Correlation Analysis between Median Household Income and LEED-Certified Public Transportation Access

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Abstract

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System provides third-party verification for environmentally sustainable construction. But while LEED-certified buildings provide healthier work and living environments, Previous studies have shown that LEED certification does not provide any direct economic incentives to owners and developers. To address this issue, this study aims to investigate the economic benefits of LEED criteria. The objective of this study is to examine whether or not there is a significant correlation between median household income and the number of bus stops and light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access. The findings showed that the number of bus stops had a positive correlation with median household income, which means that more bus stops a given parcel had that met LEED criteria, the greater the median household income of a block group where the given parcel was located would be, though this positive correlation was very weak.

Keywords : LEED, public transportation access, median household income, correlation analysis

1. Introduction

This research is designed to find out the specific reasons. It is generally agreed that transit services in disadvantaged neighborhoods can have potentially positive effects on access for socially excluded or economically marginalized families[1]. The highest quality transit modes, such as the metro or subway, may find their stations mostly surrounded by higher income households; light rail transit stations will be mostly surrounded by more moderate income households; and lower income households, located in the poorest areas of the city, will be served only by buses[2].

Household income is a metric commonly used by the United States government and private institutions. It includes all the income of all residents over the age of 18 in each household, including not only all wages and salaries, but also such items as unemployment insurance, disability payments, child support payments, regular rental receipts, as well as any personal business, investment, or other kinds of income received as a matter of routine[3]. According to the US Census Bureau, the median is "considerably lower than the average, and provides a more accurate representation[4] of socio-economic status."
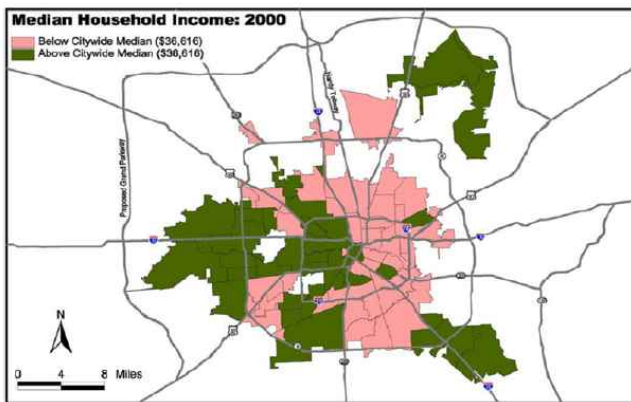
Figure 1. Median Household Income of Houston, Texas

Thus, this research uses median household income as the appropriate indicator of socio-economic status to study its correlation with the number of bus stops and light rail stations that meet LEED sustainable site criteria for public transportation access in each parcel. This study collected the household income in Houston, Texas. Figure 1 shows the Houston median household income map of 2000.

2. Literature review

Since the end of 1980, efforts to achieve sustainable development of buildings have been widely pursued by international organizations. Among the countries promoting sustainable development, the Leadership in Energy and Environmental Design (LEED) developed by the U.S. Green Building Council (USGBC) has been widely adopted in various countries. The first LEED Pilot Project Program, also referred to as LEED Version 1.0, was launched at the USGBC Membership Summit in August 1998. After extensive modifications, the LEED Green Building Rating System Version 2.0 was released in March 2000. This rating system is now called the LEED Green Building Rating System for New Commercial Construction and Major Renovations. On April 27, 2009, USGBC launched LEED version 3.0.

This study focuses only on LEED-NC Version 3.0, which has seven categories of various energy-efficient requirements:
· Sustainable Sites (26 points)
· Water Efficiency (10 points)
· Energy & Atmosphere (35 points)
· Materials & Resources (14 points)
· Indoor Environmental Quality (15 points)
· Innovation in Design (6 points)
· Regional Priority (4 points)

Of these, this study used Sustainable Sites: 4.1-Alternative Transportation: Public Transportation Access, which is stated in following pattern[5]:

2.1 Intent

To reduce pollution and land development impacts from automobile use.

2.2 Requirements

Option 1. Rail Station Proximity

Locate the project within 1/2-mile walking distance (measured from a main building entrance) of an existing or planned and funded commuter rail, light rail or subway station.

Option 2. Bus Stop Proximity

Locate the project within 1/4-mile walking distance (measured from a main building entrance) of 1 or more stops for 2 or more public, campus, or private bus lines usable by building occupants.

In this study, based on these criteria, an analysis of the correlation between median household income and public transportation access criteria is conducted.

3. Research Methodology

Pearson's correlation was examined to determine whether or not there is a significant correlation

between median household income and the number of bus stops and light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access.

Only unimproved parcels, which were within a perimeter described by a distance of 1 mile outside of Beltway 8 encircling and within the city limits of Houston, Texas, were included in this study.

In addition, median household income data obtained from Census 2000 data did not precisely represent the specific household income of a given parcel, but represented the median household income of the block group where the given parcel was located. This is because the block group is the smallest geographic unit for which the Census Bureau tabulates sample data.

Another reason is that the parcels qualified for this research were all unimproved, which means there were no buildings or structures built on these parcels, and thus no individuals or families lived there either. As a result, the specific household income of a particular unimproved parcel could be meaningless, whereas the median household income of a block group where the given parcel was located would be a appropriate as an alternative value. Therefore, this study used the median household income of the block groups.

4. Data Collection

Population is defined as all unimproved parcels, which were within a perimeter described by a distance of 1 mile outside of Beltway 8 encircling and within the city limits of Houston, Texas. Figure 2 is the GIS Map of Houston, Texas. 150 parcels qualified for LEED Sustainable Sites Criteria of Public Transportation Access were randomly selected from the population.
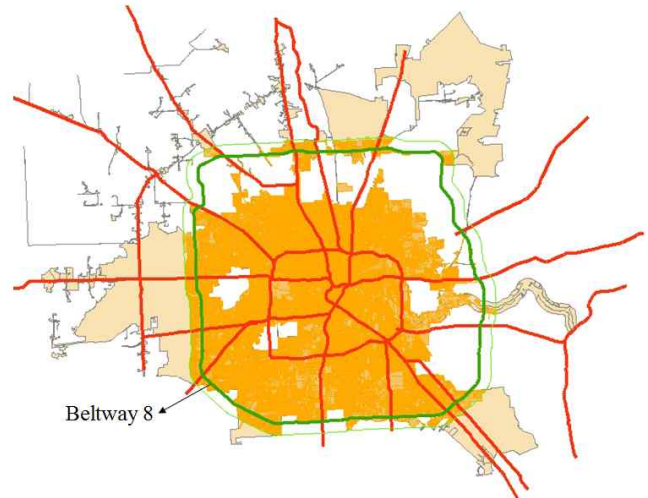

Figure 2. Population of interest (Houston, Texas)

The information of all the parcels was obtained from Harris County Appraisal District web site[6]. All parcels with zero appraised improvement value were then listed. This list formed the population of all unimproved parcels.

Transportation maps obtained from Houston-Galveston Area Council were layered over the population map[7]. The location of all bus stops and light rail stations was then displayed on the population map. Figure 3 shows the locations of all bus stops and light rail stations in Houston, Texas.
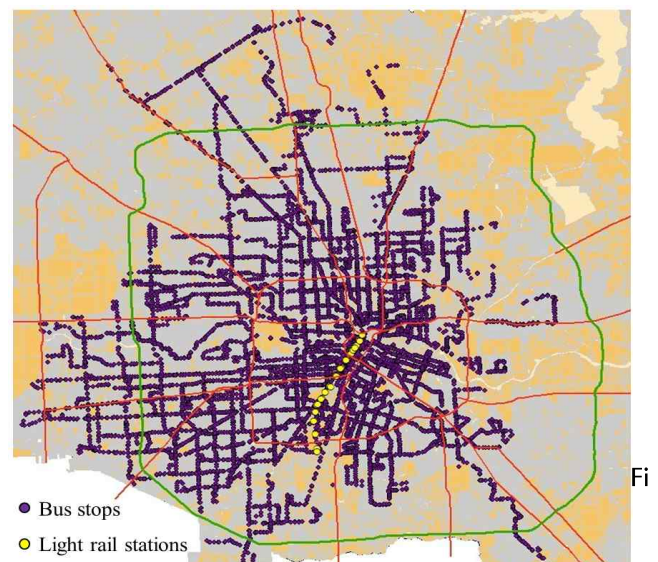

- ● Bus stops
- ○ Light rail stations

gure 3. Public Transportation Map

Figure 4(a) was created to select parcels within 1/4 mile (measured from centroid of each parcel) of any bus stop. Finally, Figure 5(b) was created to select parcels which were within 1/2 mile (measured from centroid of each parcel) of any light rail station.

After GIS mapping, the data were collected. The first group consisted of 50 parcels, which were qualified for both bus stops and light rail stations.
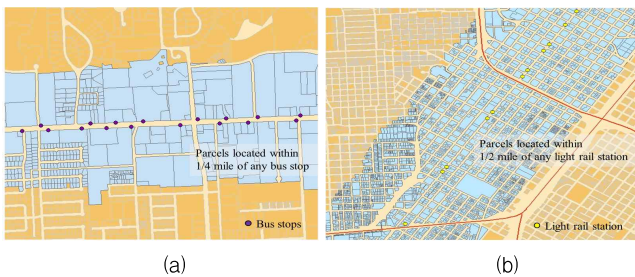

(a)   (b)

Figure 4. Qualified Parcels for Bus Stops(a) and Light Rail Stations

A second group consisted of 50 parcels, which were only qualified for bus stop requirements. The third group consisted of 50 parcels, which were only qualified for light rail station requirements. All 150 qualified parcels (50 parcels for each group) were randomly selected and formed the samples for this study.

5. Data Analysis

5.1 Descriptive Analysis

As shown in Table 1, the number of bus stops had a mean of about 8 and the number of light rail stations had a mean of about 2. Median household income had a mean of about 39.08 thousand US dollars. The lowest value was 10.15 thousand US dollars and the highest value was 163.49 thousand US dollars. Finally, the area (in square feet) had a mean of about 13,536 square feet. The lowest value was 41 square feet and the highest value was 458,251 square feet.

Table 1. Descriptive Analysis

	Num Bus	Num Rail	Median Household	Area	Unit Value
N	150	150	150	150	150
Range	72	7	153.34	458,210	174.94
Min.	0	0	10.15	41	0.05
Max.	72	7	163.49	458,251	175
Mean	8.13	1.60	39.08	13,535.81	27.24
Std. Deviation	14.51	1.72	22.52	44,894.52	27.56
Variance	210.65	2.96	507.22	20,551.87	759.96

5.2 Correlation Analysis

The scatter plot for median household income versus number of bus stops which met LEED criteria indicated a weak positive relation between the two variables, which means that as the number of bus stops in a given parcel which met LEED criteria increased, median household income of the block group where a given parcel was located increased as well (see Figure 5(a)). This positive relation was extremely weak because R square value is only 0.025 and the slop seemed very gentle. In addition, the scatter plot also indicated that number of bus stops that met LEED criteria for most qualified parcels was less than 20; furthermore, the median household income for most qualified parcels was less than 100,000 dollars.

The scatter plot for median household income versus number of light rail stations which met LEED criteria indicated a weak positive relation between the two variables, which means that as the number of light rail stations in a given parcel which met LEED criteria increased, median household income of the block group where a given parcel was located increased as well (see figure 5(b)). This positive relation was extremely weak because R square value is only 0.069 and the slope seemed very gentle.

Scatter plot for unit value versus median household income indicated a positive relation between the two variables, which means that as the median household income of the block group where a given
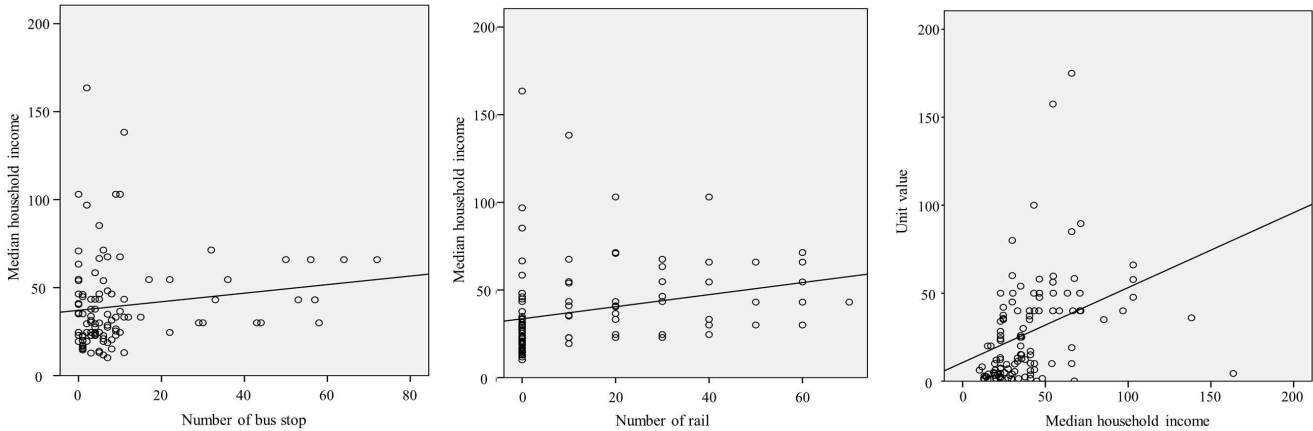
Figure 5. Scatter Plot of Median Household Income vs. Number of Bus Stops (a), Household Income vs. Number of Light Rail Stations (b), Unit Value vs. Median Household Income (c)

parcel was located increased, unit value of this parcel increased as well (see figure 5(c)). Even if the slope of the line that indicated the increment rate is obvious, this positive relation was weak because R square value is 0.121 and the data points did not seem to line up.

Finally, the scatter plot for unit value versus area indicated a weak negative relation between the two variables, which means that as the area of a given parcel increased, unit value of this parcel decreased (see figure 6). This negative relation was extremely weak because R square value is only 0.002 and the data points did not seem to line up. As displayed in this scatter plot, only 4 data points fell on the right side of point 10000 of the x-axis while most of the data points were concentrated near point 0 of the x-axis, which means only a few of the parcels had a large area whereas the majority of parcels were small in size.

Scatter plot matrix (see Figure 7), which contained scatter plots for each pair of variables, indicated a possible linear relation between number of bus stops and number of light rail stations; however, it did not indicate any other clear linear relations among the variables, especially for the scatter plots of median household income against

number of bus stops and median household income against number of light rail stations.
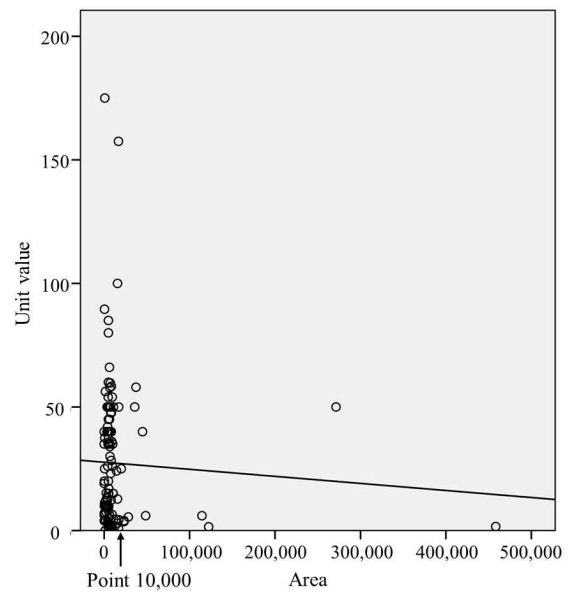

Figure 6. Scatter Plot of Unit Value vs. Area

As shown in Figure 7, only correlations for area against unit value and area against number of bus stops meeting LEED criteria were found to be negative and extremely low, which means that both unit value and number of bus stops would decrease as the parcel area increased. The likely reason was that large size parcels were located farther from the downtown area. Conversely,

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number of bus stops, number of light rail stations and median household income had positive and relatively higher correlations.
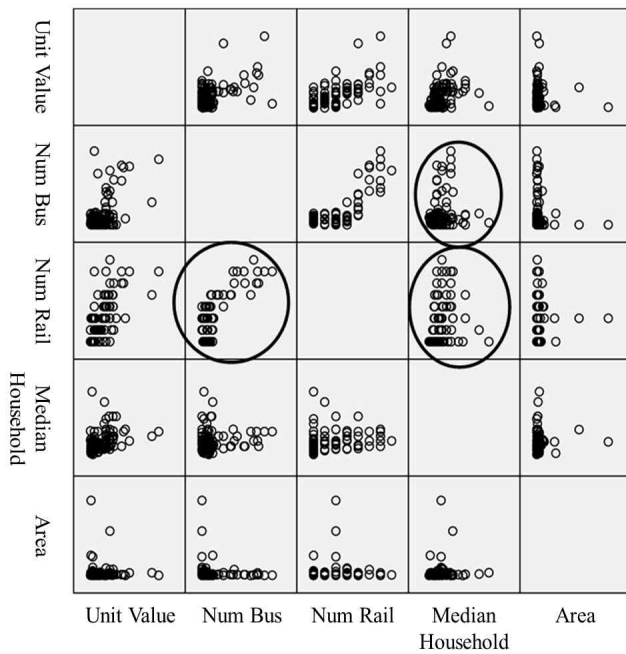

Figure 7. Scatter Plot Matrix of Variables

Table 2. Pearson Correlations

	Unit Value	Num Bus	Num Rail	Median Household	Area
Unit Value	1.000	0.524	0.679	0.348	−0.047
Num Bus	0.524	1.000	0.745	0.157	−0.075
Num Rail	0.679	0.745	1.000	0.263	0.025
Median Household	0.348	0.157	0.263	1.000	0.055
Area	−0.047	−0.075	0.024	0.055	1.000

Furthermore, correlation for each pair of variables was much less than 0.9, which means all variables were not highly correlated. From Table 2, median household income was not highly correlated to both number of bus stops and number of light rail stations, because the correlations were only 0.157 and 0.263 respectively.

6. Conclusions

Based on the correlations found among variables, the research hypothesis that there is a significant correlation between median household income and the number of bus stops and light rail stations that met LEED sustainable site criteria for public transportation access in a parcel was rejected. This was because Pearson's correlation for median household income against number of bus stops and median household income against number of light rail stations was only 0.157 and 0.263, respectively, both of which were much less than 0.9. This weak correlation could also be confirmed by the scatter plots for median household income versus number of bus stops.

Furthermore, it was important to notice that number of bus stops had a positive correlation against median household income, which means that the more bus stops which met LEED criteria a given parcel had, the greater the median household income of a block group where the given parcel was located would be. Even if this positive correlation was very weak, this interesting result still contradicted our original expectation that as median household income increased, the number of bus stops which met LEED criteria would go down.

Because of the difficulty obtaining reliable improvement value data, only unimproved parcels and appraised land values were considered in this research. It will be advantageous if future researchers could extend to their scope to improved parcels and collect data for both land value and improvement value.

In addition, median household income data were merely for the block group where a given parcel was located, not for a specifically given parcel. For this reason, in future research it will be desirable to obtain median household income data for

a block or even a parcel.

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