CORRELATION BETWEEN MEDIAN HOUSEHOLD INCOME AND LEED SUSTAINABLE SITE CRITERIA FOR PUBLIC TRANSPORTATION ACCESS AND A REGRESSION MODEL PREDICTING APPRAISED UNIT VALUE OF UNIMPROVED PARCELS IN HOUSTON, TEXAS

A Thesis

by

QUNDI JI

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2010

Major Subject: Construction Management

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Approved by:

Chair of Committee,	Paul Woods
Committee Members,	Ifte Choudhury
	Michael Speed
Head of Department,	Joe Horlen

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ABSTRACT

Correlation between Median Household Income and LEED Sustainable Site Criteria for Public Transportation Access and a Regression Model Predicting Appraised Unit Value of Unimproved Parcels in Houston, Texas. (May 2010)

Qundi Ji, B.E., Civil Engineering, Zhejiang University

Chair of Advisory Committee: Dr. Paul Woods

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System provides third-party verification for environmentally sustainable construction. LEED certified buildings often provide healthier work and living environments, however, it does not provide any direct economic incentives to the owners and developers. An early research suggested that there was a significant correlation between appraised unit value of a parcel and LEED sustainable site criteria for public transportation access. Moreover, the regression model for predicting appraised unit value of a parcel suggested that the coefficient of Number of Light Rail Stations was positive, while the coefficient of Number of Bus Stops was negative. This result contradicted our original expectation that both number of bus stops and light rail stations could have a positive effect on the appraised unit value. Hence it becomes important to conduct further research to explain this phenomenon.

In this research, Pearson correlation was examined to determine whether 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. After confirming no significant correlation exists, multiple regression analysis was applied to establish a regression model for predicting unit value of a given parcel using number of bus stops and light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access, median household income and parcel area as the independent variables.

Result of Pearson correlation indicated that there was no significant correlation exists between median household income and the number of bus stops and light rail stations for a given parcel which met LEED sustainable site criteria for public transportation access.

Findings of multiple regression analysis suggested that all independent variables were significant predictors for unit value of a parcel. Besides, this regression model had a higher adjusted R- square value than that of the model which was established by Bhagyashri Joshi. It means that this regression model could better predict appraised unit value of an unimproved parcel.

DEDICATION

This work is dedicated to my beloved parents, Mr. Jianghua Ji and Mrs. Xiaofen Xiong, and also my dear girlfriend, Yao Lin. Without their caring support, patience and love, it would not have been possible for me to complete this work.

ACKNOWLEDGEMENTS

I would like to express the deepest appreciation to my committee chair, Dr. Woods, and my committee members, Dr. Choudhury and Dr. Speed, for their guidance and support throughout the course of this research.

Thanks also go to my friends and colleagues and the department faculty and staff for making my time at Texas A&M University a great experience.

Finally, thanks to my parents for their encouragement and to my girlfriend for her patience and love.

NOMENCLATURE

GIS	Geographic Information System
HCAD	Harris County Appraisal District
HGAC	Houston – Galveston Area Council
LEED	Leadership in Energy and Environmental Design
LEED-NC	Leadership in Energy and Environmental Design for New Construction
USGBC	United States Green Building Council
VIF	Variance Inflation Factors

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CHAPTER I

INTRODUCTION

Problem Statement

In Leadership in Energy and Environmental Design for New Construction (LEED-NC) rating system, there is a particular credit for public transportation access which states how many bus stops or light rail stations should be located within a certain distance of the target building in detail. Bhagyashri Joshi’s (2009) research suggested that there was a significant correlation between appraised unit value of a parcel and LEED sustainable site criteria for public transportation access. Moreover, the regression model for predicting appraised unit value of a parcel suggested that the coefficient of Number of Light Rail Stations was positive, while the coefficient of Number of Bus Stops was negative. This result contradicted our original expectation that both number of bus stops and light rail stations could have a positive effect on the appraised unit value. One reasonable explanation might be that there was a potential link between economic status and transportation mode. Hence, Median Household Income was used in this research to represent economic status, while Number of Light Rail Stations and Number of Bus Stops were used to represent transportation mode. In addition, area of a parcel was also considered in this research because it might possibly influence its unit value.

This thesis follows the style of *International Journal of Construction Education and Research*.

Research Objective

Determine whether 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.

If there is a significant correlation, establish a regression model regarding median household income as the dependent variable and both number of bus stops and light rail stations that meet LEED sustainable site criteria for public transportation access as the independent variables.

If no significant correlation exists, establish a new predicting model for unit value of a given parcel using number of bus stops and light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access, median household income and parcel area as the independent variables. Hopefully, this new regression model could have a higher adjusted R- square value than Bhagyashri Joshi's (2009) model, which means this new regression model could better predict appraised unit value of an unimproved parcel.

Research Hypotheses

H_0: There is a significant correlation between median household income and the number of bus stops and light rail stations that meet LEED sustainable site criteria for public transportation access for a parcel.

If there is a significant correlation, then test the hypothesis:

Model: Median household income = β_0 + β_1 (Number of bus stops for a given parcel that meet LEED criteria) + β_2 (Number of light rail stations for a given parcel that meet LEED criteria) + ε, is statistically significant and $\beta_1 \leq 0$, $\beta_2 \geq 0$.

If no significant correlation exists, then test the hypothesis:

Model: Appraised unit value of an unimproved parcel=β_0 + β_1 (Number of bus stops for a given parcel that meet LEED criteria) + β_2 (Number of light rail stations for a given parcel that meet LEED criteria) + β_3 (Median household income) +β_4 (Area of a given parcel) + ε, is statistically significant.

Importance of Research

According to the findings of Bhagyashri Joshi's (2009) research, there was a significant correlation between appraised unit value of a parcel and LEED sustainable site criteria for public transportation access. Moreover, the regression model for predicting appraised unit value of a parcel suggested that the coefficient of Number of Rail Stations was positive, while the coefficient of Number of Bus Stops was negative. This means, an increase in the number of light rail stations which met LEED criteria for a given parcel led to an increase in the appraised unit value of a parcel; whereas, number of bus stops had completely opposite effect on the transformed unit value of that parcel.

This interesting result contradicted our original expectation that both number of bus stops and light rail stations could have a positive effect on the appraised unit value. Hence it becomes important to conduct further research to explain this phenomenon.

Assumptions

All data collected from public sources and used in this research are accurate and reliable.

Appraised value reasonably reflects the actual value.

Median household income of a block group where a given parcel was located is a proper indicator to represent the actual average economic conditions of that parcel.

Median household income of different block groups increased equally during the past decade (from 1999 to 2009). Hence, median household income data from census 2000 could truly indicate the present household economic conditions of each block group.

LEED-NC Sustainable Sites Credit 4.1-Alternative Transportation: Public Transportation Access-is an effective rating system. Hence, number of bus stops and light rail stations for a given parcel that meet this LEED criteria could assess the actual sustainability of public transit around parcels.

Definitions

Number of bus stops and light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access: Number of all public or campus bus stops located within 1/4 mile of a given parcel.

Number of light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access: Number of all existing light rail stations located within 1/2 mile of a given parcel.

Parcel: A fundamental cadastral unit. A piece of land which can be owned, sold, and developed.

Appraised value: The estimated value upon which property taxes are calculated.

Appraised land value: The appraised value merely assigned to the land of a given parcel by the Appraisal District Office in US dollars.

Appraised improvement value: The appraised value assigned to a structure or building by the Appraisal District Office in US dollars.

Unimproved parcel: The parcel with zero improvement value, which means there were no buildings or structures constructed on it, namely a vacant parcel.

Appraised unit value of an unimproved parcel: It is defined as the unit value (in US dollars per square foot) which is equal to appraised land value (in US dollars) of a given parcel divided by area (in square feet) of the same parcel.

Median income: The amount which divides the income distribution into two equal groups, half having income above that amount, and half having income below that amount (U.S. Census Bureau, 2006).

Household: A household is defined as one or more people living in a residence (Social Science Data Analysis Network, 2000).

Block group: A subdivision of a census tract (or, prior to 2000, a block numbering area), a block group is the smallest geographic unit for which the Census Bureau tabulates sample data (U.S. Census Bureau, 2006).

Household income: A measure commonly used by the United States government and private institutions. That measure counts all the income of all residents over the age of 18 in each household, including not only all wages and salaries, but 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 routinely (U.S. Department of Housing and Urban Development, 2009).

Median household income: In this study, median household income is defined as the median of household income data in the year 1999 of a block group where the given parcel was located, and the data will be recorded in thousands of US dollars.

Limitations

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 research. Besides, these parcels should not be exempted from tax as defined by Harris County Appraisal District.

In this research, 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 block group is the smallest geographic unit for which the Census Bureau tabulates sample data. Another reason is the parcels qualified for this research were all unimproved, which means there were no buildings or structures built on these parcels, hence no individuals or families lived there either. As a result, the specific household income of a particular unimproved parcel could be meaningless, whereas median household income of a block group where the given parcel was located would be a proper alternative value.

Harris County Appraisal District updates the GIS Parcel data quarterly on their website. Data for this research, such as appraised land value and parcel area, was obtained for the first quarter of the year 2009. For parcels whose 2009 data was not available, 2008 data was used.

Only the existing light rail lines located in the Houston were used in this research.

This research concentrated only on LEED-NC Version 2.2 Sustainable Sites Credit 4.1-Alternative Transportation: Public Transportation Access. This credit requires to measure distance from the entrance of a building. However, there were no buildings on unimproved parcels, so it becomes more rational to calculate the distance to bus stops or light rail stations from the centroid of parcels.

Delimitations

Findings and regression models of this research are only applicable to unimproved parcels in the Harris County Appraisal District, and will be inappropriate if applied to other areas.

This research study focused only on LEED-NC Sustainable Sites Credit 4.1-Alternative Transportation: Public Transportation Access. Findings and corresponding interpretation could only be applied to this LEED credit.

The Decennial Census occurs every 10 years, in years ending in zero. Median household income data for this research is obtained from Census 2000 data on U.S. Census Bureau website which is based on the data of the year 1999.

In this research, only four independent variables, which were number of bus stops for a given parcel that meet LEED criteria, number of light rail stations for a given parcel that meet LEED criteria, median household income of a block group where the given parcel was located and Area of a given parcel, were examined and analyzed. Many other relevant variables were not considered, but could be studied in future research.

CHAPTER II

LITERATURE REVIEW

Background

Buildings do have a significant impact on the environment. In the United States buildings account for 37% of the primary energy use, 40% of non-industrial solid waste, 12% of potable water use, 35% of carbon dioxide emissions, and 49% of sulphur dioxide emissions. "Green building" evolved as a means to reduce this negative environmental impact throughout the complete building life cycle (Corbett & Muthulingam, 2007).

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC), provides third-party verification that a building or community was designed and built using strategies aimed at improving performance including energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts (USGBC, 2009).

LEED certified buildings often provide healthier work and living environments, which contribute to higher productivity and lower-than-industry-standard operational costs (Wikipedia, 2009).

However, LEED rating system is a voluntary system, it does not provide any direct economic incentives, such as selling a house or renting an office out at a higher price, to the owners and developers.

The motivation for adoption of innovations, including voluntary standards, may be related to the quest for signaling, meaning that the organization wishes to communicate something about its practices to the outside world, including regulators, customers, the public, etc. Alternatively, adoption may be driven by the quest for intrinsic benefits, meaning that the organization expects actual economic and/or environmental benefits that are a direct result of the standard, regardless of perceptions in the outside world (Corbett & Muthulingam, 2007).

To assess the effectiveness of an innovation, it is essential to ascertain not just the breadth of adoption but also the depth of adoption. The depth of adoption is closely related to whether adoption occurred only for signaling reasons, in which case the depth will be the minimum required for the signal to be effective, or due to the intrinsic benefits of the standard, in which case adoption can (but need not) be deeper (Westphal, Gulati, & Shortell, 1997).

Hence it is extremely important to find out the intrinsic benefits (like actual economic and/or environmental benefits) of adopting LEED rating standards, whereas site selection is the first and essential step for a construction project. Especially for a LEED project, development of greenfield or previously undeveloped sites consumes land. Development projects must be sensitive to encroaching on agricultural lands, compromising existing wildlife habitat, and exacerbating local and regional erosion. The impacts of increased impervious surfaces to stormwater runoff should be controlled to mimic natural conditions and protect water quality in receiving waters (USGBC, 2006).

This research will only study the LEED rating standards for public transportation access in sustainable site part, because a building's location also affects ecosystems based on the occupants' options for travel to and from the site. According to the Federal Bureau of Transportation Statistics, vehicle use in America has nearly tripled, from 1 to 2.85 trillion miles per year, between 1970 and 2002. Vehicles are responsible for approximately 20% of U.S. greenhouse gas emissions annually (NRDC). Vehicle fuel consumption and emissions contribute to climate change, smog, and particulate pollution, all of which have negative impacts on human health. The infrastructure required to support vehicle travel (parking and roadway surfaces, service stations, fuel distribution networks, etc.) increase the consumption of land and nonrenewable resources, alter stormwater flow and absorb heat energy, exacerbating heat island effect (USGBC, 2006).

If we could find out some obvious economic benefits by achieving LEED sustainable site criteria for public transportation access, this will provide encouragement for investors to develop new construction projects on the sites located closer to mass transit networks. This could evidently reduce the use of private vehicles, and eventually reduce the pollution caused by automobile use.

Introduction of LEED

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC), provides a suite of standards for environmentally sustainable construction. Since its inception in 1998, LEED has grown to encompass more than 14,000 projects in the United States and 30 countries covering 1.062 billion square feet (99 km^2) of development area (Wikipedia, 2009).

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, or LEED-NC (USGBC, 2006). On April 27, 2009, USGBC launched LEED v3 (USGBC, 2010).

There are many different LEED Rating Systems available for specific project types:

- LEED for New Construction: New construction and major renovations (the most commonly applied-for LEED certification).

- LEED for Existing Buildings: Existing buildings seeking LEED certification.
- LEED for Commercial Interiors: Commercial interior fitouts by tenants.
- LEED for Core and Shell: Core-and-shell projects (total building minus tenant fitouts).
- LEED for Homes: Homes.
- LEED for Neighborhood Development: Neighborhood development.
- LEED for Schools: Recognizes the unique nature of the design and construction of K-12 schools.
- LEED for Retail: Consists of two rating systems. (Wikipedia, 2009).

Among them, LEED for New Construction is the most popular one, which provides a set of performance standards for certifying the design and construction phases of commercial, institutional buildings, and high-rise residential buildings. The intent of LEED for New Construction is to assist in the creation of high performance, healthful, durable, affordable and environmentally sound commercial and institutional buildings (USGBC, 2006).

This research only focuses 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)

This version of LEED ratings are awarded according to the following scale:

- Certified 40 – 49 points
- Silver 50 – 59 points
- Gold 60 – 79 points
- Platinum 80 points and above

The credit that will be applied to this research is Sustainable Sites Credit 4.1-Alternative Transportation: Public Transportation Access, which is stated in following pattern:

- **Intent**

  To reduce pollution and land development impacts from automobile use.

- **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.

  OR

  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.

- **Potential Technologies & Strategies**

  Perform a transportation survey of future building occupants to identify transportation needs. Locate the building near mass transit (USGBC, 2008).

Young Jun Park's Research

The primary objectives of Young Jun Park's (2009) research was to identify the relation between LEED criteria regarding the sustainable site selection and the appraised values of sites in Houston, Texas; and additionally to analyze effects of detail components which leverage the sustainable credits regarding the public transportation access in terms of economic issues.

The criteria regarding the sustainable site selection in this LEED metric are Sustainable Site Credit (SSC) #1: Site Selection, SSC #3: Brownfield, and SSC #4.1: Public Transportation Access. Linear regression method was used for the quantitative analysis regarding economic profits as well as environmental preservation. In this model, the unit appraised value of land was used as dependent variable to reflect economic values of the land and LEED sustainable site criteria were used as categorical independent variables (Park, 2009).

According to the results of statistical analysis, the criteria, SSC #4.1 was highly significant. Furthermore, the detail components of SSC #4.1 regarding the bus stops and railroad stations were also significant. These positive results can lead to environmental preservation while avoiding the development of land which is far from the public transportation access as well as the future economic merits due to enhancing the development density near the public transportation access (Park, 2009).

Bhagyashri Joshi's Research

Bhagyashri Joshi (2009) did an efficient research on finding out the economic benefits by achieving LEED-NC Sustainable Sites Credit 4.1-Alternative Transportation: Public Transportation Access.

The aim of Bhagyashri Joshi's (2009) study was to predict the appraised values (in dollars per square foot) of unimproved parcels in Houston, Texas based on the LEED sustainable rating for Public Transportation Access. Two models were established in her research, but our research just focuses on Model 1. For Model 1, the dependent variable is Appraised Value/Area of a parcel; the independent variables are Number of bus stops for a given parcel that meet LEED criteria, Number of light rail stations for a given parcel that meet LEED criteria and Area of a given parcel

She first used the account number of each parcel to obtain data concerning area and appraised value of a given parcel from Harris County Appraisal District website, then applied ArcGIS software to obtain the data concerning number of bus stops and light rail stations for a given parcel that meet LEED criteria and minimum distance of bus stops and light rail stations within a certain distance for a given parcel. Finally, a multiple regression method was adopted to analyze the data.

The final format of Model 1 is:

Predicted Transformed Unit value = 1.873 -0.015 (Num Bus Stops) + 0.426 (Num Rail Stations) – 0.000002522 (area), where Predicted Transformed Unit Value = (Appraised Value/Area of a parcel) $^{0.3}$

For this model ANOVA test p value was 0.000. This model presented significant relationship between the transformed unit value of parcels and the measurements required to earn LEED credit (Joshi, 2009).

According to results, an increase in the number of light rail stations led to the increase in the transformed appraised unit value of a parcel. Whereas, number of bus stops which met LEED criteria for a given parcel had completely opposite effect over the transformed unit value of that parcel (Joshi, 2009).

These different effects might be explained a potential link between socio-economic status and transportation mode. This could be true if the bus system has been purposefully designed to transport people primarily from economically disadvantaged areas in the city (Joshi, 2009)

Summary

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 the accessibility of socially excluded or economically marginalized families (Thakuriah, Sriraj, Sööt, & Liao, 1986). The highest quality transit mode, such as the Metro/Subway, may find its 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 the City Bus (Nembhard, 2009).

Household income is a measure commonly used by the United States government and private institutions. That measure counts all the income of all residents over the age of 18 in each household, including not only all wages and salaries, but 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 routinely (U.S. Department of Housing and Urban Development, 2009). According to the US Census Bureau, the median is "considerably lower than the average, and provides a more accurate representation." (U.S. Census Bureau, 2003)

Hence, this research will use 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 for a parcel, and also will be used as an independent variable in the regression model for predicting unit value of unimproved parcels in Houston, Texas. Figure 2.1 is Houston Median Household Income Map of 2000.

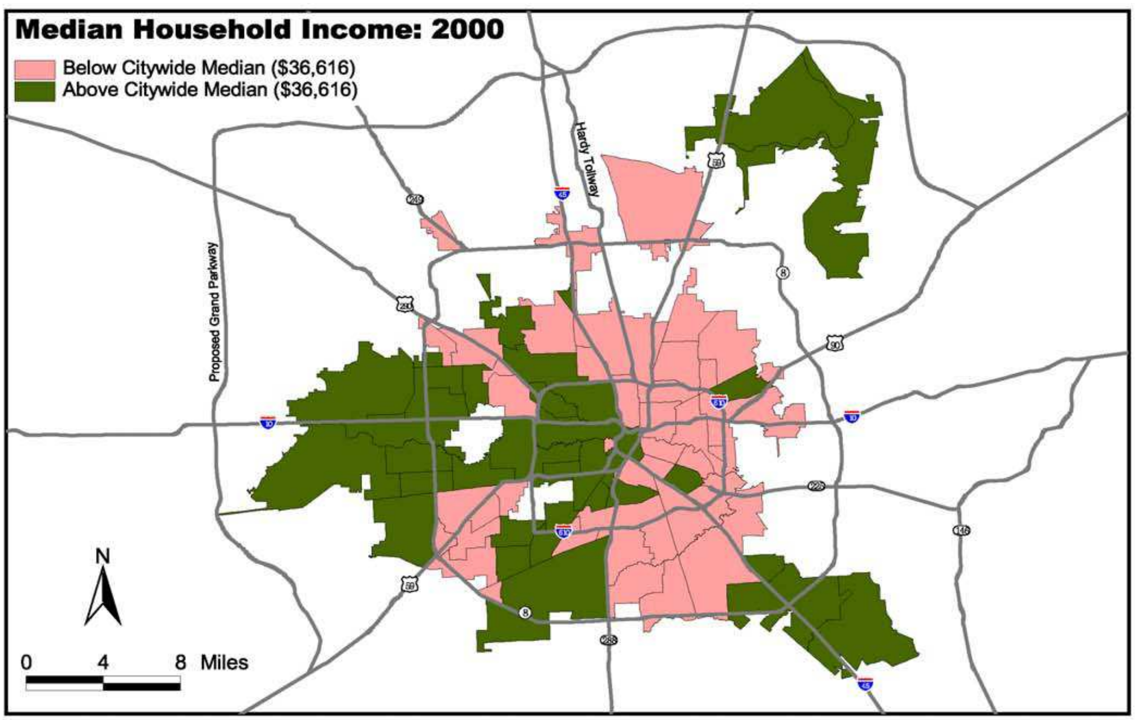

Figure 2.1: Houston Median Household Income Map of 2000

Source: (City of Houston Planning and Development Department, 2005)

CHAPTER III

DATA COLLECTION

Population of Interest

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 3.1 is the GIS Map of Target Area.

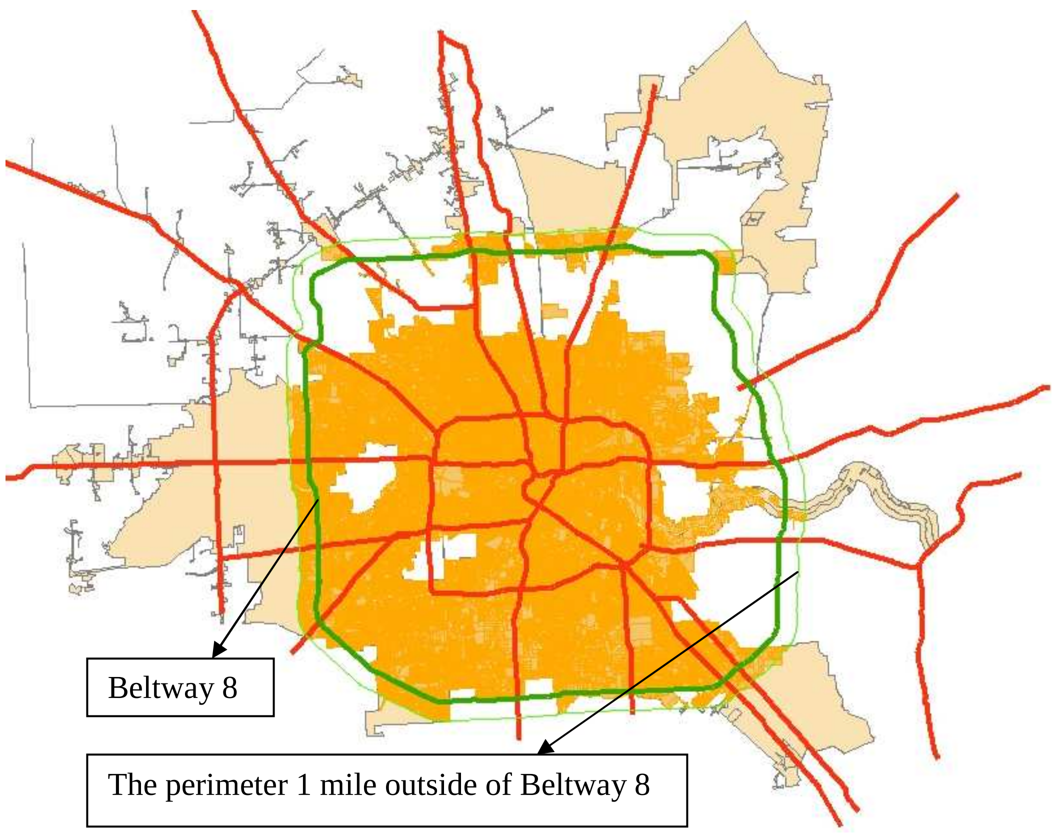

Figure 3.1: GIS Map of Target Area

Observational Unit

The observational unit for this research will be a qualified parcel.

Sample Selection

150 parcels qualified for LEED Sustainable Sites Criteria of Public Transportation Access will be randomly selected from the population.

Collection Method

Location of Target Area

Use ArcGIS open Harris County shape file which downloaded from Harris County Appraisal District website. This shape file defined Harris County boundary and displayed this boundary visually. Figure 3.2 displays the boundary of Harris County.

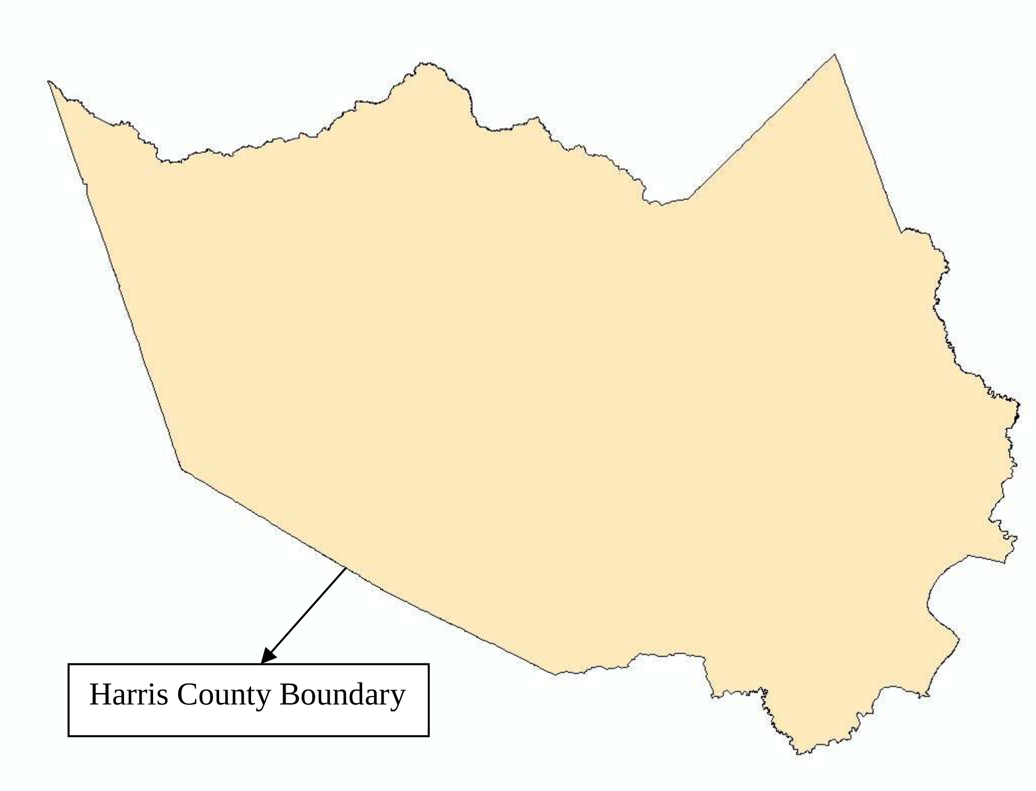

Figure 3.2: Harris County Boundary

Project Harris County Highways shape file, which downloaded from Harris County Public Infrastructure Department website, on Harris County boundary shape file using ArcGIS. Then highlight Beltway 8 using appropriate ArcGIS function. Figure 3.3 shows the location of Beltway 8.

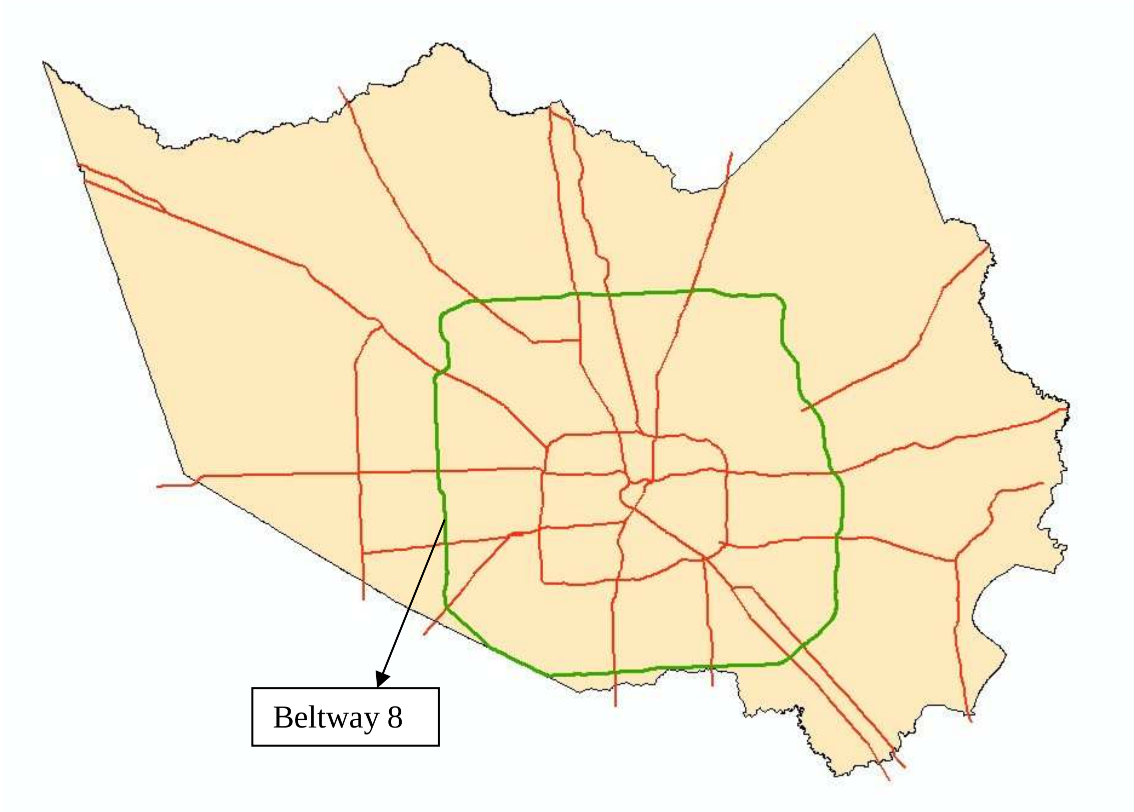

Figure 3.3: Beltway 8

Project Houston City boundary shape file, which downloaded from Harris County Public Infrastructure Department website, on Harris County boundary shape file using ArcGIS. As displayed in figure 3.4, the orange area is the region of Houston.

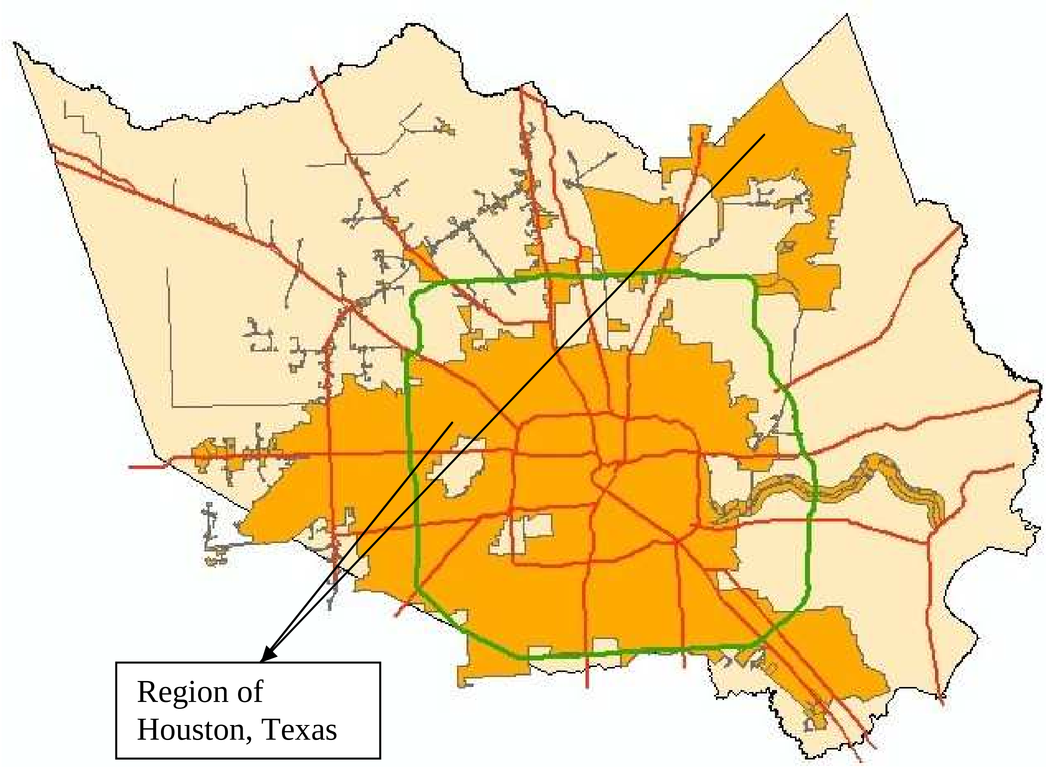

Figure 3.4: Houston City Boundary

Project parcels shape file downloaded from Harris County Appraisal District website using ArcGIS. Then create a new circumference located 1 mile outside Beltway 8 with “Buffer” function in ArcGIS. Thus the target area of population was defined. Figure 3.5 presents the target area of population.

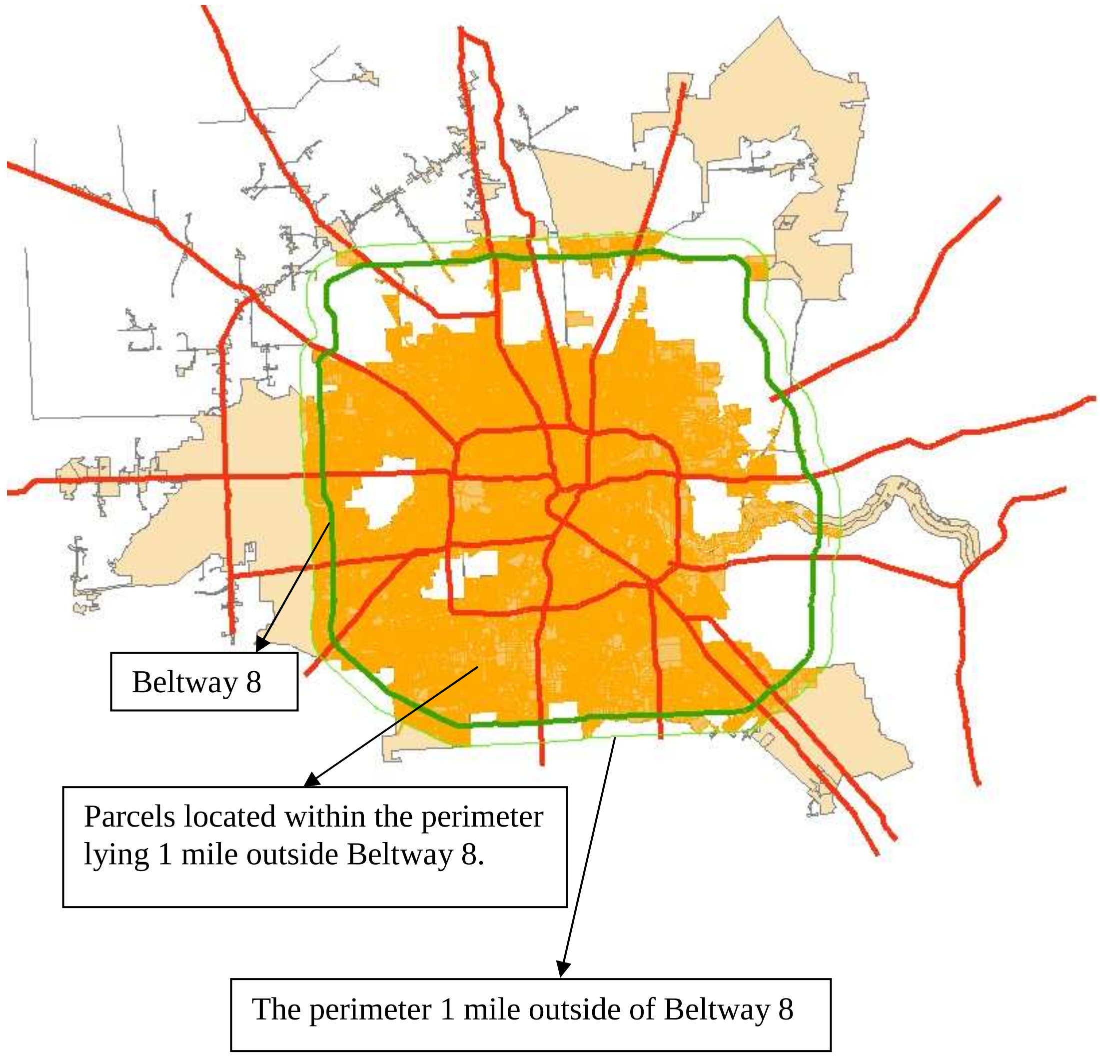

Figure 3.5: Target Area of Population

Identification of Population

All parcels along with their addresses and account numbers located within the perimeter lying 1 mile outside Beltway 8 were selected (see figure 3.5).

Use the account numbers to retrieve appraised values (in dollars) and area (in square feet) of all the parcels from Harris County Appraisal District website. Table 3.1 and table 3.2 illustrate land area and a parcel with zero appraised improvement value obtained from Harris County Appraisal District website respectively.

Table 3.1: Land Area of a Parcel

State Class Code		Land Use Code	
C2 -- Real, Vacant Commercial		7300 -- Comm. Tabled Vacant Land	
Land Area	Building Area	Net Rentable Area	Neighborhood
44,867 SF	0	0	5958.06

Table 3.2: A Parcel with Zero Appraised Improvement Value

Valuations					
Value as of January 1, 2008			Value as of January 1, 2009		
	Market	Appraised		Market	Appraised
Land	1,794,680		Land	1,794,680	
Improvement	0		Improvement	0	
Total	1,794,680	1,794,680	Total	1,794,680	1,794,680

All parcels with zero appraised improvement value were then listed. This list formed the population of all unimproved parcels. Meanwhile, both **appraised land value** (in dollars) and **land area** (in square feet) of each parcel were recorded. Table 3.3 shows the list of population.

Table 3.3: List of Population

	A	B	C
1	Account Number	Land Area	Appraised Land Value
2	0010020000001	5,000	375,000
3	0010020000003	18,120	1,064,721
4	0010020000004	9,060	532,360
5	0010020000024	9,060	532,360
6	0010050000020	5,000	187,500
7	0010060000010	45,638	1,711,425
8	0010070000013	25,482	955,575
9	0010070000014	43,007	1,612,763
10	0010080000002	10,802	459,085
11	0010080000014	741	27,788
12	0010090000001	62,500	4,062,500
13	0010100000006	22,500	1,462,500

Selection of Qualified Parcels

Transportation maps obtained from Houston-Galveston Area Council (HGAC) were layered over the population map. Then the location of all bus stops and light rail stations were displayed on the population map. Figure 3.6 shows locations of all bus stops and light rail stations in Houston, Texas.

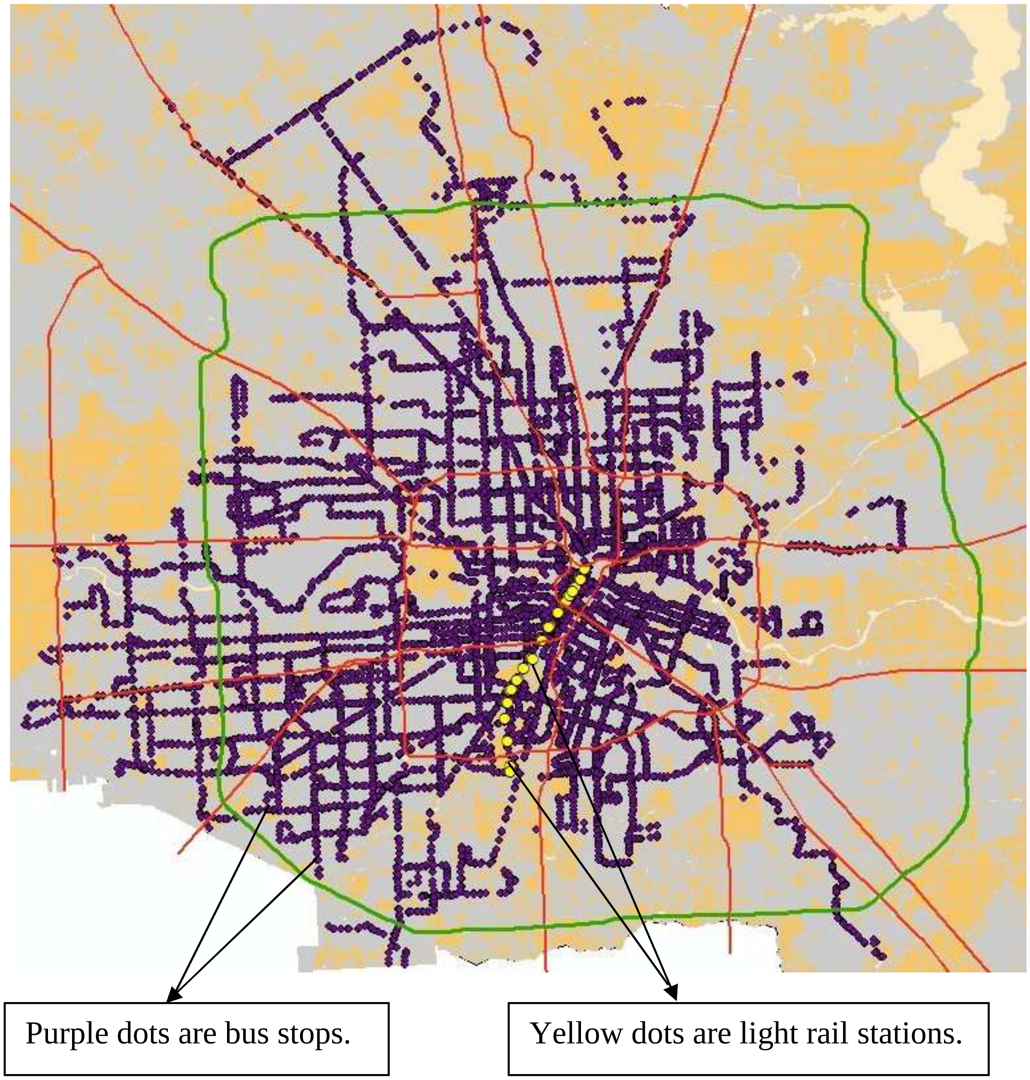

Figure 3.6: Map of Bus Stops and Light Rail Stations

Use “Buffer” function of ArcGIS to select parcels which were within 1/4 mile (measured from centroid of each parcel) of any bus stop. Figure 3.7 illustrates these qualified parcels.

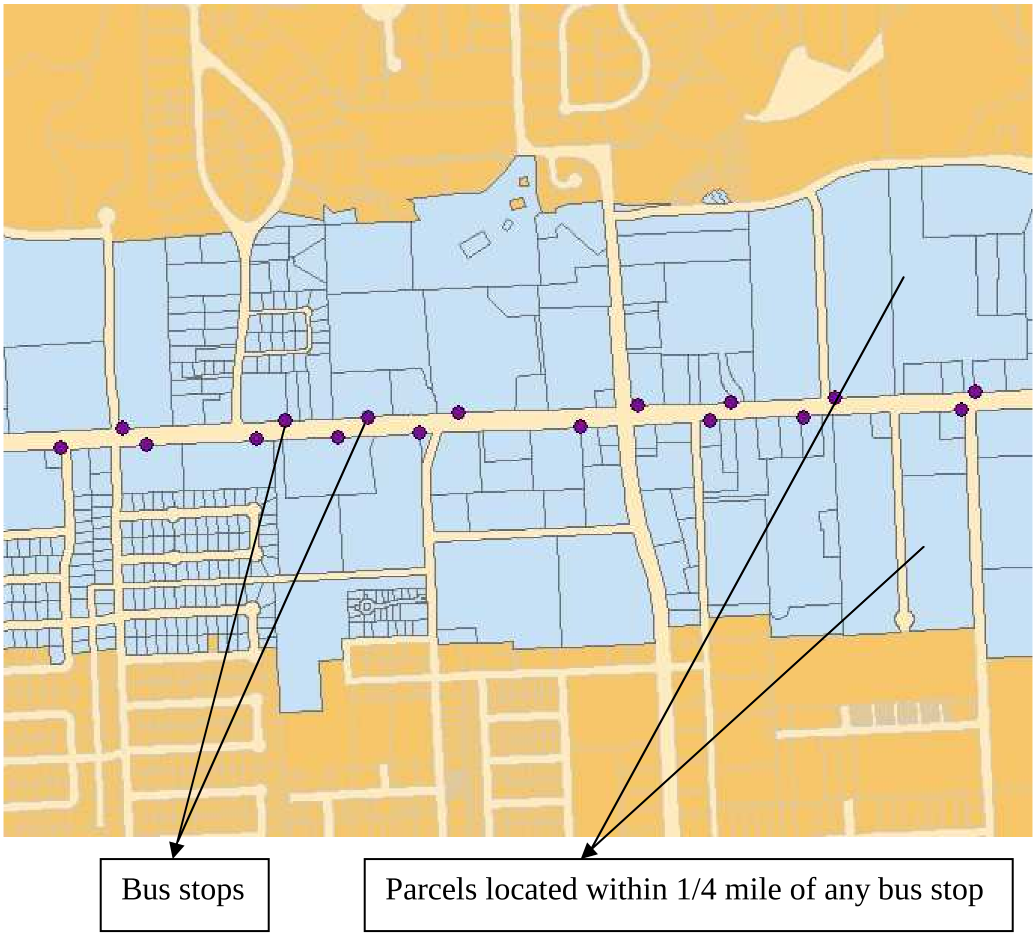

Figure 3.7: Parcels Located within 1/4 Mile of Any Bus Stop

Use “Buffer” function of ArcGIS to select parcels which were within 1/2 mile (measured from centroid of each parcel) of any light rail station. Figure 3.8 illustrates these qualified parcels.

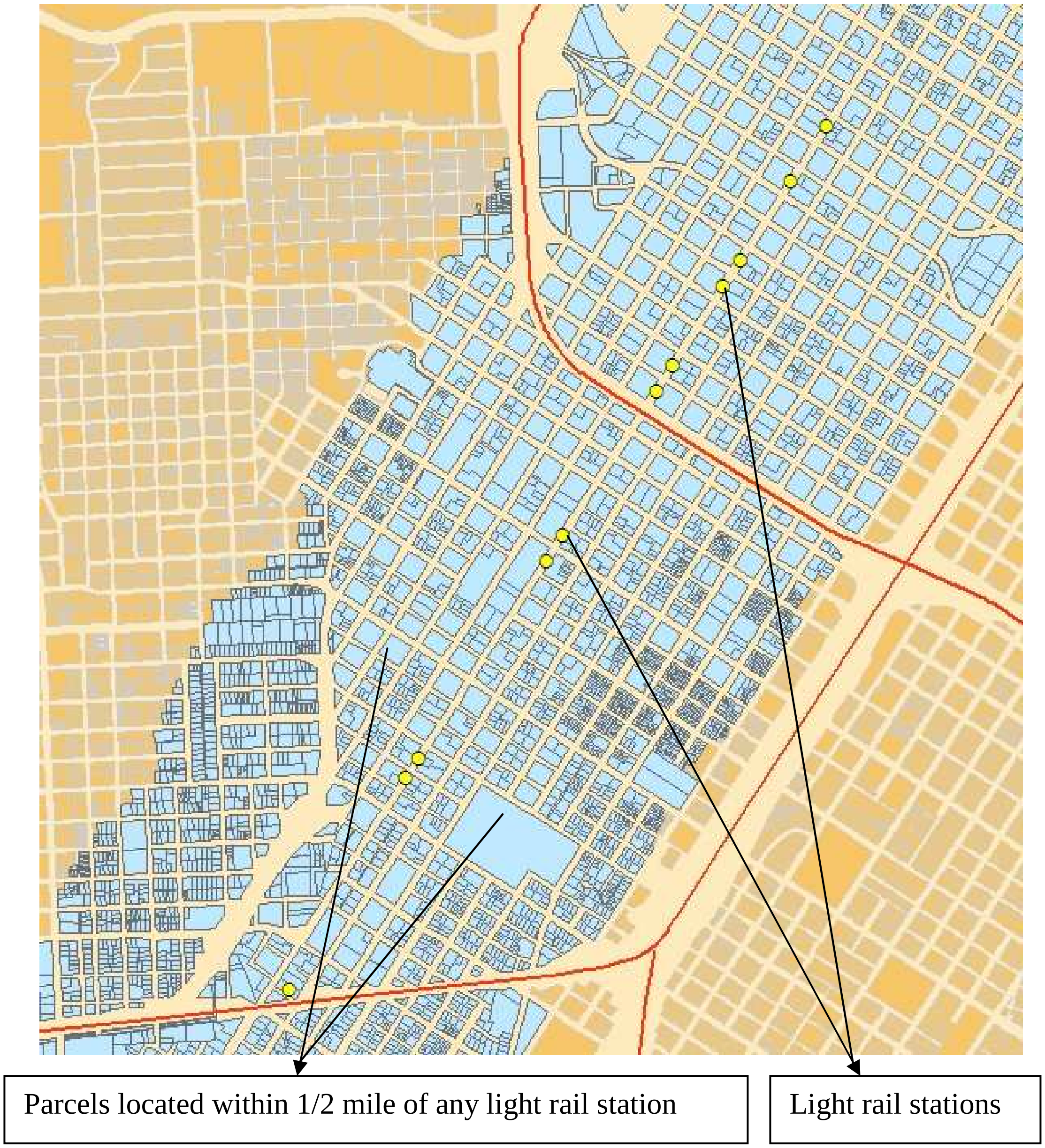

Figure 3.8: Parcels Located within 1/2 Mile of Any Light Rail Station

During the process of selection, it was found that only a few parcels were qualified for both bus and light rail. That is both bus stops and light rail stations were located within 1/4 mile and 1/2 mile distance respectively from the parcel. While a majority of parcels only met either bus stop or light rail requirements. Hence, selecting three groups of qualified parcels were more representative and reasonable for data analysis.

The first group consisted of 50 parcels, which were qualified for both bus stops and light rail stations. A second group consisted of 50 parcels, which were only qualified for bus stop requirements. And 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 research study.

Collection of Public Transportation Points Data

Addresses of these 150 parcels were converted to corresponding coordinates using the website: http://www.gpsvisualizer.com/geocoder/. Then use these coordinates were used to create an excel matrix model based on the spherical law of cosines. This matrix will calculate distances between each parcel and all transportation points (bus stops and light rail stations).

The result was that the number of bus stops and/or number of light rail stations that met LEED criteria for a parcel were counted. Table 3.4 is the table recording number of qualified bus stops and light rail stations near each parcel.

Table 3.4: Number of Qualified Bus Stops and Light Rail Stations

NO.	Account Number	Number of Bus Stops	Number of Light Rail Stations
1	0250020230007	3	3
2	0010190000028	50	4
3	0250120000004	5	1
4	0250340000011	4	3
5	0370300000001	12	2
6	0370380000012	11	2
7	0010080000014	22	3
8	0152240000007	22	4
9	0010440000005	56	5
10	0132410000013	15	4
11	0021750000008	32	6

Collection of Median Household Income Data

Project coordinates of all 150 parcels on Harris County shape file downloaded from Census Bureau website. The coordinates represented the centroids of parcels. Figure 3.9 displays the locations of all 150 parcels.

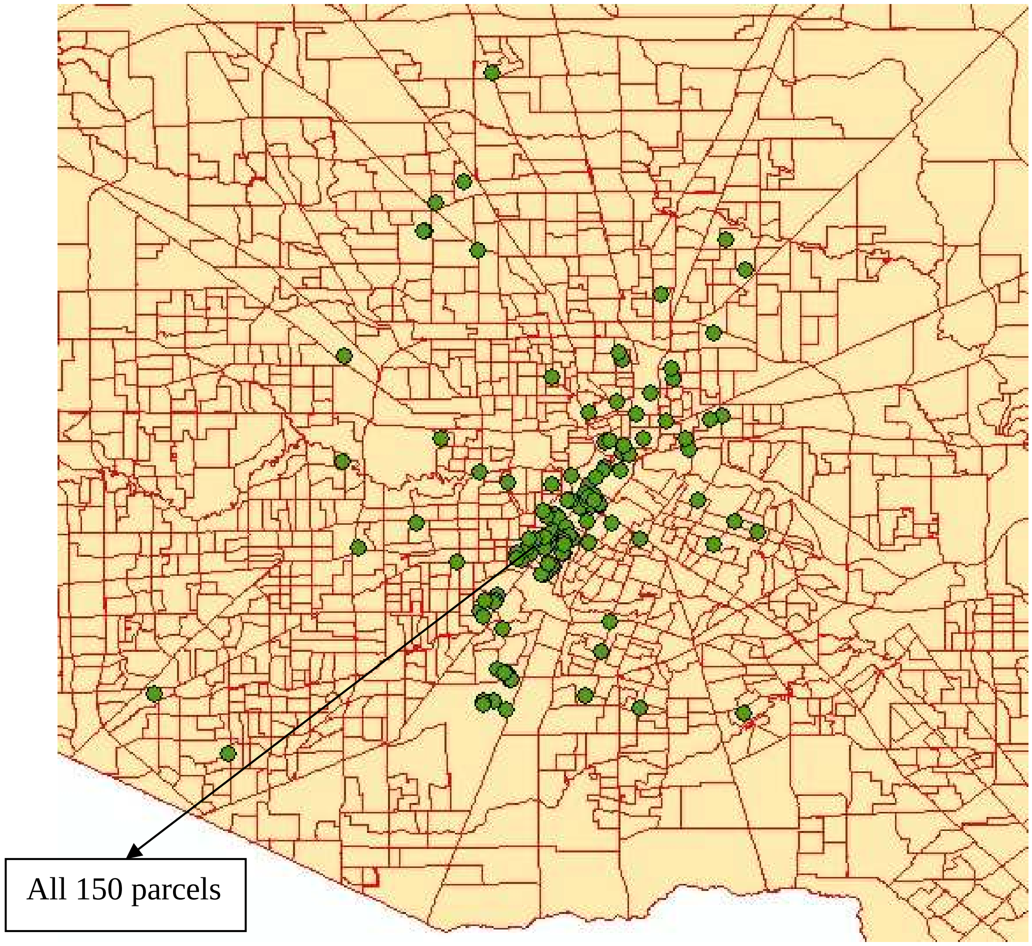

Figure 3.9: Locations of All 150 Parcels

This demographic shape file not only displays boundary of each census tract and each block group (see figure 3.10), it also contains corresponding tract number and block group number in the attribute table of the shape file (see figure 3.10). Figure 3.10 shows boundary of census tracts and block groups, while table 3.5 shows the attribute table.

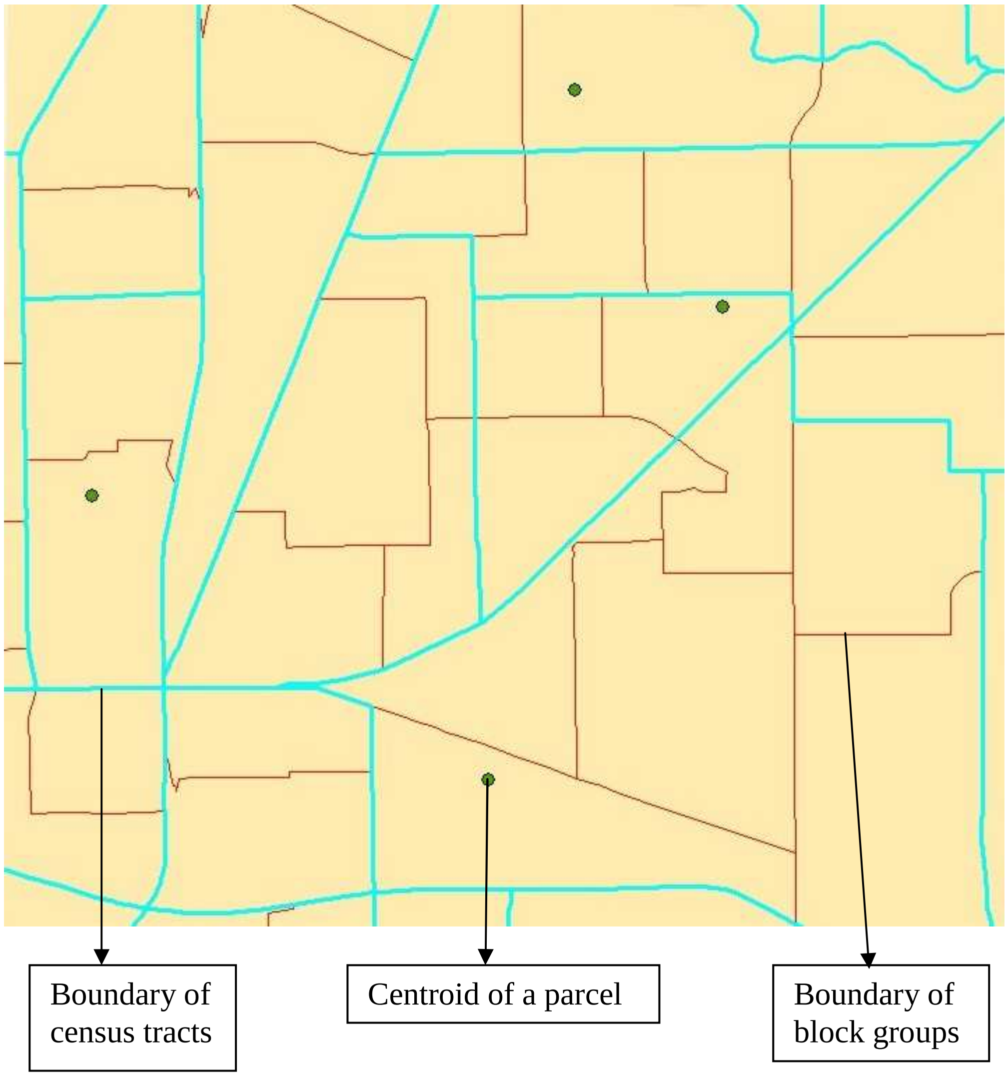

Figure 3.10: Boundary of Census Tracts and Block Groups

Table 3.5: The Attribute Table Containing Tract Numbers and Block Group Numbers

Tract number → TRACTCE00; Block group number → BLKGRPCE0

Attributes of tl_2009_48201_bg00

FID	Shape	ST	COU	TRACTCE00	BLKGRPCE0	BKGPIDFP00
429	Polygon	48	201	210300	5	482012103005
430	Polygon	48	201	210300	4	482012103004
521	Polygon	48	201	210300	3	482012103003
522	Polygon	48	201	210300	2	482012103002
523	Polygon	48	201	210300	1	482012103001
1637	Polygon	48	201	210400	4	482012104004
1756	Polygon	48	201	210400	3	482012104003
1757	Polygon	48	201	210400	2	482012104002
1758	Polygon	48	201	210400	1	482012104001
1631	Polygon	48	201	210500	6	482012105006
1632	Polygon	48	201	210500	5	482012105005
1633	Polygon	48	201	210500	4	482012105004
1634	Polygon	48	201	210500	3	482012105003

Record tract numbers and block group numbers of all 150 parcels using ArcGIS, then use each tract number and block group number to retrieve median household income data from Census Bureau website. Table 3.6 illustrates the median household income for Block Group 1, Census Tract 2208, where a parcel is located.

Table 3.6: Median Household Income for Block Group 1, Census Tract 2208

	Block Group 1, Census Tract 2208, Harris County, Texas
Median household income in 1999	27,969

U.S. Census Bureau
Census 2000

Admissibility of Data

Data of all 150 sample parcels including appraised land value, parcel area, number of bus stops, number of light rail stations and median household income are complete and accurate. Hence all 150 data records are admissible.

Any data whose absolute value of standardized residual is greater than 3.0 will be regard as an outlier.

Data Collected

Firstly, for the study on the correlation between median household income and the number of bus stops and light rail stations that meet LEED sustainable site criteria for public transportation access of a given parcel, we could establish a regression model with one dependent variable and two independent variables:

- **Dependent variable:** Median Household Income.
- **Independent variables:** Number of bus stops for a given parcel that met LEED criteria and Number of light rail stations for a given parcel that met LEED criteria.

Then the hypothesis: $\beta_1 \leq 0$, $\beta_2 \geq 0$ could be tested.

If the result shows there was no significant correlation existing, the subsequent research would try to establish a new regression model for predicting unit value of unimproved parcels in Houston, Texas, by adding median household income of a block group where the given parcel was located as an independent variable. For this new model, variables were:

- **Dependent variable:** Appraised unit value of an unimproved parcel, which equals to appraised land value divided by parcel area.
- **Independent variables:** Number of bus stops for a given parcel that met LEED criteria, Number of light rail stations for a given parcel that met LEED criteria, Median household income of a block group where the given parcel was located and Area of a given parcel.

CHAPTER IV

DATA ANALYSIS AND INTERPRETATION

Descriptive Statistics

Results

Table 4.1: Descriptive Statistics of Independent and Dependent Variables

Descriptive Statistics						
		NumBus	NumRail	MedianHousehold	Area	Unitvalue
N Statistic		150	150	150	150	150
Range Statistic		72	7	153.344	458210	174.9496344
Minimum Statistic		0	0	10.15	41	0.050365556
Maximum Statistic		72	7	163.494	458251	175
Mean	Statistic	8.133333333	1.606666667	39.08426	13535.81333	27.24717195
	Std. Error	1.185054834	0.140595304	1.838879325	3665.622992	2.250873198
Std. Deviation		14.5138983	1.721933776	22.52158022	44894.5296	27.56745405
Variance Statistic		210.6532438	2.965055928	507.2215757	2015518788	759.9645229

Interpretation of Results

As shown in table 4.1, the independent variable Number of bus stops had a mean of about 8. The lowest value was 0 and the highest value was 72. The independent variable Number of light rail stations had a mean of about 2. The lowest value was 0 and the highest value was 7. The independent variable Median household income (in thousands US dollars) had a mean of about 39.084 thousands dollars. The lowest value was 10.15 thousands dollars and the highest value was 163.494 thousands dollars. The independent variable Area (in square feet) had a mean of about 13536 square feet. The lowest value was 41 square feet and the highest value was 458251 square feet.

The dependent variable Unit value (in US dollars per square foot) had a mean of about 27.25 dollars per square foot. The lowest unit value was about 0.05 dollars per square foot and the highest was 175.00 dollars per square foot (see table 4.1).

Scatterplots

Results

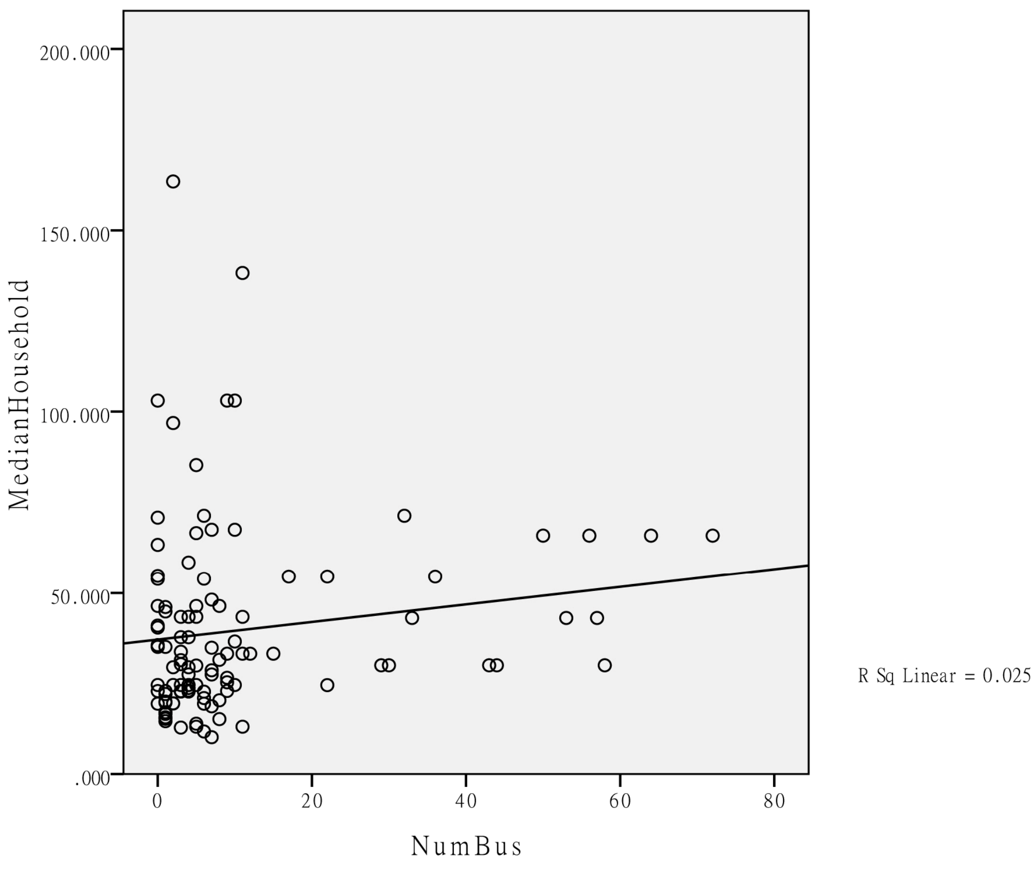

Figure 4.1: Scatterplot of Median Household Income vs. Number of Bus Stops

Interpretation of Results

Scatterplot 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 number of bus stops which met LEED criteria of a given parcel increased, median household income of the block group where a given parcel was located increased as well (see figure 4.1). This positive relation was extremely weak because R Square value is only 0.025 and the slop seemed very gentle.

Scatterplot also indicated that number of bus stops which met LEED criteria for most qualified parcels were less than 20; besides, the median household income for most qualified parcels was less than 100,000 dollars (see figure 4.1).

Results

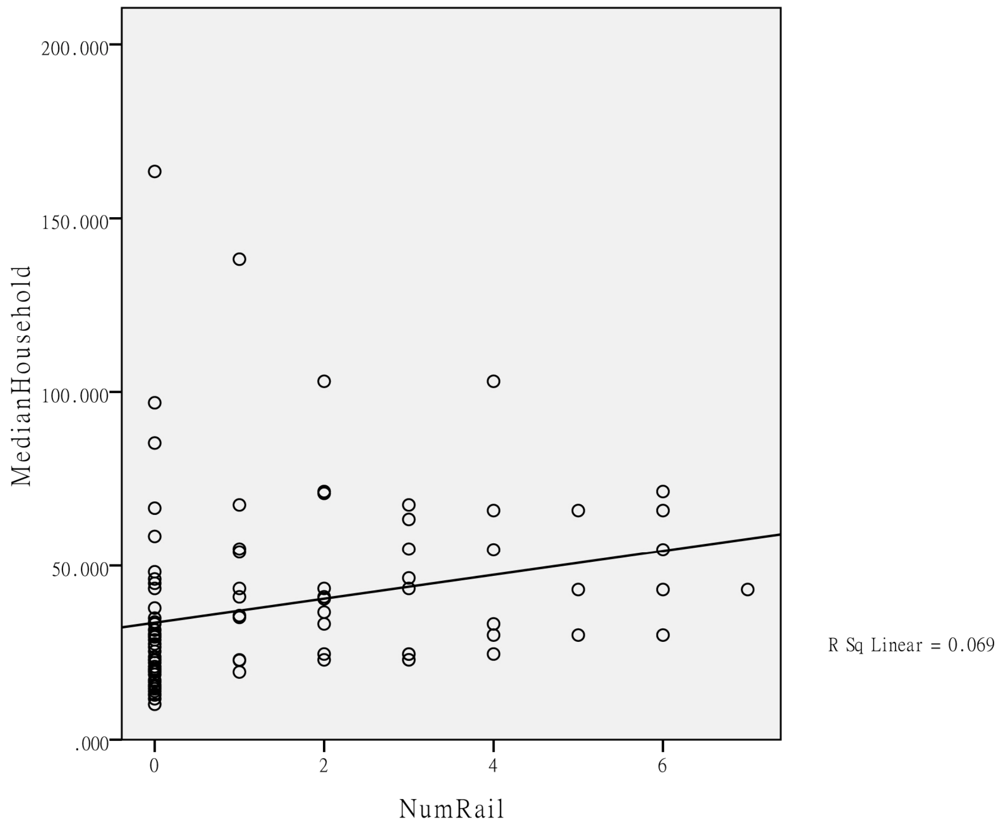

Figure 4.2: Scatterplot of Median Household Income vs. Number of Light Rail Stations

Interpretation of Results

Scatterplot 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 number of light rail stations which met LEED criteria of a given parcel increased, median household income of the block group where a given parcel was located increased as well (see figure 4.2). This positive relation was extremely weak because R Square value is only 0.069 and the slop seemed very gentle.

Results

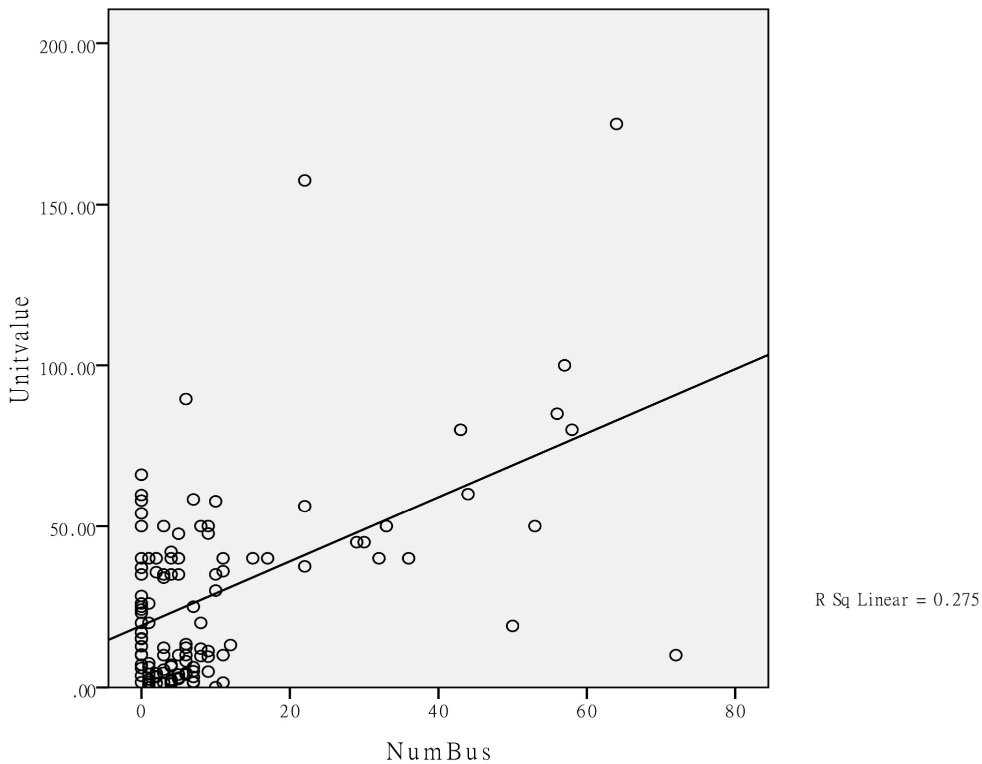

Figure 4.3: Scatterplot of Unit Value vs. Number of Bus Stops

Interpretation of Results

Scatterplot for unit value versus number of bus stops which met LEED criteria indicated a positive relation between the two variables, which means that as the number of bus stops that met LEED criteria of a given parcel increased, unit value of this parcel increased as well (see figure 4.3). Even if the slop of the line indicated the increment rate is obvious, this positive relation was weak because R Square value is only 0.275 and data points did not seem to line up apparently. Scatterplot also indicated that unit value for most qualified parcels was less than 100 dollars/square foot (see figure 4.3)

Results

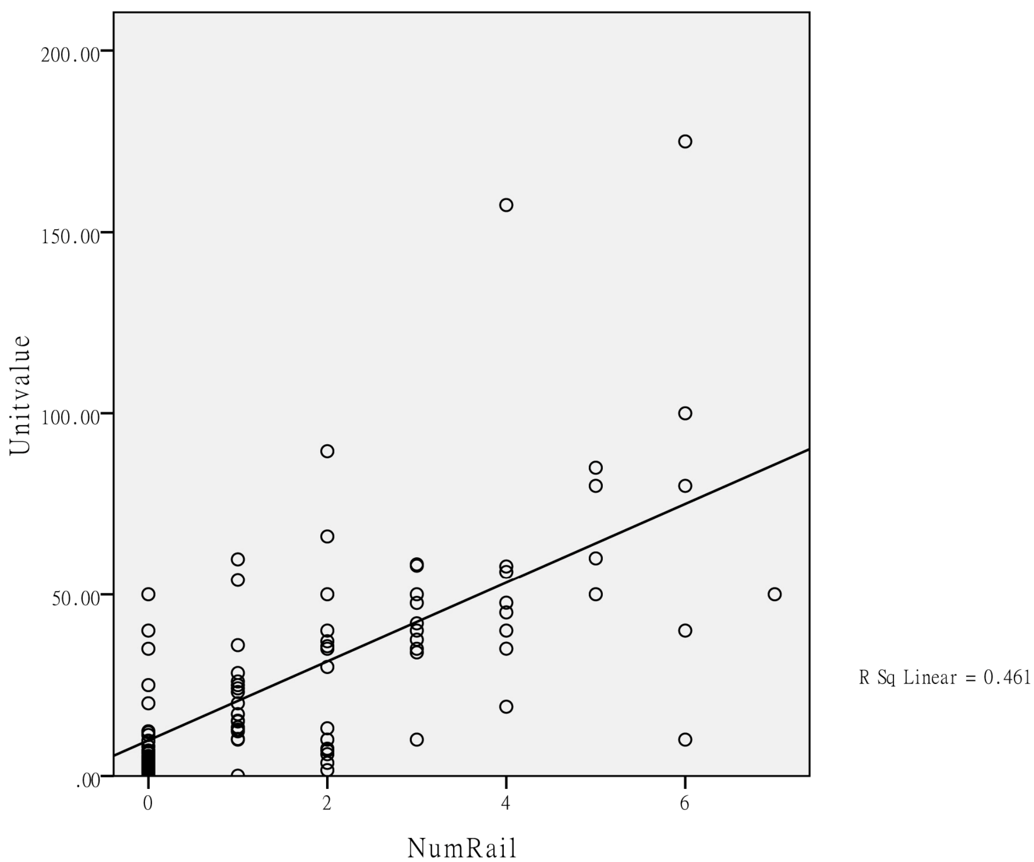

Figure 4.4: Scatterplot of Unit Value vs. Number of Light Rail Stations

Interpretation of Results

Scatterplot for unit value versus number of light rail stations which met LEED criteria indicated a positive relation between the two variables, which means that as the number of light rail stations that met LEED criteria for a given parcel increased, unit value of this parcel increased as well (see figure 4.4). This positive relation was still weak even if R Square value, 0.461, was relatively higher than that of previous figure (see figure 4.3).

However, this relatively stronger positive relation probably did not reflect the real reason for the high unit value of a parcel. Because there was only one light rail line in Houston (see figure 3.9) which was located in downtown area. As a result, parcels were expensive probably just because they were in downtown area, but not because they were close to the light rail line or had a lot of light rail stations.

Results

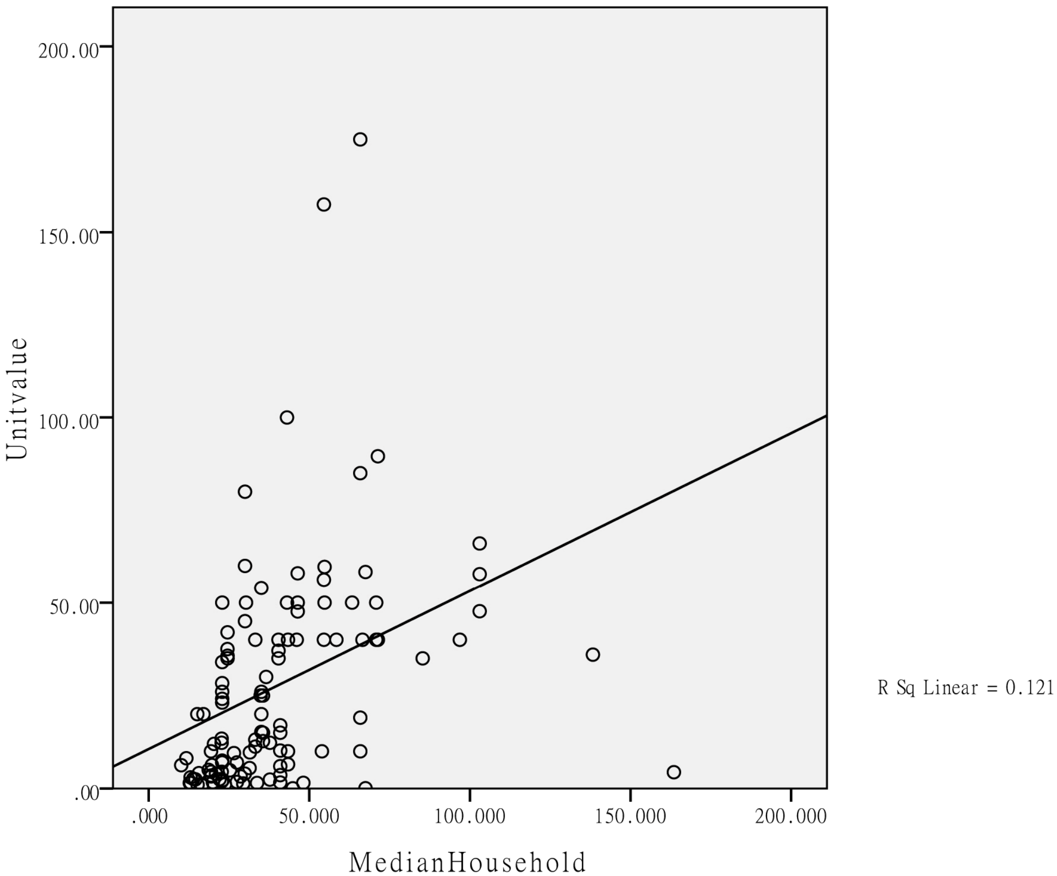

Figure 4.5: Scatterplot of Unit Value vs. Median Household Income

Interpretation of Results

Scatterplot 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 parcel was located increased, unit value of this parcel increased as well (see figure 4.5). Even if the slop of the line indicated the increment rate is obvious, this positive relation was weak because R Square value is 0.121 and data points did not seem to line up apparently.

Results

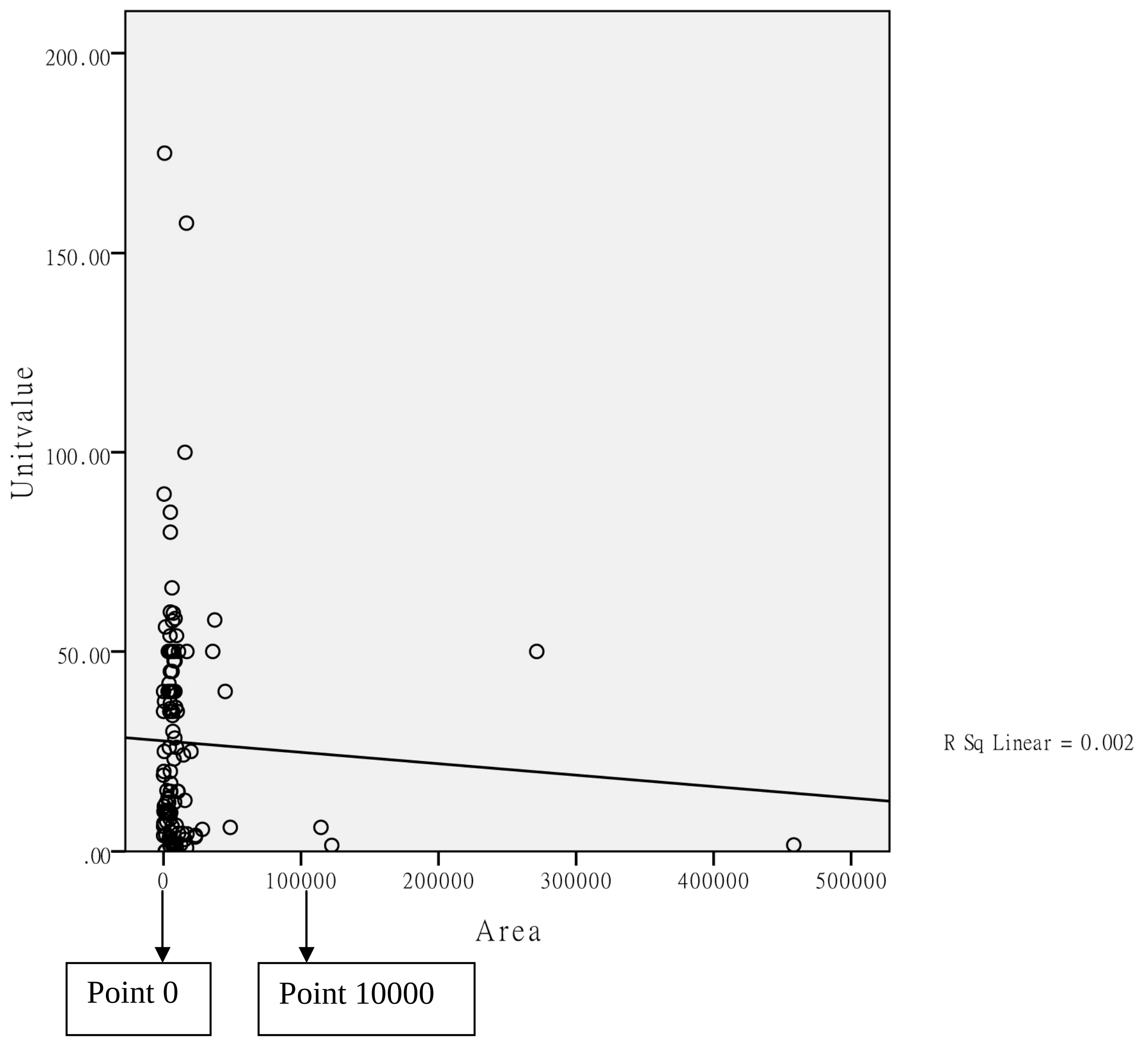

Figure 4.6: Scatterplot of Unit Value vs. Area

Interpretation of Results

Scatterplot 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 4.6). This negative relation was extremely weak because R Square value is only 0.002 and data points did not seem to line up apparently.

As displayed in this scatterplot, only four data points fell on the right side of point 10000 of x-axis while most of data points were concentrated near point 0 of x-axis, which means only few of the parcels had large area whereas the majority of parcels were in small size.

Also, as seen from figure 4.6, the unit value for the parcels ranged from nearly 0 to around 175. While the unit value for most of parcels were less than 100 dollars per square foot.

Correlation among Variables

Results

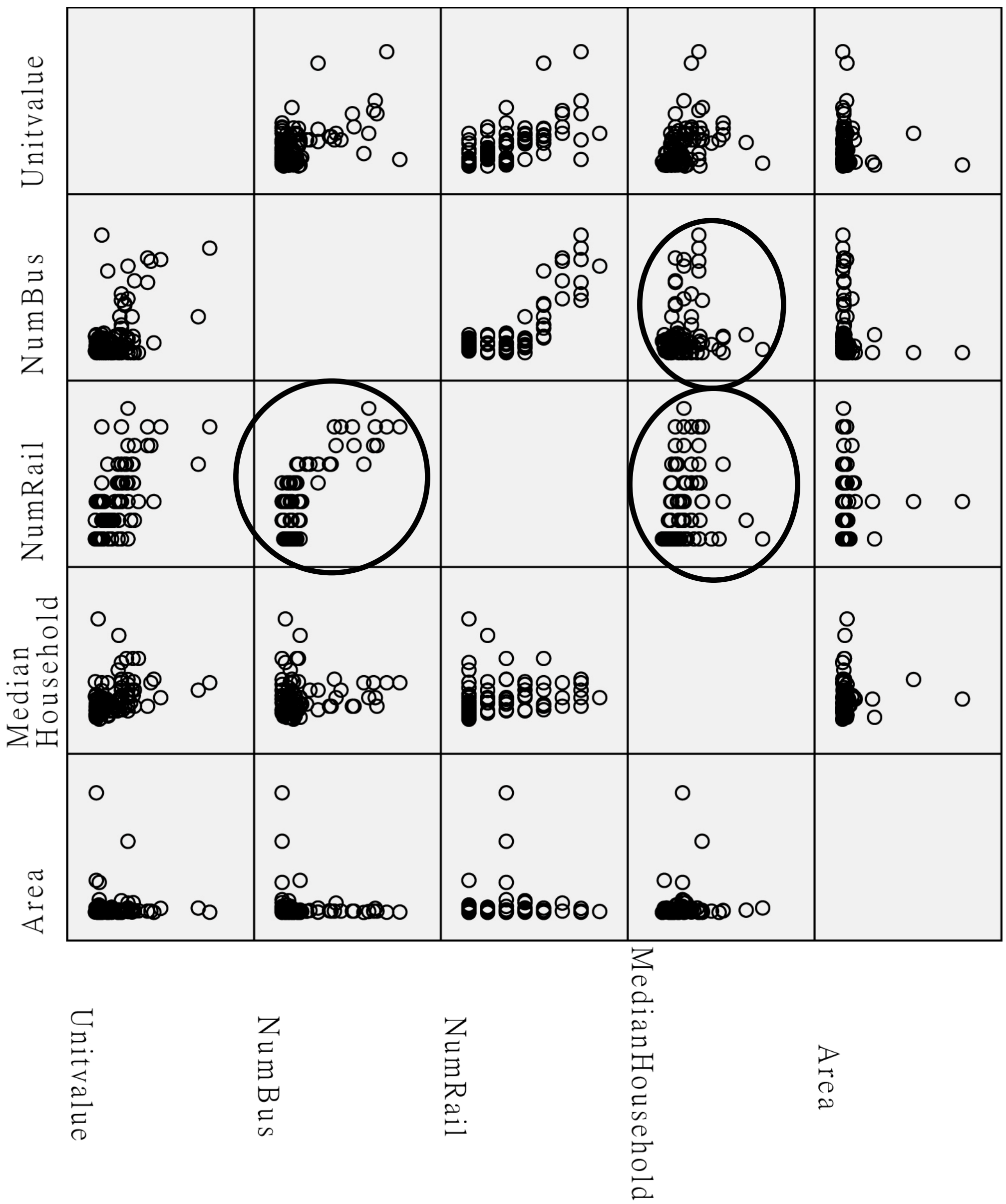

Figure 4.7: Scatterplot Matrix of Variables

Table 4.2: Pearson Correlation Results

Correlations

		Unitvalue	NumBus	NumRail	Median Household	Area
Pearson Correlation	Unitvalue	1.000	.524	.679	.348	-.047
	NumBus	.524	1.000	.745	.157	-.075
	NumRail	.679	.745	1.000	.263	.025
	MedianHousehold	.348	.157	.263	1.000	.055
	Area	-.047	-.075	.025	.055	1.000

Interpretation of Results

Scatterplot matrix (see figure 4.7), which contained scatterplots for each pair of variables, indicated a possible linear relation between Number of Bus Stops and Number of Light Rail Stations. But it did not indicate any other clear linear relations among the variables, especially for the scatterplots of Median Household Income against Number of Bus Stops and Median Household Income against Number of Light Rail Stations.

As shown in table 4.2, only correlations for Area against Unit value and Area against Number of bus stops meeting LEED criteria were found negative and extremely low, which means both Unit value and Number of bus stops would decrease as the parcel area increased. The reason probably was that large size parcels were located farther from the downtown area. Conversely, Number of bus stops, Number of light rail stations and Median household income had positive and relatively higher correlation.

Furthermore, correlation for each pair of variables was much less than 0.9, which means all variables were not highly correlated, but it was crucial to notice that the correlation between Number of bus stops and Number of light rail stations which was 0.745 (see table 4.2) had the highest value in Pearson Correlation Results. Hence, it was necessary to confirm that they were not correlated by checking their Variance Inflation Factors in following sections. According to our first research objective, correlations between Median household income and both Number of bus stops and Number of light rail stations should be examined. From table 4.2, 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. Figure 4.1 and figure 4.2 also provided evidences which indicated they were not highly correlated.

Hence, there was no need to establish a regression model regarding median household income as the dependent variable and both number of bus stops and light rail stations that meet LEED sustainable site criteria for public transportation access as the independent variables; and the following sections would merely focus on the establishment of the regression model for predicting appraised unit value using number of bus stops and light rail stations for a given parcel that meet LEED sustainable site criteria for public transportation access, median household income and parcel area as the independent variables.

Regression Model for Predicting Appraised Unit Value

Multiple Regression Analysis for Original Data

Results

Table 4.3: Adjusted R- Square for Original Model

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.706[a]	.498	.484	19.79940

a. Predictors: (Constant), Area, NumRail, MedianHousehold, NumBus

Table 4.4: ANOVA Table for Original Model

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	56392.376	4	14098.094	35.963	.000[a]
	Residual	56842.338	145	392.016		
	Total	113234.714	149			

a. Predictors: (Constant), Area, NumRail, MedianHousehold, NumBus

b. Dependent Variable: Unitvalue

Table 4.5: Coefficients of Original Model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	2.788	3.362		.829	.408	-3.857	9.432		
	NumBus	.083	.169	.044	.491	.624	-.252	.418	.435	2.299
	NumRail	9.589	1.457	.599	6.581	.000	6.709	12.469	.418	2.393
	MedianHousehold	.229	.075	.187	3.058	.003	.081	.377	.926	1.080
	Area	-4.218E-5	.000	-.069	-1.154	.250	.000	.000	.978	1.023

a. Dependent Variable: Unitvalue

Interpretation of Results

All independent variables were entered to run multiple regression analysis with original data. The Adjusted R-Square of the model was 0.484 (see table 4.3), while p value of the model was 0.000 (see table 4.4) which proved that the model was significant. As shown in table 4.5, only two independent variables (number of light rail stations which met LEED criteria and median household income of a block group where the given parcel was located) appeared as significant predictors for the model, because p value of these two independent variables were 0.000 and 0.003 respectively (see table 4.5). The other two independent variables were not significant predictors. However, it was necessary to check for the existence of outliers and check whether the assumptions underlying the chosen model were valid before making a further interpretation of the analysis results.

Check for Existence of Outliers

Results

Table 4.6: Outliers Diagnostics Results

Casewise Outliers Diagnostics[a]

Case Number	Std. Residual	Unitvalue	Predicted Value	Residual
14	5.189	157.50	54.7576	102.74241
15	-3.603	10.00	81.3379	-71.33790
31	4.763	175.00	80.6978	94.30221

a. Dependent Variable: Unitvalue

Table 4.7: List of Outliers

NO.	Account	Number of Bus Stops	Number of Light Rail Stations	CensusTract	Block Group	Median household income in 1999 (thousand dollar)	Appraised Value (dollar)	Area (sft)	Unit Value (dollar/sft)
14	0321650000003	22	4	4106	1	54.551	2633243	16719	157.50
15	0360030000001	72	6	1000	2	65.882	14160	1416	10.00
31	0010750000016	64	6	1000	2	65.882	140000	800	175.00

Table 4.8: List of Land Use Code for Outliers

No.	Account	Land Use Code
14	0321650000003	4300 -- General Commercial Vacant
15	0360030000001	4400 -- Vacant Industrial Land
31	0010750000016	4300 -- General Commercial Vacant

Interpretation of Results

There were 3 outliers whose absolute value of standardized residual was greater than 3, which were parcel No. 14, No. 15 and No. 31 (see table 4.6). Their account numbers were 0321650000003, 0360030000001 and 0010750000016 respectively (see table 4.7). After check the admissibility of these three parcels, it was found that all of them had zero improvement value and met LEED criteria of public transportation access. In addition, it was also found that they were not exempted from tax. Hence, these three outliers should not be deleted from the dataset. The reason why these three parcels had high standardized residuals might be that, most parcels in the sample were intended for residential use while parcel No. 14 and No. 31 were intended for general commercial use and No. 15 was intended for industrial use (see table 4.8). Usually, general commercial land is much more expensive than residential land, whereas industrial land is much cheaper than residential land.

Diagnostics

Collinearity between Independent Variables

Results

Table 4.9: Variance Inflation Factors for Independent Variables

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	2.788	3.362		.829	.408	-3.857	9.432		
	NumBus	.083	.169	.044	.491	.624	-.252	.418	.435	2.299
	NumRail	9.589	1.457	.599	6.581	.000	6.709	12.469	.418	2.393
	MedianHousehold	.229	.075	.187	3.058	.003	.081	.377	.926	1.080
	Area	-4.218E-5	.000	-.069	-1.154	.250	.000	.000	.978	1.023

a. Dependent Variable: Unitvalue

Interpretation of Results

Variance inflation factors were used to diagnose the collinearity between independent variables. As shown in table 4.9, variance inflation factors (VIF) for all four independent variables were much less than 10 and close to 1. Hence we could conclude that there was no strong evidence of collinearity among these four independent variables. This conclusion could also be reinforced by the results interpreted in “Correlation among Variables” section (see table 4.2).

Normality of Residuals

Results

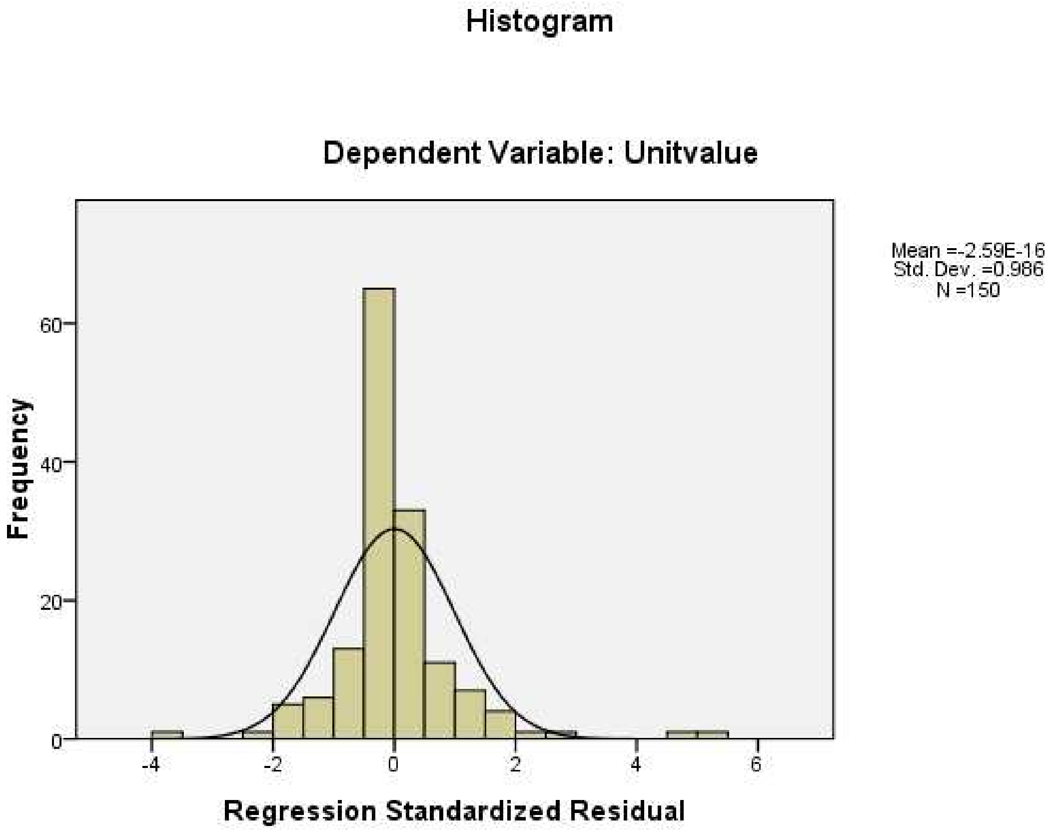

Figure 4.8: Histogram for Standardized Residuals

Table 4.10: Tests of Normality Results

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual	.141	150	.000	.844	150	.000

a. Lilliefors Significance Correction

Interpretation of Results

Histogram of standardized residuals was presented in figure 4.8 which intuitively indicated the non-normal distribution of residuals. Moreover, Kolmogorov-Smirnov test had been used to check the normality of residuals since the sample size of this model was larger than 50. The results showed that p value was 0.000 (see table 4.10). Hence, normality assumption was failed.

Constant Variance of Residuals

Results

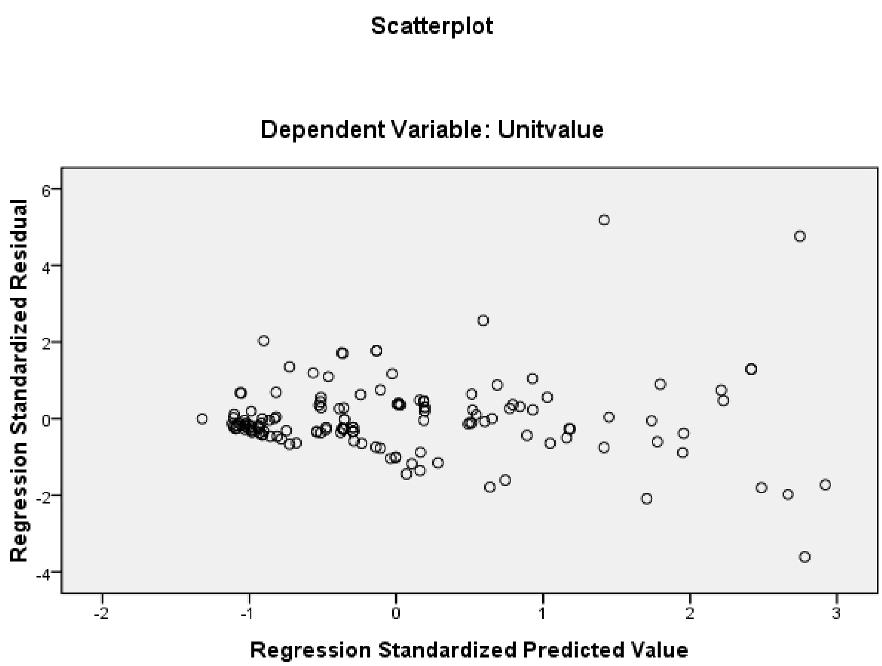

Figure 4.9: Scatterplot of Standardized Residual vs. Standardized Predicted Value

Interpretation of Results

As shown in figure 4.9, the spread in the standardized residuals were generally increasing with the magnitudes of the standardized predicted value of dependent variable. This type of pattern suggested nonconstant variance of the standardized residual. Hence the constant variance assumption was not met either.

Transformation of Dependent Variable

Method

Since two basic assumptions for this model, namely normality of residuals and constant variance of residuals, were not met, it was necessary to find the appropriate transformation for the original model. Box-Cox transformation was applied in this research.

Results

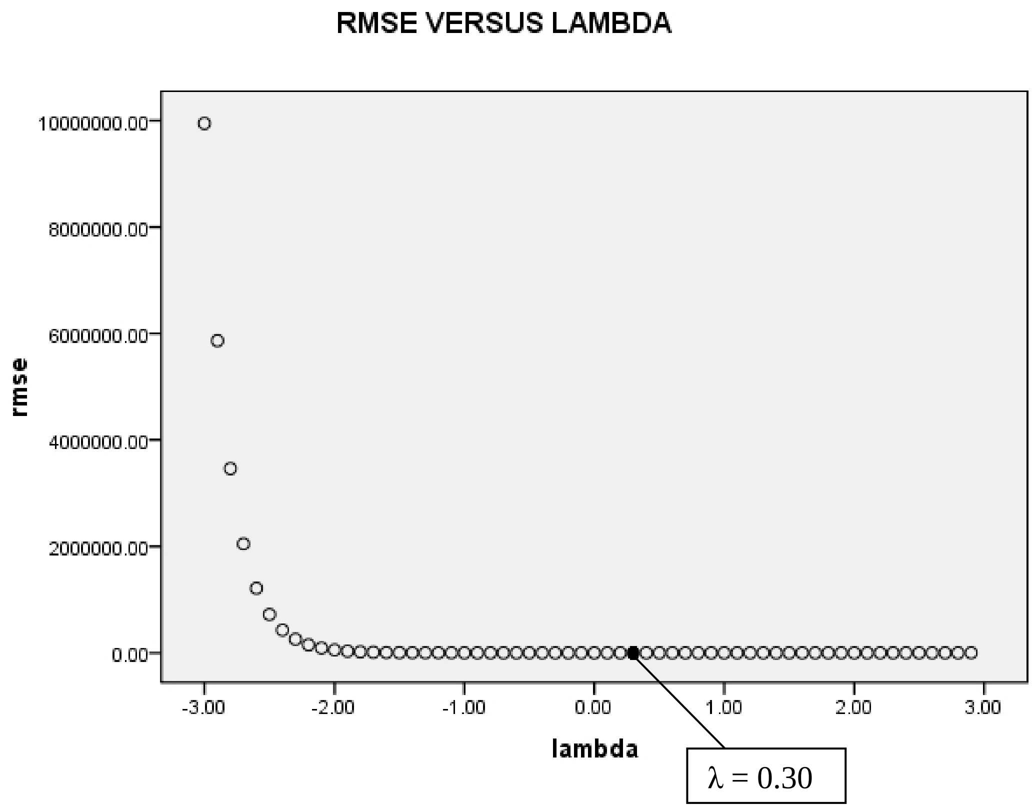

Figure 4.10: Plot for Box-Cox Transformation Results

Table 4.11: List for Box-Cox Transformation Results

	lambda	rmse
28	-0.30	26.54
29	-0.20	20.66
30	-0.10	16.97
31	0.00	14.69
32	0.10	13.33
33	0.20	12.59
34	0.30	12.31
35	0.40	12.38
36	0.50	12.75
37	0.60	13.42
38	0.70	14.38
39	0.80	15.68
40	0.90	17.35
41	1.00	19.47
42	1.10	22.11
43	1.20	25.38

Table 4.12: Original and Transformed Dependent Variable

Unitvalue	Transformed_Unitvalue
34.00	2.88
19.05	2.42
10.00	2.00
40.00	3.02
13.12	2.16
10.00	2.00
37.50	2.97
56.25	3.35
85.00	3.79
40.00	3.02
40.00	3.02
100.00	3.98
40.00	3.02

Interpretation of Results

In both figure 4.10 and table 4.11, “rmse” was the abbreviation for “root-mean-square error”. As shown in table 4.11, the root-mean-square error had its minimum value when $\lambda = 0.30$, which suggested an appropriate transformation for the dependent variable. The black dot graphically presented this λ value (see figure 4.10). Hence, following transformation was used for dependent variable:

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

And following transformation was used for the original model:

Transformed appraised unit value of an unimproved parcel= $\beta_0 + \beta_1$ (Number of bus stops for a given parcel that meet LEED criteria) + β_2 (Number of light rail stations for a given parcel that meet LEED criteria) + β_3 (Median household income) +β_4 (Area of a given parcel) + ε

Table 4.12 listed both original and transformed values of dependent variable (Appraised unit value of an unimproved parcel).

Multiple Regression Analysis for Transformed Data

Results

Table 4.13: Backward Elimination Method for Transformed Model

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	NumBus, NumRail, MedianHousehold, Area [a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Transformed_Unitvalue

Table 4.14: Adjusted R- Square for Transformed Model

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.731[a]	.534	.521	.57742

a. Predictors: (Constant), Area, NumRail, MedianHousehold, NumBus

b. Dependent Variable: Transformed_Unitvalue

Table 4.15: ANOVA Table for Transformed Model

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	55.439	4	13.860	41.569	.000[a]
	Residual	48.346	145	.333		
	Total	103.785	149			

a. Predictors: (Constant), Area, NumRail, MedianHousehold, NumBus

b. Dependent Variable: Transformed_Unitvalue

Interpretation of Results

Backward elimination method was used to select independent variables for the transformed model. As seen from table 4.13, all independent variables entered into the model. None of them was removed by this method.

The Adjusted R-Square of the transformed model was 0.521 (see table 4.14), which means 52.1% variability in transformed unit value of parcels could be explained by these four independent variables. P value of the transformed model was 0.000 (see table 4.15) which proved that the model was significant. Also, after transformation of the dependent variable, p values of all four independent variables became much less than 0.05, which were 0.004, 0.000, 0.002 and 0.014 respectively (see table 4.16). This means all independent variables were significant for the transformed model. This result was interesting, because only two independent variables (number of light rail stations which met LEED criteria and median household income of a block group where the given parcel was located) appeared as significant predictors for the original model. Even if Adjusted R-Square of transformed model was higher than that of the original model which was 0.484 and all independent variables were significant predictors in the transformed model, the transformed model was not powerful. Because other than these four independent variables, there was still 47.9% variability was explained by some other relevant variables.

Results

Table 4.16: Coefficients of Transformed Model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.648	.098		16.815	.000		
	NumBus	-.014	.005	-.251	-2.916	.004	.435	2.299
	NumRail	.398	.042	.820	9.355	.000	.418	2.393
	MedianHousehold	.007	.002	.184	3.116	.002	.926	1.080
	Area	-2.659E-6	.000	-.143	-2.496	.014	.978	1.023

a. Dependent Variable: Transformed_Unitvalue

Interpretation of Results

Since variance inflation factors (VIF) for all four independent variables in the transformed model were much less than 10 and close to 1 (see table 4.16), we could conclude that there was no strong evidence of collinearity among these four independent variables.

Estimated coefficients of the transformed model were shown in table 4.16. β_1= -0.014 means that as the number of bus stops for a given parcel which met LEED criteria increased by 1 unit, transformed unit value of that parcel decreased by 0.014 unit.

β_2 = 0.398 means that as the number of light rail stations for a given parcel which met LEED criteria increased by 1 unit, transformed unit value of that parcel increased by 0.398 unit.

β_3 = 0.007 means that as the median household income of a block group where the given parcel was located increased by 1 unit, transformed unit value of that parcel increased by 0.007 unit.

β_4 = -0.000002659 means that as the area of a given parcel increased by 1 unit, transformed unit value of that parcel decreased by 0.000002659 unit.

The corresponding predictive model was as follows:

Transformed appraised unit value of an unimproved parcel= 1.648 - 0.014 (Number of bus stops for a given parcel that meet LEED criteria) + 0.398 (Number of light rail stations for a given parcel that meet LEED criteria) + 0.007 (Median household income) - 0.000002659 (Area of a given parcel)

This model could be further switched to the following format:

Predicted appraised unit value of an unimproved parcel= [1.648 - 0.014 (Number of bus stops for a given parcel that meet LEED criteria) + 0.398 (Number of light rail stations for a given parcel that meet LEED criteria) + 0.007 (Median household income) - 0.000002659 (Area of a given parcel)] $^{(1/0.3)}$

CHAPTER V

CONCLUSION

For Correlation between Median Household Income and Number of Bus Stops and Light Rail Stations

According to the results of previous research on correlation among variables, the research hypothesis: 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 for a parcel, was rejected. Because, Pearson correlation for Median Household Income against Number of Bus Stops and Median Household Income against Number of Light Rail Stations were only 0.157 and 0.263 respectively (see table 4.2), both of which were much less than 0.9. This weak correlation could also be confirmed by the scatterplots for Median Household Income versus Number of Bus Stops (see figure 4.1) and Median Household Income versus Number of Light Rail Stations (see figure 4.2) in “Scatterplots” section.

Besides, it was important to notice that Number of Bus Stops had a positive correlation against Median Household Income, which means that 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, number of bus stops which met LEED criteria went down. Hence, based on this result, the phenomenon, mentioned in Bhagyashri Joshi's (2009) study, that an increase in the number of bus stops led to the decrease in the transformed appraised unit value of a parcel, could not be reasonably explained by saying that the bus systems were purposefully designed to transport people primarily from economically disadvantaged areas in the city. One possible reason for this result could be that, the median household income data was collected about ten years ago whereas the transportation data and land value data were both for the year 2009, there could be a great change in median household income among different block groups in Houston during ten years. This difference led to the inaccuracy of the model.

For Regression Model for Predicting Appraised Unit Value

After done with multiple regression analysis for the transformed data, a significant predicting model was established, which was:

Predicted appraised unit value of an unimproved parcel= [1.648 - 0.014 (Number of bus stops for a given parcel that meet LEED criteria) + 0.398 (Number of light rail stations for a given parcel that meet LEED criteria) + 0.007 (Median household income) - 0.000002659 (Area of a given parcel)] $^{(1/0.3)}$.

The p value for this model was very encouraging and the Adjusted R-Square of this model was higher than that of Bhagyashri Joshi's (2009) model, of which Adjusted R-

Square was 0.493. This result achieved the objective of this research. Further more, the analysis results also indicated that the independent variable, median household income, was a significant variable for predicting the appraised unit value of a given parcel.

However, this model was not powerful enough, because only 52.1% variability of the model could be explained by these four independent variables, while the rest 47.9% variability was explained by some other relevant variables.

An interesting finding for the predicting model was that the independent variable, number of bus stops which met LEED criteria for a given parcel, still had a negative coefficient. This means that an increase in the number of bus stops led to the decrease in transformed unit value of parcel. However, a possible explanation for this phenomenon that there might be a potential link between socio-economic status and transportation mode was not supported by the results of the data analysis. Hence it would be necessary to find out the reasonable explanations for this phenomenon from other aspects.

In addition, both number of light rail stations and median household income had positive coefficients, which means more light rail stations which met LEED criteria a given parcel had and higher median household income of a block group where the given parcel was located was, the higher the appraised unit value of this parcel would be. This finding was valuable, because it suggested investors to select parcels which were close to light rail stations and located in economically developed area and eventually reduce both the use of private vehicles and damages of undeveloped land resources.

Recommendations for Future Research

Since the Adjusted R-Square of this model was not so satisfactory, it will be meaningful to find out other possible variables to formulate a better regression model in future research. For example, other LEED criteria but the sustainable sites criteria might be a possible factor to predict the unit land value.

The entire research only focused on the City of Houston. So, similar research could be conducted in other cities.

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

Median household income data were merely for the block group where a given parcel was located, not for a specifically given parcel. Hence, it will be quite necessary to obtain median household income data for a block or even a parcel in future research. Besides, the median household income data was collected about ten years ago and a new census is just about to start around 2010. If the newest median household income data could be gained, future research will be much more reliable.

Second order models, such as squared number of bus stops and non-linear models could be examined.

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