Parcel unit appraised value and LEED Criteria: Number of Public Transport Nodes

Bhagyashri B Joshi, M.S. Paul Woods, D.E.D. Michael Speed, Ph.D. Kiyoung Son, M.S. Texas A&M University College Station, TX Young Jun Park, Ph.D. University of Florida Gainesville, FL

The objective of this study was to determine if the appraised unit value (\$/sf) of unimproved land parcels in Houston, Texas could be predicted by a regression equation containing a group of independent variables that represent LEED transportation access criteria and the area of a land parcel. The independent variables: Number of Bus Stops, Number of Rail Stops and Parcel Area were all found to contribute significantly to the independent variable: Appraised Unit Value. The observational unit was properties in Houston, Texas that were unimproved (had zero improvement value). Findings suggest that the acceptance criteria for the LEED green building rating system regarding public transportation access have a significant influence on the appraised value in dollars per square foot of the subject properties. Based on the sample median lot size of 5300 square feet, the predicted lot value increases dramatically in proportion to the number of qualifying light rail stations and decreases marginally in proportion to the number of qualifying bus stops. Since the regression model and each independent variable were all significant at p<0.05 and the adjusted R-square was near 0.50, the study objective was deemed to have been answered in the affirmative. The final equation found is Predicted Un-Transformed Unit value = [1.873 - 0.015 (Num Bus stops) + 0.426 (Num Rail Stations) -0.000002522 (area)] (1/0.3).

Key Words: LEED, Sustainable Site, Harris County, Houston, Value

Introduction

Awareness of sustainability and the environment has led to the emergence of various voluntary standards for buildings such as LEED (USA). These standards claim to be market driven and serve as environmental building assessment methods. For these approaches to be viable as well as successful, it is essential to find out if the value of green projects incorporate environmental costs and benefits. "Green buildings" have gained popularity in some sectors of the economy in response to pricing signals. Little empirical evidence is available supporting that commercial real estate prices incorporate sustainability characteristics despite widely popularized financial and environmental benefits. Unfortunately, very few studies have attempted to gauge the price effects of green building ratings. (Fuerst and McAllister, 2008)

The aim of this study was to predict the appraised values (in dollars per square foot) of unimproved parcels in Harris County, Texas, based on the LEED sustainable rating for Public Transportation Access. The population of interest was parcels which were within a perimeter described by a distance of one mile outside of Beltway 8 encircling Houston, Texas. Parcels, randomly selected, were unimproved. As specified by the Harris County Appraisal District, these parcels had zero improvement value. Each parcel served as an observational unit based on which the data was collected and analyzed. Theme of this research was quantitative and the data gathered was analyzed using appropriate statistical tools. If the suggested model indicates a significant relationship between unit value (dollars per square foot) of a land and the LEED rating then it will indicate that the market accepts the economic value of the LEED public transportation access criteria. Also, it may encourage project developers to site their projects where public transportation is accessible.

Literature Review

According to the U.S. Census Bureau (2000) data, mean travel time to work in Houston is 27 minutes. This data also shows that 77.8 % drove alone and 12.7 % car-pooled with private automobiles. This has put local government under constant pressure to keep the infrastructure, such as highways, roads, public transit, etc, on a satisfactory level. New highways are under construction and more lanes are added to existing highways to meet the current need of the public and to keep up with the future increase in capacity. U.S Census data also reflects that people are more comfortable using their private automobiles than the existing mass transit system. This might be because the existing transit facilities are not that efficient or that they have limited connectivity. Though costly, local authorities may have to consider setting up an efficient alternative mass transit system to reduce ever-increasing pollution caused by automobiles. Therefore, LEED encourages developers to select sites that have convenient access to mass transportation networks (USGBC, 2005).

Research Hypothesis

The linear regression model tested the predictability of unit value of a parcel using the area of parcel, number of bus stops and number of rail stations that met LEED criteria for that parcel. The model was used only for those parcels that qualified for LEED credit.

Data Collection

The population of parcels was located within a perimeter described by a distance of one mile outside of Beltway 8 encircling and within the city limits of Houston, Texas. The population of interest contained only parcels which were unimproved. According to the Harris County Appraisal Data, parcels with zero improvement value were considered unimproved. All these parcels formed the population of interest for this research.

Sample Selection

From the population of unimproved parcels, all parcels that met LEED criteria for public transportation were listed. A random selection of 150 parcels, which qualified for LEED rating for Public Transportation Access, was then made. These parcels formed the treatment group.

Data Collected

This model had one dependent variable; the Appraised value/ Square foot of a parcel and the following were the independent variables which were considered as the predictors of the dependent variable:

- Independent Variable 1: Number of Bus stops which met the LEED criteria
- Independent Variable 2: Number of Rail stations which met the LEED criteria
- Independent Variable 3: Area of parcel, measured in square feet

Appraised Value/square foot of a parcel= $\beta_0 + \beta_1$ (Number of bus stops for a given parcel that met LEED criteria) + β_2 (Number of rail stations for a given parcel that met LEED criteria) + β_3 (Area of parcel) + ϵ

- β_0 = intercept, appraised value per square foot of a parcel when neither bus stops nor rail stations met the LEED criteria
- β_1 = partial slope for number of bus stops or expected change in appraised value per square foot of a parcel when one more bus stop which met LEED criteria was added to the parcel while controlling other independent variable

- β_2 = partial slope for number of rail stations or expected change in appraised value per square foot of a parcel when one more rail station which met LEED criteria was added to the parcel while controlling other independent variable
- β_3 = partial slope for area of parcel
- $\varepsilon = \text{error}$

This model was derived from a sample of 150 parcels that included the number of bus stops and rail stations which were within the qualifying LEED distances.

Collection Method

Population Mapping

The population of parcels lies within a perimeter described by a distance of one mile outside of Beltway 8 encircling Houston, Texas. This population will be represented on a map using GIS. In addition, appraised values of all the parcels selected in the previous step were recorded using Harris County Appraisal District data (HCAD). For collecting this information a 13-digit parcel ID was used and appraised value was retrieved. All parcels which had zero improvement value were then listed. This list thus formed the population of all parcels with zero improvement value. This population so obtained was considered for this research.

Selection of Treatment Group

A GIS file containing all population parcels was then projected on the Arc Map. Transportation maps of bus stops and light rail stations were obtained from Houston- Galveston Area Council (HGAC). These maps were then layered over the population map. This defined the location of all bus stops and light rail stations with respect to the population considered. Figure 1 illustrates this procedure graphically.



Figure 1: Station maps layered on parcels map and treatment group in GIS

In order to select treatment group, the buffer function of GIS was used. The Parcels which were within quarter mile distance (measured from centroid of parcel) from bus stops and/or half mile distance from light rail stations were selected. Figure 1 is a pictorial presentation of this procedure. All these selected parcels met LEED criteria of public transportation.

While collecting data it was found that a few of the parcels which qualified for LEED credit had both bus stop and light rail stations within qualifying distances i.e. both bus stop and light rail station were located within quarter mile

and half mile distances respectively from the parcel. And the rest of the parcels either met bus stop distance criteria or the light rail distance criteria. So, three groups of LEED qualifying parcels were formed for the analysis.

The first group consisted of all parcels which had both bus stops and light rail stations within qualifying distances. All the parcels in second group were located within a quarter mile of a bus stop. All parcels in the third group were located within half a mile of a light rail station. In this study, 50 parcels were randomly selected from each of the three groups. Thus, total 150 parcels were randomly selected. This formed the treatment group for this research.

Area of parcels and number data

Area of all 150 parcels was obtained from Harris County Appraisal District public data. Using 13-digit parcel ID. Also, using centroid of parcels as reference point, the distance to transit points was calculated. An excel matrix model was created using spherical law of cosines. With the help of matrix model number of bus stops and/or light rail stations that met LEED criteria for each parcel was calculated.

Analysis Method

Following statistical procedures were used to analyze the data.

- Graphs Scatter plots between all dependent and independent variables.
- Descriptive statistics Statistics about the means, standard deviations and variances of populations.
- Bivariate Correlation
- Multivariate analysis Analysis of Variance (ANOVA), Analysis of CO-Variance (ANCOVA) and General Linear Model (GLM) Analysis to check validity of proposed model
- Diagnostics tests Verifying that all the formal assumptions of analyses are satisfied: Tests for Normality using Kolmolgorov-Smirnov and Constant variance tests. Data translation analysis using Box-Cox procedure.

Findings

Descriptive Statistics

According to table 1, the dependent variable Unit value, (\$/SF), had a mean value of about \$27.25 per square foot and a median value of \$ 17.00 per square foot. The lowest unit value was about \$0.05 per square foot and the highest was \$175.00 per square foot. There were a few parcels that had a very high unit value per square foot in the sample. The independent variable Area, (SF), had a mean of about 13,536 square feet and a median of 5300 square feet. The lowest value was 41 square feet and the highest value was 458251 square feet. Few of the parcels had a very high value of the land area associated with them whereas a large number of parcels were in the low land area category. Area considered for this set of results was 0.51% of the total undeveloped land area of City of Houston. The appraised value, (\$), had a mean value of about \$311,638.00 and a median of \$91,590. It ranged from \$62 to \$13,568,900. Parcels with these lowest and highest appraised values met all the criteria to be in the population. These parcels had zero improvement value and qualified for LEED public transportation access credit.

Table 1

Contents	Unit Value	Area	Appraised Value
Mean	27.2471	13,535.81	311637.61
Median	17	5,300	91,590
Minimum	0.05	41	62
Maximum	175	458,251	13,568,900

Std Deviation	27.5674	44894.530	1.15749E6
Skewness	2.178	8.074	10.342
Kurtosis	7.725	72.243	117.398

Diagnostics

Since the sample size for this model was more than 50; Kolmogorov Smirnov significance value was used for testing normality of residuals. p = 0.000 < 0.05 (Alpha level) for Kolmogorov- Smirnov test of normality proved that residuals were not normal (see table 2). Hence, normality test was failed by residuals from the initial regression using original values for the dependent variable.

Table 2

Test of Normality

	Kolmogorov-Smirnov		
	Statistic	df	Siq.
Standardized Residual	0.173	150	0.000

Transformation of Dependent Variable

Since, formal assumptions to carry out regression were not met, dependent variable i.e. unit value was transformed. Box-Cox transformation was used to find the appropriate transformation.

Box-Cox suggested two possible transformations for the dependent variable. For the analysis purposes, following transformation was used.

Transformed Unit Value = $(Original Unit Value)^{0.3}$

Variance Analysis

Following model was considered after the transformation:

• Transformed Unit Value = $\beta_0 + \beta_1$ (Number of bus stops) + β_2 (Number of light rail stations) + β_3 (Area) + ε

P-value for this model was 0.000 < 0.05. Anova table p value tested the hypothesis that there was no linear relationship between dependent and independent variables. From the p value obtained from the analysis it could be said that this hypothesis was rejected. Hence, the statistical model was significant and that linear relationship existed between dependent and independent variables.

Speaking in terms of the research variables, transformed unit value of parcels was found linearly related to the area, number of bus stops and number of rail stations. Since, this relationship existed; the multiple regression correlation value was also significant.

Table 3

ANOVA	

Model	Sum of Squares	df	Mean Square	F	Siq.
Regression	52.203	3	17.401	40 252	0.000
Residual	51.582	146	0.353	49.232	
Total	103.785	149			

a. Predictors: (Constant), Area, Number of rail stations, Number of bus stops

b. Dependent Variable: Transformed Unit Value

Adjusted R- square for this model was 0.493. That is 49.3% variability in transformed unit value of parcels could be explained by the independent variables.

Table 4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.709	0.503	0.493	0.59439

a. Predictors: (Costant), Area, Number of rail stations, Number of bus stops

b. Dependent Variable: Transformed Unit Value

Even though all independent variables were found to be significant predictors, they were not as powerful as one might hope. About half, 49.3%, of the variability in the transformed unit value of parcels could be explained by these independent variables, whereas 51.7% of the variability was due to other factors not considered in this research.

Table 5

Coefficients

Madal	Unstandardized Coeffients		Standardized Coefficients		
Wibuei	В	Std. Error	Beta	t	Siq.
1. (Constant)	1.873	0.068		27.422	0.000
NumBus	-0.015	0.005	-0.265	-3.004	0.003
NumRail	0.426	0.043	0.879	9.980	0.000
Area	-2.522E-6	0.000	-0.136	-2.301	0.023

a. Dependent Variable: Transformed Unit Value

Parameter estimates showed that all three independent variables; number of bus stops, number of rail stations and area were significant predictors of transformed unit value of parcel. Number of rail stations meeting LEED criteria for a given parcel had the greatest effect on the transformed unit value as compared to other independent variables of the model.

Following was the predictive equation obtained for transformed unit value and un-transformed unit value. This model used the best estimates of the population parameters. Also, actual unit value and predicted unit value were compared (See Figure 2).

- Predicted Transformed Unit value= 1.873 -0.015 (Num Bus stops) + 0.426 (Num Rail Stations) 0.000002522 (area)]
- Predicted Un-Transformed Unit value= 1.873 -0.015 (Num Bus stops) + 0.426 (Num Rail Stations) 0.000002522 (area)]^(1/0.3)



Figure 2: Comparison between Actual Unit Value and Predicted Unit Value

Interpretation

The multiple regression analysis showed that both number of bus stops and area were significant predictors of the transformed unit value. For this model Anova test p value was 0.000. So, the research hypothesis; the model was significant and that number of bus stops, number of light rail stations and area were significant predictors of the transformed unit value of parcel was accepted. This model presented significant relationship between the transformed unit value of parcels and the measurements required to earn LEED credit. Independent variables used in this model namely number of bus stops meeting LEED criteria, number of light rail stations meeting LEED criteria and area together accounted for 49.3% variability in the transformed unit value of parcels. These variables emerged as significant predictors but they were not very powerful since 51.7% of the variation in the transformed unit value was explained by other factors which were not considered in this research.

Conclusions

For the model, predictability of transformed unit value of a parcel meeting LEED criteria using number of transit points i.e. bus stops and light rail stations (located within the qualifying LEED distances) and area was calculated. According to the results, an increase in the number of light rail stations led to the increase in transformed unit value of parcel. Whereas, number of bus stops which met LEED criteria for a given parcel had the completely opposite effect.

Bus and Rail Stop Effect on Value				
Bus Stops	Rail Stops	Predicted Value		
0.00	0.00	\$41,915		
1.00	0.00	\$40,798		
2.00	0.00	\$39,703		
3.00	0.00	\$38,628		
4.00	0.00	\$37,574		
0.00	1.00	\$83,361		
1.00	1.00	\$81,552		
2.00	1.00	\$79,770		
3.00	1.00	\$78,015		
4.00	1.00	\$76,288		
0.00	2.00	\$147,360		
1.00	2.00	\$144,660		
2.00	2.00	\$141,995		
3.00	2.00	\$139,365		
4.00	2.00	\$136,769		

Based on the sample median lot size of 5300 square feet, the predicted lot value increases dramatically in proportion to the number of qualifying light rail stations and decreases marginally in proportion to the number of qualifying bus stops. This effect can be clearly seen in Table 6 for a lot with an area held constant at the sample median of 5300 square feet. Here as the number of rail and bus stops are varied over a range of zero to four bus stops and zero to two rail stops, the predicted value of the parcel is calculated. In every case, the value of the median lot increases when the number of rail stops increases and decreases when the number of bus stops increases.

For example the predicted value for a median sized lot of 5300 square feet with no bus stop or rail stop is \$41,915. The same size lot with no bus stops and one rail stop has a predicted value of \$83.361. The lot value almost doubled by adding access to a qualified rail stop.

For the same lot size with a value of \$41,915 with access to neither a bus nor rail stop, the difference is noticeable relative to the addition of a bus stop rather than a rail stop. With zero rail stops and one bus stop, the predicted value is \$40,798. This is a drop in predicted value of over \$1,100 due to adding one bus stop. The difference between adding one bus stop and adding one rail stop is \$42,563.

This pattern may be particular to Houston because the light rail stations are concentrated more towards the center of the city i.e. downtown area, than being distributed all over the city. On the other hand bus stops are located all over the city. Area was found to be a significant predictor of the transformed unit value. As the plot area was increased, the transformed unit value of a parcel went down.

The model suggested that selection characteristics of the LEED green building rating system for public transportation access influences the appraised value, dollars per square foot, of properties. This finding further implies that the market indirectly considers the economic effect of the LEED rating system even though this assessment method does not explicitly include financial aspects in the evaluation framework. Findings of this research suggest that a sustainable feature of a site may be related to the economic worth of a related land development project. This could provide encouragement for new sustainable land development projects.

This is the first investigation of its kind. Future studies will need to identify other factors that could explain more of the variation in the unit value of parcels. Also, findings of this research were based on the City of Houston. Future studies could focus on other cities.

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