.006
Basement	-0.017	0.011	-0.011	0.010	-0.010	0.007
Garage	0.034**	0.009	0.008	0.008	0.014	0.008
Air Conditioning	0.109**	0.008	0.086**	0.007	0.080**	0.008
Fireplace	0.049**	0.006	0.041**	0.005	0.036**	0.006
# of Bedrooms	0.031**	0.005	0.037**	0.005	0.036**	0.006
# of Full Baths	0.229**	0.007	0.158**	0.006	0.150**	0.008
# of Half Baths	0.125**	0.007	0.086**	0.006	0.082**	0.007
Age	-0.001**	0.000	-0.001**	1.56E-04	-0.001**	1.89E-04
Lot Size	3.06E-06**	2.25E-07	2.70E-06**	1.97E-07	2.48E-06**	5.15E-07
Pool	0.076**	0.031	0.071**	0.027	0.069	0.038
Property Tax	0.001	0.001	0.002*	0.001	0.002*	0.001
School Rating	0.016**	0.003	0.010**	0.003	0.009**	0.003
Disposal	-1.63E-06**	8.49E-08	-8.70E-07**	0.00E+00	-1.36E-07**	0.000
Particulates	0.002	0.001	0.001	0.001	0.001	0.001
% Black	-0.002**	0.000	-0.001**	1.37E-04	-0.001**	1.52E-04
% HS Diploma	-0.001**	0.001	-2.67E-04	4.72E-04	-4.02E-04	4.88E-04
% College Graduates	0.013**	0.001	0.006**	0.001	0.006**	0.001
Median Household Income	3.48E-06**	2.53E-07	1.01E-06**	2.28E-07	1.06E-06**	2.75E-07
# Crimes per 1000	-1.16E-04*	5.17E-05	-4.80E-05	4.53E-05	-8.86E-05*	4.00E-05
Near Ohio Stadium	0.041**	0.013	0.023*	0.011	0.027*	0.012
Distance to Interstate	0.039**	0.004	0.017**	0.004	0.015**	0.004
# Retail Establishments	4.86E-04**	1.09E-04	3.34E-04**	0.000	3.68E-04**	9.04E-05
# Finance Establishments	-5.91E-04**	1.57E-04	-0.001**	1.38E-04	-0.001**	1.33E-04
# Food Establishments	-9.84E-04**	2.35E-04	-0.001**	2.06E-04	-0.001**	2.19E-04
# Service Establishments	9.42E-04**	2.11E-04	0.001**	1.85E-04	0.001**	1.89E-04
Constant	10.720**	0.062	5.292**	0.129	5.039**	0.229
R^2	0.707		0.775		0.778	

** significant at 0.01, * significant at 0.05.

OLS generates a larger parameter estimate on both the distance variables than S2SLS. The estimated effect of proximity on housing values from a hedonic model with no spatial effects is less than the estimated effect of proximity from the spatial lag hedonic model by 0.04% (0.175%-0.135%) with each 1% decrease of distance. In dollar terms, a 1% decrease in distance from each house to the arena, on average, increases the price of an average house by around $171 based on the OLS estimates, and by about $222 based on S2SLS estimates using a spatial lag hedonic model. Distance to Crew Stadium shows a similar, but weaker pattern. This difference may be due to bias in the OLS estimates from spatial dependence in the data. The estimated parameter on the dummy variable indicating proximity to Ohio Stadium has a significant and positive sign. This indicates that the presence of Ohio Stadium has a larger effect on the values of houses which are located in its surrounding 3-mile ring than farther away. However, this effect is observationally equivalent to the effect of the Ohio State University campus on property values.

Nearly all the parameters on the house-specific and neighborhood-specific characteristics have the expected sign and are statistically significant. Among the house-specific characteristics, the number of full bathrooms has the largest positive effect. The number of half bathrooms, dummies for air conditioning, one story dwellings, fire places, and the number of bedrooms also increase housing values in the sample. The presence of a garage, a finished basement, and a pool turn out not to be significant. The lot size has a very small positive although significant effect. All the neighborhood characteristics have the expected and significant effects on housing values. For example, increasing school quality is associated with higher property values, as expected.

Some, but not all environmental disamenities reduce housing values in the sample. The estimated parameter on the variable capturing total disposal to land on site, which reflects releases of toxic chemicals, use of surface impoundments, and waste piles in each census block group, has the expected negative sign and is significant. But the estimated parameter on the variable reflecting release of particulate matter with diameter less than 10 micrometers into the air for each census block group has no effect on property values.

The distance to the nearest interstate highway interchange is associated with higher property values, which is consistent with results in the literature. The parameters on the number of businesses in the Zip Code variables are all statistically significant. Larger numbers of retail trade and service establishments are associated with higher housing values, other things equal; larger numbers of finance and insurance and accommodation and food establishments are associated with lower housing values. As there no other papers in the literature have included business variables in a spatial hedonic housing price model, there is no other evidence on the signs of these variables. From economic theory we know that a concentration of commercial establishments implies a high demand of land which might affect residential property values. The positive parameters on the number of retail trade and service establishments variables confirms this. However, there may be two opposing factors at work here: on one hand these business establishments represent accessibility and convenience, and have a positive effect on housing values; on the other hand, more business establishments also generate disamenities such as crowds, traffic, noise and trash, and have a negative effect on housing values. So it is not surprising that the estimated parameter on the number of finance and insurance establishments and the number of accommodation and food establishments are negative, as the negative effect of crowds and traffic may dominate the positive effect in this case.

Estimating Marginal and Total WTP

In an hedonic housing price model, the marginal implicit price of a particular housing attribute can be found by taking the first derivative of the housing price with respect to the variable of interest.

This can also be interpreted as the marginal WTP for some particular characteristic. In this case we are interested in estimating the willingness to pay for proximity to sports facilities in Columbus. The formula for calculating marginal WTP for proximity to a sports facility, denoted as $DIST_i$, varies across the functional forms used in hedonic housing price models. For the log-log form used here, calculation of the marginal WTP for proximity to a sports facility depends on

$$\hat{\beta}_D = \frac{dlny}{dlnDIST} = \frac{dy/y}{dDIST/DIST} = \frac{dy}{dDist} \cdot \frac{DIST}{y} \tag{4}$$

where $\hat{\beta}_D$ is the estimated parameter on the distance variable $DIST$. Because houses are varying distances from the sports facilities, the WTP for proximity differs. For a given $\hat{\beta}_D$, marginal willingness to pay for proximity to sports facility s for housing unit i can be calculated by

$$MWTP_{i,s} = \frac{dy}{dDIST} = \frac{1}{1-\hat{\rho}} \cdot \frac{DIST_i}{y_i} \cdot \hat{\beta}_D \tag{5}$$

if W is row-standardized and $|\hat{\rho}| < 1$. The Leontief Inverse spatial multiplier implies a global range of spillover effects where the magnitude of the spillovers decays with distance. As a component of the marginal WTP for proximity, it means one household's marginal WTP for a reduction in the distance to the sports facility would spill over to all neighbors defined by the spatial weights matrix W. Based on the log-log functional form, the estimated marginal WTP in our sample varies from \$533 to \$134,581 using the estimates from the spatial lag hedonic model and from \$412 to \$104,036 using the hedonic model with no correction for spatial autocorrelation. This implies that households are willing to pay between \$533 and \$134,581 for a marginal unit of reduction in distance to Nationwide Arena depending on the value of the house, distance to the facility from the house, income level, and other factors. The average marginal WTP for each model is \$4,924 for the spatial lag hedonic model estimated using ML and \$3,806 for the traditional hedonic model estimated with OLS.

While these marginal WTP estimates provide some information about the value of intangible benefits generated by sports facilities in Columbus, it is also of considerable interest to estimate the total value of these benefits in the area. To estimate the total benefits from the presence of a sports facility, an estimate of total WTP needs to be calculated. An estimate of total WTP can be found by summing the marginal WTP over all housing units around a sports facilities. Equation (5) is an expression for the hedonic price of proximity, a resident's marginal willingness to pay for proximity to a sports facility. Based on this expression, estimated total willingness to pay for proximity to sports facility s for any housing unit i can be estimated from

$$TWTP_{i,s} = MWTP_{i,s} \times DIST_i \tag{6}$$

a function of marginal WTP and the distance from the house to the sports facility, $DIST_i$. For any sample of housing units in the area, an estimate of aggregate willingness to pay can be found by adding up each individual's total WTP

$$AWTP_s = \sum_{i=1}^{N} TWTP_{i,s}. \tag{7}$$

The aggregate WTP measures the total value of the non-market benefits enjoyed by residents from proximity to a sports facility. An estimate of $AWTP_s$ in Columbus would provide information about the value of the intangible benefits generated by the two professional sports facilities in Columbus, to the extent that they are capitalized into residential housing prices, holding other factors like individual housing unit characteristics and neighborhood characteristics constant. We cannot calculate an estimate of $AWTP_s$ for either facility using our existing data. We have a sample of 9504 single family housing units that were sold in Columbus in 2000. Estimating $AWTP_s$ would require data on all housing units in Columbus, since WTP is capitalized into all housing prices, not just those houses that were sold in 2000.

The 2000 Census contains enough data on housing units to generate a rough estimate of $AWTP_s$ based on the results from the spatial hedonic housing prices presented above. The 2000 Census partitions Columbus, and all US cities, into Census Blocks, and also divides each Census Block into smaller Census Block Groups containing about 250 housing units. From the 2000 Census, we can determine the total number of residential housing units in each Block Group and the median housing price in each block group. Using GIS software, we calculated the distance from the centroid of each Block Group in Columbus to both Crew Stadium and Nationwide arena.

The median housing price in each Block Group, the distance from the centroid in each block group to each sports facility, and the estimated parameters from the spatial hedonic housing price model discussed above can be plugged into equations (5) and (6) to generate an estimate of the total willingness to pay for proximity to each sports facility for each house in the Block Group. Making this calculation implicitly assumes that, on average, the characteristics of the housing units in each Block Group are the same as the housing units in the sample, since the point estimates from the spatial hedonic housing model are conditional on the characteristics of the housing units in the 2000 transactions sample. In addition, the lack of detailed housing characteristics data at the Block Group level means that all of the variation in this estimated willingness to pay for proximity cones from distance to the facility. This estimated total willingness to pay for proximity to each sports facility for each housing unit in each Block Group in Columbus can be multiplied by the total number of housing units in each Block Group to get an estimated total willingness to pay for proximity to each sports facility for the entire block group. With this estimate in hand, estimated total willingness to pay for proximity in each block group can be summed over block groups to generate an estimate of the total willingness to pay for the presence of a sports facility.

In theory, the effect of proximity of a sports facility extends over the entire Columbus area, and declines with distance to the facility. In practice, the willingness to pay for some spatial amenity like proximity to a sports facility is calculated for some "impact area" around the source of the amenity. Tu (2005) uses a 2.5 mile impact area around FedEx Field in suburban Washington, DC; Ahlfeldt and Maennig find effects within about 1.5 miles of the three facilities in their sample. Since Nationwide arena and Crew Stadium are located several miles apart, and we want to avoid any overlapping impact areas, we calculated aggregate willingness to pay for proximity to each facility using an impact area of one mile from each facility. We added up the estimated total willingness to pay in each Census Block Group within one mile of each facility. The estimated aggregate willingness to pay for proximity to Nationwide Arena was $222.5 million for all residential housing units located in Census Block Groups with a centroid within one mile of Nationwide Arena. The estimated aggregate willingness to pay for proximity to Crew Stadium was $35.7 million for all residential housing units located in Census Block Groups with a centroid within one mile of Crew Stadium. These represent back-of-the-envelope estimates of the dollar value of the intangible benefits generated by Nationwide Arena and Crew Stadium and capitalized into housing prices in Columbus. Expanding the impact area would expand the estimated value of the benefits, but this would also include some Census Block Groups in both impact areas.

We emphasize that these estimates of the dollar value of the intangible benefits of these two sports facilities must be interpreted carefully. We have made a number of strong assumptions to arrive at these estimates, including assumptions about the composition of the housing stock in Census Block Groups, and the applicability of the estimated regression parameters generated from a sample of 9504 residential housing units sold in 2000 to the entire housing stock in Columbus. In addition, the estimated dollar value of the intangible benefits generated by Nationwide Arena is biased up because the facility is located in downtown Columbus and we are unable to disentangle the effect of proximity to downtown Columbus from the effect of proximity to Nationwide Arena in this setting. In addition, nationwide Arena is the primary element of a long term, far reaching, integrated urban redevelopment program. Few sports facilities in North America have been designed and built this carefully. Because of these factors, the estimated value of the intangible benefits generated by Nationwide Arena may be much larger than those generated by similar facilities in other cities.

However, the fact that Crew Stadium, which is not in downtown Columbus and not part of a major urban redevelopment plan, generates and estimated $35.7 in intangible economic benefits is evidence that these benefits are an important feature of the urban professional sports environment. Crew Stadium is located in the middle of parking lots adjacent to the Ohio State Fairgrounds. It is used by a team in a relatively low profile professional sport, Major League Soccer, that plays a relatively small number of home games compared to most other major North American sports leagues. It cost only $25 million to build, so the structure is modest by North American professional sports facility standards. Yet our back of the envelope estimates indicate that Crew Stadium generates a non-trivial amount of intangible benefits, based on our estimated aggregate willingness to pay for proximity to the facility.

Conclusions and Policy Implications

Past research generally focused on the economic impacts of sports facilities on local income and employment growth, but ignored intangible benefits enjoyed by the residents derived from the presence of a sports facility, such as cultural importance, increased community visibility, and public image enhancement. This paper evaluates the intangible benefits of professional sports facilities, in terms of the economic impacts on residential property values, using a spatial hedonic approach applied to Nationwide Arena, home of the Columbus Blue Jackets and Crew Stadium, home of the Columbus Crew. The results show that the presence of both facilities has a significant positive effect on the value of surrounding houses and this positive effect decreases as the distance from the facilities increases. In particular, based on S2SLS estimates of a spatial hedonic price model that corrects for spatial autocorrelation with queen weights, housing values increase by 1.75% for each 10% decrease in the distance from the house to the facility. In dollar values the average increase in house value is $2,214 per house and the total increased house value associated with a 10% decrease in distance to Nationwide Arena is around $21 million for the 9504 houses in the sample. Based on data from the 2000 Census, the aggregate value of the willingness to pay for proximity to Nationwide Arena within one mile of the facility is $222.5 million; the aggregate value of the willingness to pay for proximity to Crew Stadium within one mile of the facility is $35.7 million. While both these facilities were built using private financing, the willingness to pay should not depend on the financing of the facility. If other similar publicly financed sports facilities generate similar willingness to pay in the surrounding areas, then this willingness to pay does not appear to be large enough to justify public subsidies for the construction of modern professional sports facilities.

This paper also demonstrates the importance of incorporating spatial effects in hedonic housing price models when assessing the effect of proximity to a sports facility on housing prices. The spatial hedonic model employed avoids the problem of biased and inconsistent estimates resulting from uncorrected spatial autocorrelation. The incorporation of spatial dependence into a traditional hedonic model illustrates how OLS estimates from traditional hedonic housing price models tend to overestimate the parameters on explanatory variables. However, when we incorporate the spatial multiplier effect in a spatial lag hedonic model, the estimated impact of changes in each explanatory variable is larger than that from the traditional hedonic model. For example, although the estimated coefficient on the variable reflecting distance to Nationwide Arena is larger when estimated by OLS than when estimated by S2SLS with spatial autocorrelation (0.135 compared to 0.084), the actual effect is less using OLS than using S2SLS with spatial lags ($0.135 < [1/(1-0.519)*0.084] = 0.175$). In other words, the increased housing value is 0.040% higher under S2SLS than under OLS for a 10% decrease in proximity.

The estimated value of intangible benefits generated by the two facilities in Columbus capitalized into residential housing prices provide a rough bound on the size of the intangible benefits that can be expected from other sports facilities. A new state of the art facility integrated in a comprehensive urban redevelopment program and located in the heart of a large city might be expected to generate increases in residential property values in the vicinity of hundreds of millions of dollars within a mile of the facility, if the location, planning, construction, and development is carried out carefully. A facility located outside the downtown core of a city that is not connected to any other economic development activities will still increase residential property values around the facility, but this increase will amount to tens of millions of dollars. By assessing the impacts of sports facilities on residential housing values, we add to the understanding of the economic benefits generated by professional sports facilities and help explain why cities continue to compete to subsidize sports facility construction. In particular, our results suggest that cities continue to subsidize the construction of professional sports facilities despite the lack of evidence that these facilities generate important tangible economic benefits because the facilities generate important intangible economic benefits. The presence of a professional sports facility and team, will generate substantial intangible benefits that are capitalized into housing values and enjoyed by the residents of the community. This has significant policy implications. In most cases, cities compete to attract a professional team or retain their current teams by subsidizing the construction of a new sports facility or the renovation of a current sport facility, not only because of the direct economic impacts but also because of these intangible benefits. The increased housing values, or households' WTP for it, combined with the other direct economic impacts, may justify the subsidies. From that perspective, this study provides an analytical framework for both policy decision-makers and researchers to better evaluate sports facility construction project.

References

Ahlfeldt, G. and W. Maennig (2007) "Impact of Sports Arenas on Land Values: Evidence from Berlin," International Association of Sports Economists Working Paper No. 07-03.

Anselin, L. (1988), *Spatial econometrics: Methods and Models.* Boston: Kluwer Academic.

Anselin, L. (2002), "Under the Hood: Issues in the Specification and Interpretation of Spatial Regression Model," *Agricultural Economics* 27: pp.247-267.

Anselin, L. (2003a) "GeoDa^{TM} 0.9 User's Guide," Spatial Analysis Laboratory, Department of Agricultural and Consumer Economics University of Illinois, Urbana-Champaign.

Anselin, L. (2003b), "Spatial Externalities, Spatial Multipliers, and Spatial Econometrics," *International Regional Science Review*, 26(2): pp.153-166.

Anselin, L., Florax, R.J.G.M., and Rey, S.J. (Ed.) (2004), *Advances in Spatial Econometrics:*

Methodology, Tools and Applications. Berlin: Springer-Verlag.

Baade, R.A. (1996), "Professional Sports as Catalyst for Metropolitan Economic Development," *Journal of Urban Affairs*, 18(1): pp. 1-17.

Baade, R. A. and Dye, R. F. (1990), "The Impact of Stadiums and Professional Sports on Metropolitan Area Development," *Growth and Change*, (Spring): pp.1-14.

Brasington, D.M. (2006), "Private Schools and the Willingness to Pay for Public Schooling," *Education Finance and Policy*, Spring 2007, Vol. 2, No. 2: pp.152-174..

Brasington, D.M. and Haurin, D.R. (2006), "Educational Outcomes and House Values: A Test of the Value-Added Approach," *Journal of Regional Science* 46(2): pp.245-268.

Brasington, D.M. and Hite, D. (2006), "A Mixed Index Approach to Identifying Hedonic Price Models," Working paper, Louisiana State University, Department of Economics, January 2006.

Basu, S. and Thibodeau, T.G. (1998), "Analysis of Spatial Autocorrelation in House Prices," *Journal of Real Estate Finance and Economics* 17 (1): pp.61-85.

Can, A. (1992), "Specification and Estimation of Hedonic Housing Price Models," *Regional Science and Urban Economics* 22(3): pp.453-474.

Carlino, G.A. and Coulson, N.E. (2004), "Compensating Differentials and the Social Benefits of the NFL," *Journal of Urban Economics* 56(1): pp.25-50.

Coates, D. and Humphreys, B. R. (1999), "The Growth Effects of Sports Franchises, Stadiums, and Arenas," *Journal of Policy Analysis and Management*, 18(4): pp.601-624.

Coates, D. and Humphreys, B.R. (2003), "The Effect of Professional Sports on Earnings and Employment in the Services and Retail Sectors in US Cities," *Regional Science and Urban Economics* 33: pp.175-198.

Coates, D. and Humphreys, B.R. (2005), "Proximity Benefits and Voting on Stadium and Arena Subsidies," *Journal of Urban Economics* 59(2): pp.285-299.

Crompton, J.L. (2004), "Beyond Economic Impact: an Alternative Rationale for the Public Subsidy of Major League Sports Facilities," *Journal of Sports Management* 18: pp.40-58.

Dehring, C.A., Depken, C.A., and Ward, M.R., (2007), "The Impact of Stadium Announcements on Residential Property Values: Evidence from a Natural Experiment in Dallas-Fort Worth, " *Contemporary Economic Policy* 25(4): pp. 627-638.

Economic Research Associates (2004), "Economic and Fiscal Impacts for the Proposed NFL Stadium in Arlington, Texas," ERA Project No. 15652. Prepared for City of Arlington.

Harrison, D. Jr. and Rubinfeld, D.L. (1978), "Hedonic Housing Prices and the Demand for Clean Air," *Journal of Environmental Economics and Management* 5(1): pp.81-102.

Irwin, E. G. (2002), "The Effects of Open Space on Residential Property Values," *Land Economics*, 78(4): pp. 465-480.

Johnson, B.K. and Whitehead, J.C. (2000), "Value of Public Goods from Sports Stadiums: the CVM Approach," *Contemporary Economic Policy* 18(1): pp.48-58.

Johnson, B.K., Groothuis, P.A., and Whitehead, J.C. (2001), “The Value of Public Goods Generated by a Major League Sports Team: CVM,” *Journal of Sports Economics*, 2(1): pp.6-21.

Johnson, B.K., Mondello,M.J., and Whitehead, J.C. (2005), “Contingent Valuation of Sports: Temporal Embedding and Ordering Effects,” *Journal of Sports Economics* 6(2): pp.1-23.

Kim, C.W., Phipps, T.T., and Anselin, L. (2003), “Measuring the Benefits of Air Quality Improvement: A Spatial Hedonic Approach,” *Journal of Environmental Economics and Management* 45(1): pp.24-39.

Michael, H.J., Boyle, K.J. and Bouchard, R. (2000), ”Does the Measurement of Environmental Quality Affect Implicit Prices Estimated from Hedonic Models?”, Land Economics, 76(2): pp. 283-298.

Mikelbank, B.A. (2004), ”Spatial Analysis of the Relationship between Housing Values and Investments in Transportation Infrastructure”, The Annals of Regional Science, 38: pp.705-726.

Nelson, A. C. (2001), ”Prosperity or Blight? A Question of Major League Stadiums Locations”, Economic Development Quarterly, 15(3): pp.255-265.

Noll, R. G. and Zimbalist, A. (1997), ”The Economic Impact of Sports Teams and Facilities”, Sports, Jobs, and Taxes, Eds by Noll, R.G. and Zimbalist, A., Washington, DC: Brookings Institution Press, 1997, Ch2.

Palmquist, R.B.(1984), ”Estimating the Demand for the Characteristics of Housing”, The Review of Economics and Statistics, 66(3): pp.394-404.

Rappaport, J. and Wilkerson, C. (2001), ”What Are the Benefits of Hosting a Major League Sports Franchise?”, Economic Review (Fed. Res. Bank of Kansas City).

Rasmussen, D.W. and Zuehlke, T.W. (1990), ”On the Choice of Functional Form for Hedonic Price Function”, Applied Economics, 22: pp.431-438.

Rosen, S. (1974), ”Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition”, Journal of Political Economy, 82: pp.34-55.

Siegfried, J. and Zimbalist, A. (2000), “The Economics of Sports Facilities and Their Communities,” *Journal of Economics Perspectives*, 14(3): pp.95-114.

Tu, C. C. (2005), “How Does a New Sports Stadium Affect Housing Values? The Case of FedEx Field,” *Land Economics*, 81(3): pp.379-395.

Figure 1: Dwellings and Facilities in the Sample