EVALUATION OF VALUE CREATION CONCEPTS

IN SINGLE FAMILY RESIDENTIAL SUBDIVISIONS

A Dissertation

by

WOO JIN SHIN

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

DOCTOR OF PHILOSOPHY

May 2009

Major Subject: Urban and Regional Sciences

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ABSTRACT

Evaluation of Value Creation Concepts in Single Family Residential Subdivisions.

(May 2009)

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To increase real estate values, developers often apply designs on the land. In the case of a single family housing development, the designs are applied to the unit of subdivisions. In this study, the designs are defined as “value creation concepts,” which increase housing values at the subdivision level. The value creation concepts are classified into five categories – the sense of arrival, product mix, walkability, circulation system, and amenity.

This cross-sectional study focuses on exploring the effects of value creation concepts in the subdivision. Two methodologies – the Hedonic Price Model (HPM) and the Hierarchical Linear Model (HLM) – are used to test whether or not the value creation concepts would increase or decrease single family housing values.

The study sample is composed of 6,562 single family houses nested in 85 subdivisions in College Station, Texas. Data are composed of two levels: the housing level and the subdivision level. The scores of the sense of arrival were provided by sixty-one graduate students at Texas A&M University using photograph evaluations. Most structural variables were obtained from the Brazos County Appraisal District, and physical environmental variables were objectively measured using the Geographical Information System.

In the both models, sense of arrival, greenway connectivity, sidewalk connectivity, and median length of cul-de-sac variables have positive effects on single family housing values while phased project, the number of accessible entrances, street density, single family density, and median length of block variables have negative effects on single family housing values. At the housing level, several structural variables (e.g. bathrooms, attached garage, porches, etc), attached to a golf course, sports facilities, network distance from the nearest elementary school, population density, and personal variables (i.e., tenure, workable age, employment) were significant ($p<.05$) predictors of single family housing value.

Findings support that the value creation concepts have effects on increasing housing values at the subdivision level, which would provide thoughtful insights for developers in residential areas. In addition, the HLM can be used as the complement of the HPM by controlling interaction terms between housing variables and subdivision variables, or among the subdivision variables themselves.

DEDICATION

To my beautiful lover Woo-Hwa and sweet son Jun-Soo

ACKNOWLEDGEMENTS

First of all, I would like to give all glory to God, who has always been with me in every difficult and joyful moment. With his precious aid, from the beginning of this study to the end, I could accomplish my Ph.D. degree.

Indeed, I could only complete this dissertation with the great support, concerns, and love of many people. First, I would like to express my great gratitude to my co-chairs, Dr. Jesse Saginor and Dr. M. Atef Shrakawy. Dr. Saginor is the one who guided me through my Ph.D. studies and encouraged me to be a creative researcher. Without his enthusiastic and thoughtful direction, I would never have reached my goal. From Dr. Sharkawy, I learn how to interpret and understand real estate and land developments. I also would like to thank my committee members, Dr. Shannon Van Zandt and Dr. Ifte Choudhury, for their advice, guidance, and support throughout the course of this dissertation. Their encouragement helped me to become the person I am now.

I also would like to give great thanks to Dr. Chang-Mu Jung, Dr. Sang-Kyung Lee, and Dr. Christopher D Ellis. Dr. Jung, a warm-hearted mentor for me, encouraged me to become a scientist and gave me chances to participate in a lot of projects. Dr. Lee gave me an opportunity to work at Seoul Development Institute and to be a co-author in several publications. Dr. Ellis gave me a chance to work as a GIS specialist in a National Park Service project and a Study Abroad Program in Costa Rica. Working with them provided a foundation for me to learn how to begin academic research projects.

I also express gratitude to Dr. Sam Brody, Dr. Douglas Wunneburger and Dr. Wes Highfield at Texas A&M University who worked together for creative ideas in GIS program works. Special gratitude is given to Dawn Killian, who provided GIS data of the City of College Station, and to Mary Landreth, who provided structural variables and appraisal values of single family houses in the City of College Station, which enriched my dissertation.

I want to extend my gratitude to Dr. U-Jong Lee, Chang-Su Lee, and Hwan-Yong Park, who are professors at Kyung Won University. Without their supportive recommendations and great help, I would not have pursued my Ph.D. at Texas A&M University. I also would like to express appreciation to two visiting scholars, Dr. Suckhwan Lee and Dr. Songhyun Choi for insightful discussions during their stays in College Station. Great thanks are expressed to Jae-Chun Lee's family, Dr. Hyung-chul Ryu's family, Jun-Hyun's family, and my friends Dae-Young, Jung-Ju, Sang-Gyun, Jee-Hwan, Jae-Bum, Sang-Hun, Jae-Su, Young-Jae, Jung-Eun, Jung-Yim, Chan-Yong, In-Chul, Kyu-Bok, Jung-Hyun, In-Hyo, Yun-Young, Eun-A, Sun-Ju, Song-Gang, Kent, Judy, and all colleagues at Texas A&M University and University of Seoul.

Finally, I thank my family for their everlasting love, patience, and support. My beautiful love, Woo-Hwa, is a fan as well as colleague throughout my whole life. Without her lavish support and trust, I could not have completed my Ph.D. My accomplishment could also not have been achieved without my parents' sacrifice and my parent-in-laws' encouragement. Finally, I want my invaluable son, Jun-Soo, to know that I really love him, and thank God for protecting him in good health.

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CHAPTER I

INTRODUCTION

1.1 Background of the Study

The business goal of developers is to recapture enough profit to cover risks by creating higher real estate market values than the developer costs (Graaskamp, 1981). Developers focus on creating real estate value to take full advantage of Returns on Investment (ROI) by both increasing returns from sales proceeds and decreasing equity (Sharkawy, 1994).

In real estate development, developers create the real estate value in two ways. First, they increase real estate value by financial support with public incentives from considering financing vehicles such as Public Improvement District (PID) or Tax Increment Financing (TIF) (Johnson and Man, 2001; Khan and Parra, 2003). Next, developers can create real estate value by applying value creation concepts to the design of real estate development products. The value creation concepts are defined as the notions of trade-offs in design economy engaging in creating real estate value (Sharkawy, 1994). Land development is engaged in the acquisition of the lands to construct utilities or surface improvements, and to re-sell the developed site to developers or home builders (Brueggeman and Fisher, 1997).

This dissertation follows the style of *Environment and Behavior*.

To increase real estate value, developers apply designs on the land in the unit of a subdivision. Developers split a large land area into an appropriate number of lots that can be efficiently sold for single family housing (Peiser, 1989; Owen, 1998). Hence, the value creation concepts in a single family residential development should be evaluated in a subdivision level.

1.2 Statement of the Problem

Single family housing values have been predicted by structural, locational, environmental, and neighborhood attributes. Studies have found that structural variables (e.g. the number of bedrooms, the number of bathrooms, the number of fireplaces, and garage size) have effects on single family housing values (Lutzenhiser and Netusil, 2001; Simon et al., 2001; Geoghegan, 2002; Irwin, 2002; Pompe and Rinehart, 2002; Grudnitski, 2003). Locational variables (e.g. the distance from amenities, such as shopping centers, churches, elementary public schools, and CBD [Central Business Districts]) affect single family housing values (Palmquist, 1980; Jud, 1985; Rosiers et al., 2001; Simons et al., 2001; Geoghegan, 2002; Irwin, 2002; Grudnitski, 2003). A great deal of research has also examined the effects of environmental variables, such as the distance from parks, golf courses, open spaces, or greenways, on single family housing values (Do and Grudnitski, 1995; Bolitzer and Netusil, 2000; Lutzenhiser and Netusil, 2001; Geoghegan, 2002; Irwin, 2002; Grudnitski, 2003). Several researchers discovered that neighborhood attributes (e.g. median income of a block group and the population density in a block group) influenced single family housing value (Palmquist, 1980; Geoghegan, 2002; Irwin, 2002).

Until recently, the effects of value creation concepts on the single family houses have rarely been examined. In the single family housing development, the value creation concepts are defined as variables that increase housing value at the subdivision level. For example, all houses in one subdivision may share a common value (e.g. the number of entrances, the presence of fountains, etc.) when the subdivision is designed and built by a developer. In this case, although such common values in a subdivision may influence the increase of single house values, the effects of the common values on the single family houses may not be identified. Only a few recently published papers discussed a few variables at the subdivision level that evaluate common value effects on single family housing. For example, Thorsnes (2002) found a positive relationship between the value of houses and the preserved area attached to the subdivisions. Guttery (2002) showed the negative effects of an alleyway in a subdivision on single family housing values.

In conventional housing value studies, structural, locational, environmental, and neighborhood attributes are considered as factors affecting single family housing values. Among these four, neighborhood attributes somehow account for the effects of variables at the neighborhood level on housing values. Nonetheless, neighborhood attributes differ from subdivision characteristics.

The neighborhood attributes are generally measured on the basis of the neighborhood geographical boundaries. For example, neighborhood variables are measured on the basis of Census Tracks/ Block Group/ Block, which are geographic units defined by the United States Census Bureau (U.S. Census Bureau, 2008). That is, the census data are used as proxies for neighborhood attributed. On the other hand, subdivision boundaries are defined by developers. Both census tracks and census blocks are normally not equal to subdivision boundaries (see the example in Figure 1-1). Hence, neighborhood attributes may not reflect a developer's unique design values as well as represent the precise value of the subdivisions. As a result, a subdivision should be considered a new essential unit in the study of the effects of the unique value in each subdivision on single family housing values.

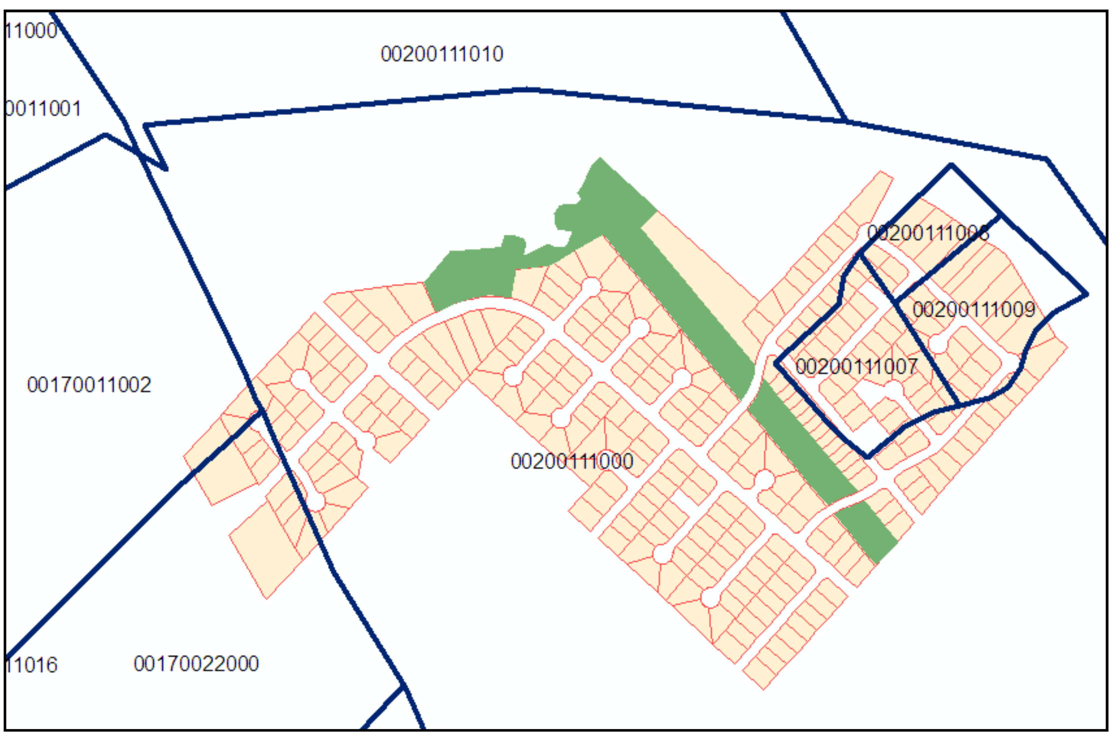


Figure 1-1. Raintree Subdivision in College Station Covered by Six U.S. Census Blocks.

CHAPTER II

LITERATURE REVIEW

The following sections briefly summarize pertinent research findings related to single family property values. This literature review identifies the value creation concepts, and the eight factors affecting housing values at the two different levels—housing and subdivision.

2.1 Value Creation Concepts

Sharkawy (1994) defined value creation concepts as notions of trade-offs in the design economy that engages in creating real estate values. The value creation concepts appear in two models: one is the Revised Multidisciplinary Development Planning Model (RMDPM) built by Sharkawy and Graaskamp, and the other is the "PHYS-FI: A Physical-Financial Model for Design Economy Trade-Offs" developed by Sharkawy. The RMDPM is composed of a financial side and a physical side. The financial side of the model consists of three deductive inference-based steps—market analysis, marketability analysis, and financial modeling. The physical part of the model involves five inductive reasoning-based steps: site analysis, environmental analysis, developer's facilities program, value creation concepts for design, and design plans. The value creation concepts belong to the physical side; however, these concepts are developed by considering not only site analysis and environmental analysis on the physical side, but also market analysis and marketability on the financial side. In addition, the value creation concepts have effects on a schematic design of land development (See Appendix 1).

In the PHYS-FI model, the value creation concepts are specified by three categories; the environment, product synergy, and design differentials. Nine concepts (topographic fit, water context, amenity dollars, contextual fit, product mix, thematic frameworks, cultural schemata, relational schemata, and form schemata) evolved from the three categories, and are applied to land development designs to create higher real estate market values on single family houses (See Appendix 2).

Sharkawy (1994) tracked the value creation concepts through 126 projects built during 1978-1989 and described in the Urban Land Institute's project files. The projects included offices, retail stores, multi-family houses, and single family houses. During this process, he categorized the value creation concepts dividing real estate value into three categories and several sub-categories. In addition, the value creation concepts in subdivisions have two different characteristics: dynamic and partial static traits.

2.1.1 Dynamic Traits of Value Creation Concepts

Sharkawy (1975) argues that value creation concepts are made by combining some dimensions of land planning and design (e.g. natural, physical, man-made, financial, etc.) into a unique composition. He also says that new value creation concepts are produced by an input of stimuli and schemata, and new and/or adjusted concepts are continuously redeveloped from previously experienced concepts (See Figure 2-1).

Hence, each subdivision has different components of value creation concepts such as different amenities and/or circulation systems, etc.

For example, three subdivisions were developed in 1980, 1990, and 2000, respectively (See Figure 2-2). Subdivision "A" was developed with a circulation concept, subdivision "B" was developed using circulation and/or amenity concepts, and the development of subdivision "C" employed circulation, and/or amenity, and/or sense of arrival concepts. These differences across three subdivisions over time can illustrate "dynamic traits" of the value creation concepts in subdivisions. This suggests that newer subdivisions may have more value creation concepts than older subdivisions. Practically, dynamic traits of value creation concepts can be found in College Station, Texas (See Figure 2-3). Most residential houses in College Station, Texas were built from 1920 on (actually, less than ten houses were built between 1880 and 1920).

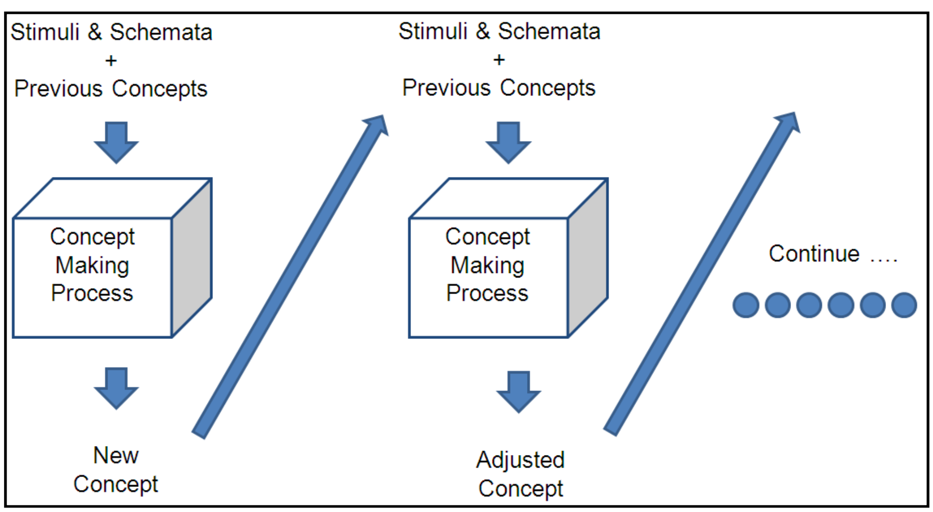


Figure 2-1. New and/or Adjusted Reoccurring Process of Value Creation Concepts.
(Source: Sharkawy, 1975)

Region "A" was developed earlier than other regions (from 1960 through 1980). That is, most subdivisions in Region "A" are older than other subdivisions. The main reason for this can be explained by the distance from Texas A&M University (TAMU). The interesting thing is that it is hard to find the boundaries of these subdivisions. They are separated by roads, and sometimes houses in the same block are included in separate subdivisions. The boundary of a park in Region "A" is shared by several other subdivisions (See Figure 2-4).

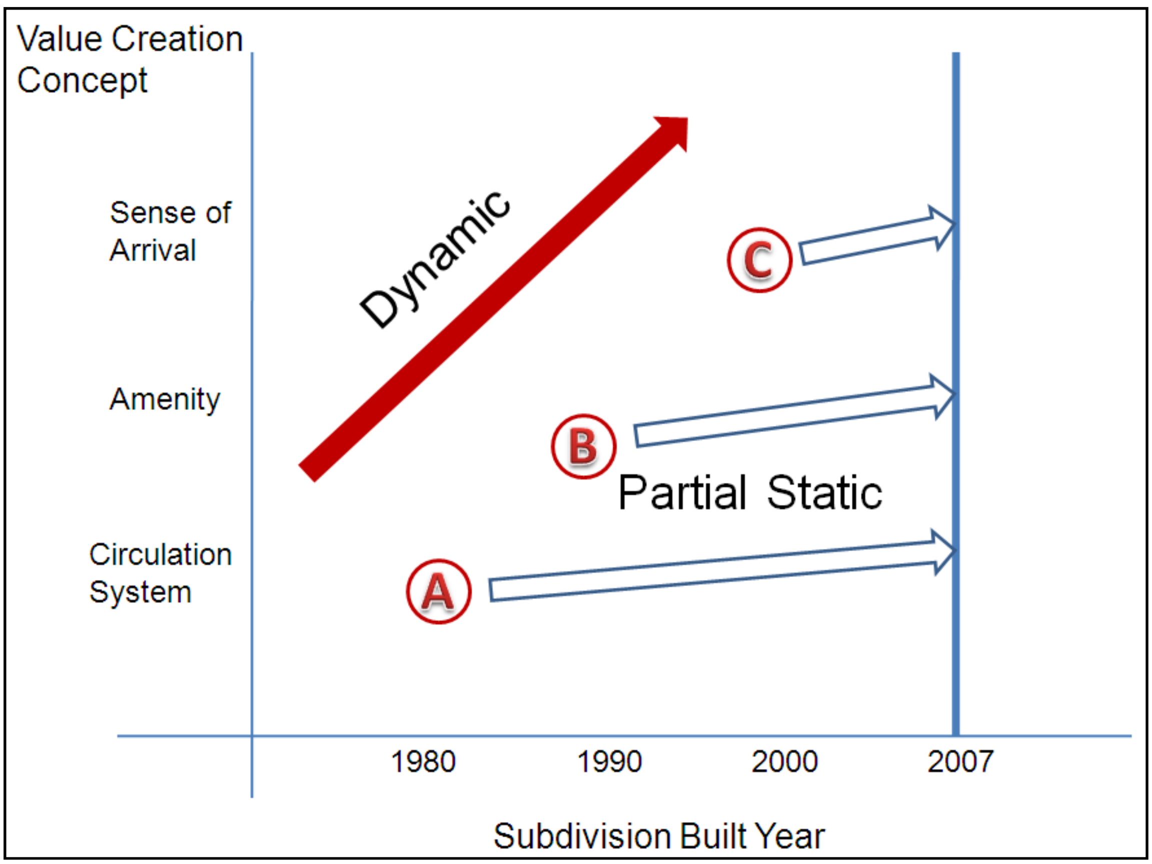


Figure 2-2. Both Dynamic and Partially Static Traits of the Value Creation Concepts in Subdivisions.

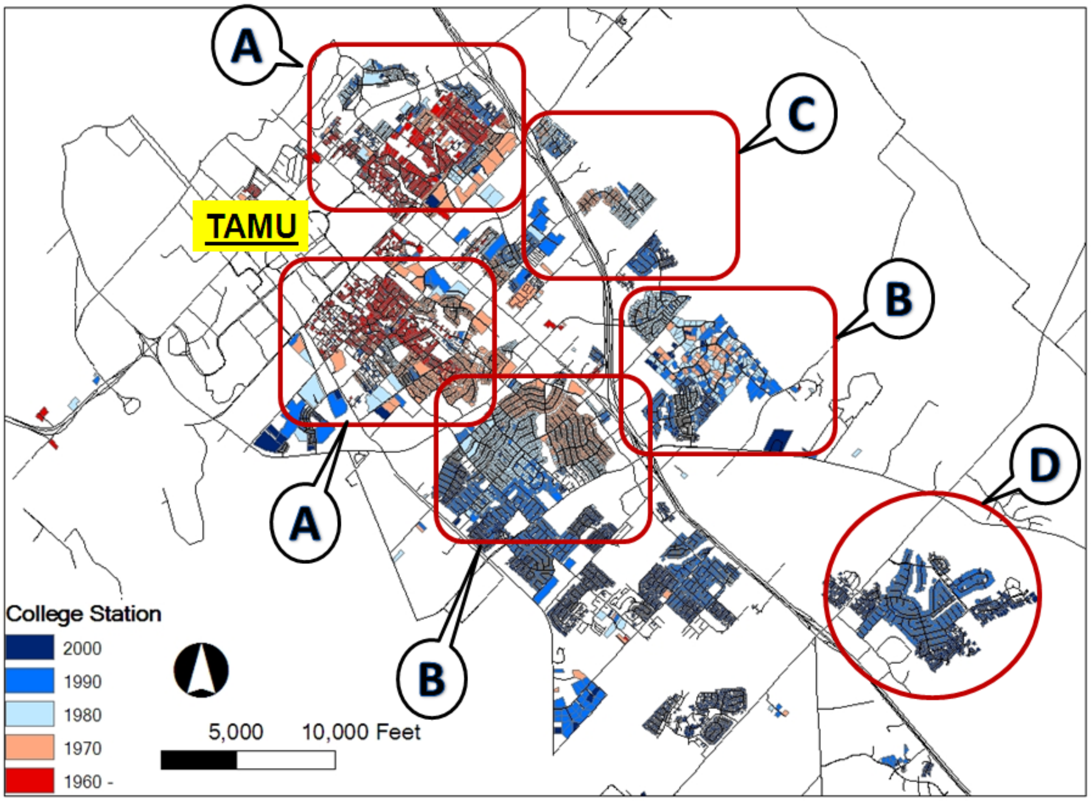


Figure 2-3. A Map of Built-Year of Residential Houses in College Station, Texas.

Region “B” was developed from 1970 through 1990. There are some big subdivisions in Region “B” which are separated from Region “A.” In general, each subdivision includes a park, or a private park. Region “C’ was developed from 1980 through 1990. Subdivisions in Region “C” are gated communities and are separated from each other by open space and woods. The subdivisions include a small park for use only residents of the subdivision. Finally, Region “D” was developed from 1990 through 2000. This region includes a golf course, which is a new amenity. From a rough comparison of the groups of subdivisions based on year built, the dynamic traits of the value creation concepts can be identified.

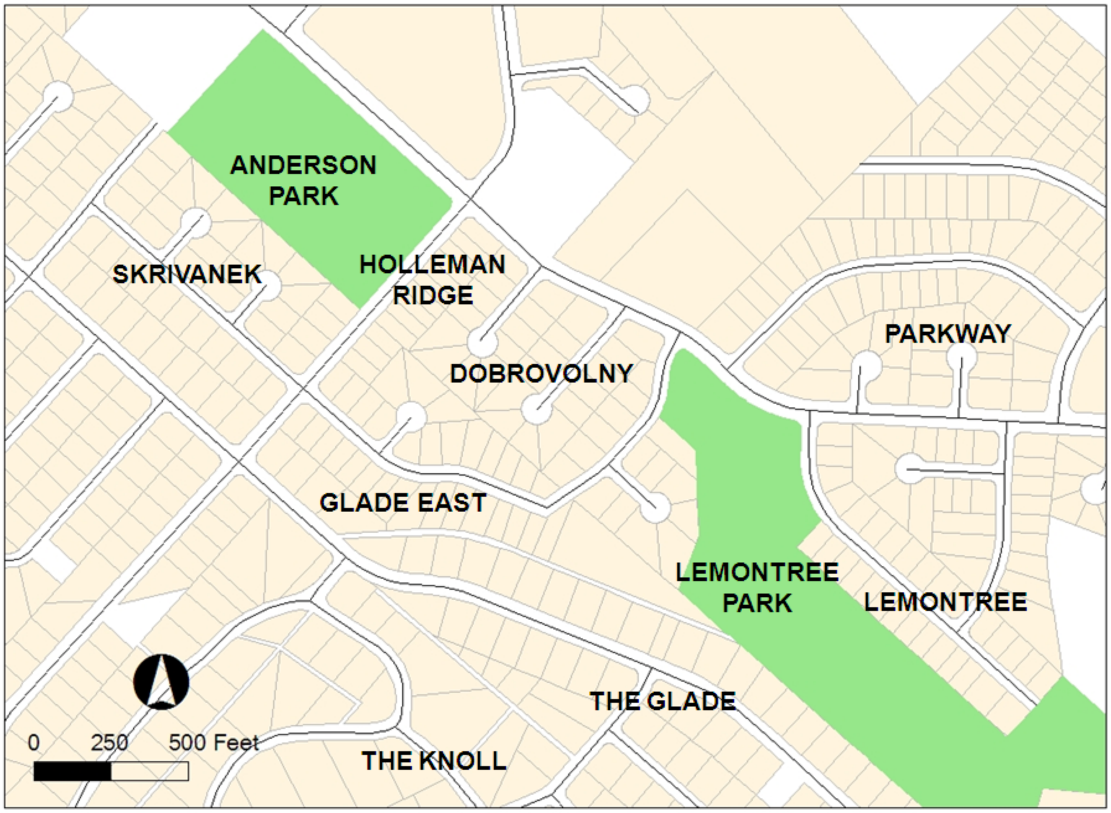


Figure 2-4. Several Subdivisions Sharing a Park Boundary in Region "A" of Figure 2-3.

2.1.2 Partially Static Traits of the Value Creation Concepts

Once a subdivision is developed with its specific value creation concepts, characteristics of the subdivision are not usually seriously changed. That is, the characteristics in subdivisions may be changed slightly (i.e. rezoning of some parcels, or paving a new bike-lane or walk-lane, etc.). For example, according to "The Bikeway and Pedestrian Master Plan in 2002," there were about 25 miles of existing bike lanes in 2002 in College Station, Texas (College Station, 2002a). The master plan showed that approximately 20 miles of planned bike lanes would be developed (See Figure 2-5). In other words, some existing subdivisions which did not have bikeway or pedestrian lanes may develop the lanes based on new city plans. Changes in the circulation system have an effect on value creation concepts in that changes may create value.

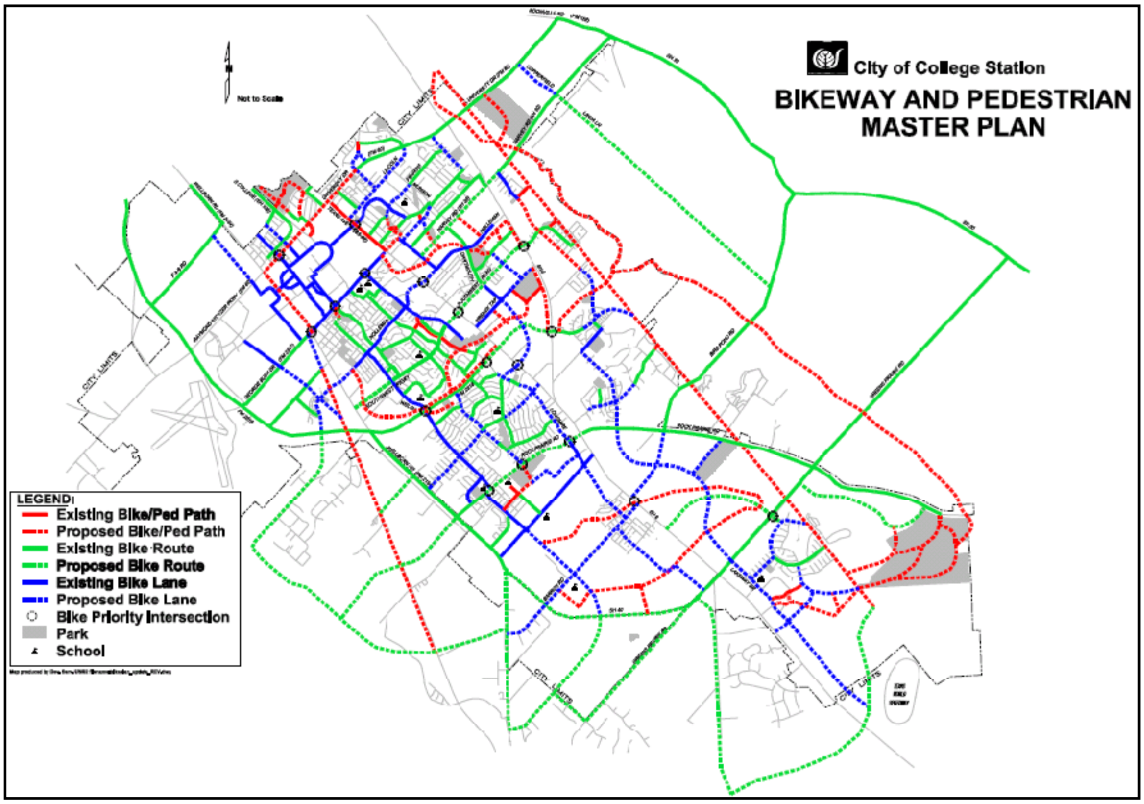


Figure 2-5. Bikeway and Pedestrian Master Plan in 2002 in College Station, Texas. (Source: College Station, 2002a)

Several large-sized subdivisions are developed in several stages. Some part of a subdivision is developed first, and then rest of the subdivision is developed later.

However, even in this case, housing purchasers generally know the boundary and amenities of the subdivision when they buy.

2.2 Subdivision Level

Five important factors at the subdivision level that buyers look at are sense of arrival, product mix, walkability, circulation system, and amenity factors.

2.2.1 Sense of Arrival Factor

It was hard to find research about the effects of the sense of arrival on single family housing values. The vista of a subdivision entrance, which may lead neighbors to feel a sense of arrival, can be composed of several characteristics such as signage, divided curving, a gate, walls, or landscaping. Several papers used photographs to evaluate participants' perceptions of landscape sites by assigning a score to each scene. Buhyoff et al. (1982) evaluated perceptions of forest vista landscapes using picture scoring. Results showed that the negative visual impact of insect damage was diminished by the presence of long viewing distances, thick forests, and hilly terrain. Yamashita (2002) examined the perception of water in the landscape using photographs of good or bad scenes which were taken by the participants. Researchers have found that adults like to see dynamic aspects of water more than do children. Tunstall et al. (2004) used photography to evaluate children's perceptions of a river landscape. This paper showed that children recognized the aesthetic appeal of trees in the river landscapes. The Scenic America (1999) showed specific ways to evaluate a scene quality with the use of photograph slides. The sense of arrival rating response sheet measurement was based on the Scenic America report (See Appendix 3).

2.2.2 Product Mix Factor

Product mix factor reflects land use mix, single family density, or phased development of the subdivision. Song and Knaap (2003) argue that negative relationships exist between single family housing values and the land use mix, when the mix includes single-family residential as well as other land uses (multi-family residential, industrial, public, and commercial). Next, low single family density means that each single family house has a large space for open space, green area, or privacy (Dipasquale and Wheaton, 1995). Hence, there will be a negative relationship between single family density and the housing value. Many subdivisions are developed in more than two phases. The phased development (or phased project) is also included in product mix characteristics (Sharkawy, 1994). For example, among 85 subdivisions in College Station, Texas, 45 subdivisions are developed in only one phase. The average size of a one phase developed subdivision (50.3 hectare) is much larger than the average size of a more than 2 phased developed subdivision (13.6 hectare). The size of recently developed subdivisions is larger than the size of older subdivisions, and the subdivisions are located on the south-west side of College Station. Hence, there will be a negative relationship between phased development and housing value.

2.2.3 Walkability Factor

In several papers, walkable environments are considered in order to encourage more physical activities and active life-styles (Handy, 1996; Cervero and Kockelman, 1997; Hess et al., 1999; Randall and Baetz, 2001; Moudon and Lee, 2003; Saelens et al., 2003). The researchers argue that walking is encouraged by the continuous sidewalk and bike route system, fewer dead-ends, and smaller blocks. However, it is hard to find any literature examining the relationships between walkability factors and single family housing values. Song and Knaap (2003) show that single family housing values rise when the neighborhood block size is smaller. In addition, several researchers found that cul-de-sacs generated about a 30 percent; house price premium compared to grid street patterns (Asabere, 1990; Song and Knaap, 2003).

2.2.4 Circulation System Factor

The Circulation system factor is related to street design including nodes, street lengths, and cul-de-sacs. Song and Knaap (2003) show that single family housing values rise when the length of streets are longer, and the fewer the number of street nodes in the neighborhood. The connected node ratio (the number of street intersections divided by the number of intersections plus cul-de-sacs) can be used to measure the effects of cul-de-sacs on housing value (Asabere, 1990; Song and Knaap, 2003). The number of intersections per hectare can be a barometer of the connectivity of the transportation network (McNally and Kulkarni, 1997), and the ratio of 4-way intersections to all intersections can be an indicator of grid street patterns. The larger the ratio, the more connected the streets and the more supportive for walking (University of Minnesota, 2005).

2.2.5 Amenity Factor

The amenity factor is mainly related to park and greenway connections. A number of papers show the positive effects of parks on single family housing values (Lyon, 1972; Hammer et al., 1974; Palmquist, 1980; More et al., 1982; Buffington, 2000; Crompton, 2000; Crompton, 2005). In addition, positive relationships are shown between single family housing values and the proximity to an open space or the types of open spaces (Frech and Lafferty, 1984; Bolitzer and Netusil, 2000; Lutzenhiser and Netusil, 2001; Geoghegan, 2002; Irwin, 2002).

2.3 Housing Level

Three important factors at the housing level are structural, locational, and neighborhood factors, which are control variables.

2.3.1 Structural Factor

The structural factor includes the characteristics of a house itself, such as the number of bedrooms, the number of bathrooms, the number of fireplaces, garage size, square footage of house, lot size, age of the building in years, pool, stories, and so on (Weicher and Zerbst, 1973; Palmquist, 1980; Gillard, 1981; Rodriguez and Sirmans, 1994; Do and Grudnitski, 1995; Lutzenhiser and Netusil, 2001; Simon et al., 2001;

Geoghegan, 2002; Irwin, 2002; Pompe and Rinehart, 2002; Grudnitski, 2003). All these variables are positively related to the single family housing price except for the age of the building in years (Song and Knaap, 2003). In general, the building-age variable is a proxy of the variable regarding the quality of the construction of the home because the building-age variable is negatively related to sale price, since older houses have experienced greater depreciation.

2.3.2 Locational Factor

Several papers show the negative relationships between single family housing values and the geographic distance from amenities such as shopping centers, churches, highways, elementary public schools, and CBD (Central Business Districts), except hazardous waste sites (Palmquist, 1980; Jud, 1985; Kiel, 1995; Rosiers et al., 2001; Simons et al., 2001; Geoghegan, 2002; Irwin, 2002; Grudnitski, 2003).

The locational factor also includes the impact of the distance from parks, open spaces, golf courses or greenways on single family housing values. Many papers show the positive effects of parks on single family housing values (Lyon, 1972; Hammer et al., 1974; Palmquist, 1980; More et al., 1982; Buffington, 2000; Crompton, 2000; Crompton, 2005). Even though there is a positive effect on the value of properties backing up to a park, it is lower than the impact on single family properties a block or two away (Lyon, 1972; Buffington, 2000) (See Figure 2-6 and Table 2-1). Properties abutting a park were subjected to many nuisances such as noise and lights, etc. (Crompton, 2000). Several papers pointed out the negative effects of facing heavily-used park facilities on single family housing values (Weicher and Zerbst, 1973; Li and Brown, 1980; More et al., 1982). However, in their papers, heavily-used recreational facilities were not defined, and were not evaluated as an independent variable on single family housing values.

Others show that a single family house with the amenity of a view of parks or water features has a higher value than a house having an obstructed view of parks or water features (Weicher and Zerbst, 1973; Gillard, 1981; Rodriguez and Sirmans, 1994; Benson et al., 1998).

Table 2-1

Cases of the Proximity Principle

Author	Year	State/City	Site Characteristics	Results
Lyon	1972	Philadelphia	- 7 Sites: Park (3), School (3), Combined (1)	- All sites show positive impact - Abutting Impact < Impact of one or two block away (∵ School with athletic field can be "nuisance")
Hammer et al.	1974	Philadelphia	- A park	- Parks account for: 33% of land value at 40 feet 9% at 1,000ft, and 4.2% at 2,500 feet
More et al.	1982	Massachusetts	- 4 parks / Data: within 4,000ft for 5 yrs	- A house located 20 feet from a park sold for $2,675 more than a house located within 2,000 feet. - Properties located within 500 feet account for an 80% aggregate increase in value. - Effects are not taken into account beyond 2,000 feet
Buffing-ton	2000	Minnesota	- 74 Parks	- <75 feet: Building ($80,994) Land ($1.88/feet^2) - >75 feet: Building ($69,338) Land ($1.94/feet^2)

Golf courses also show the positive effects on the value of single family houses. The golf course frontage or specific golf course types have a positive premium (Hirsh, 1994; Do and Grudnitski, 1995; Grudnitski, 2003); however, houses located within a mile from the golf course gate have a negative relation to single family housing values because of the noise and traffic from golfers (Asabere and Huffman, 1996). In addition, when there are a lot of amenities, especially a water view, in a community, the effects of a golf course on single family houses are not significant (Pompe and Rinehart, 2002).

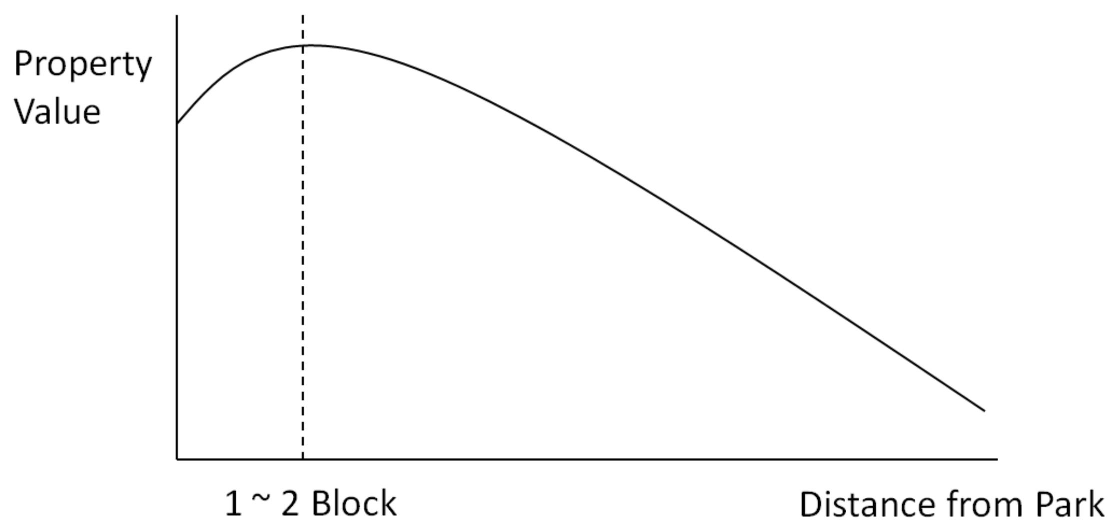


Figure 2-6. Relationship between the Distance from a Park and Housing Value.
(Source: Crompton, 2000)

2.3.3 Neighborhood Factor

Neighborhood factor reflects on the characteristics of the neighborhood, such as the socio-economic characteristics of neighboring residents, the quality of neighboring structures, the median income of the block group, population density in the block group, crime and vandalism, and the percent of individuals in the block group with a bachelor's degree (Li and Brown, 1980; Palmquist, 1980; Gillard, 1981; Simons et al., 1998; Ding et al., 2000; Geoghegan, 2002; Irwin, 2002). African-American households make a negative impact on single family housing values, because of three reasons. First, it is not clear what percent of African-American density causes Anglo-Americans to move from the neighborhood (Pettigrew, 1973; Taylor, 1979; Bobo et al., 1986). Second, African-American families like to live in integrated neighborhoods (Pettigrew, 1973; Palm, 1985; Bobo et al., 1986; Charles, 2003). Finally, the number of African-American households shows consistently negative impact on single family housing value (Gillard, 1981; Simons et al., 1998; Ding et al., 2000; Irwin, 2002). Several papers show the effects of poverty, median income, population density, crime rate, and education level on single family housing values (Li and Brown, 1980; Simons et al., 1998; Ding et al., 2000; Geoghegan, 2002; Irwin, 2002).

From the literature, it is clear that variables related to the degree of homogeneity of the neighborhood maintain a consistent relationship with housing values. African-American, poverty, population density, and crime variables have a negative relationship with single family housing values. On the other hand, median income and education variables show positive relationships with residential sales prices (See Table 2-2).

Table 2-2

Relationship between Variables Related to the Degree of Homogeneity of Neighborhood and Residential Sales Price through Literature Review

Authors	African-American	Poverty	Median Income	Population Density	Crime	Education (Bachelor Degree)
Li & Brown (1980)			+		− **	
Gillard (1981)	−					
Simons et al (1998)	−	− **	+ **		− **	
Ding et al (2000)	− **	−	+ **		− **	
Geoghegan (2002)			+ **	− **		+ **
Irwin (2002)	− **		+ **	− **		

+ indicates positive relationship between the variable and residential sale price.
- indicates negative relationship between the variable and residential sale price.
** indicates statistically significant at .05 levels.

Research about the effects of neighborhood variables on housing value are conducted with only housing level variables. Equations in the research include the neighborhood variables, even though the neighborhood factor for each house is gathered from the U.S. census block or block group data to which the home belongs. Hence, in this research, the neighborhood characteristics will be in the housing level to control for socio-economic characteristics of each house and to compare the results of this research to previous literature, even if neighborhood boundaries differ from both the subdivision boundary and the housing parcel.

CHAPTER III

STUDY PURPOSE AND HYPOTHESES

3.1 Purpose of the Study

The primary purpose of this research is to determine the effects of value creation concepts on the single family housing values in a single family residential development at the subdivision level. Sharkawy (1994) classified the value concepts that create the real estate values into three categories and several concepts (See Appendix 2). In this paper, five value creation concepts, which are extracted from single family housing-related projects, will be used. Table 3-1 shows the five value concepts (sense of arrival, product mix, wakability, circulation system, and greenery) which are nested in two categories (product synergy and design differentials). The product synergy category is related to systematic or required design; while the design differentials category is related to phenomena, which are differently perceived because of designers' difference. These five value creation concepts will be used in this research (Sharkawy, 1994).

The three specific objectives for this research are:

1) To identify the value of the characteristics of sense of arrival, product mix, walkability, circulation system, and amenity of each subdivision.
2) To explore the relations between single family housing values and the five attributes at the subdivision level.
3) To identify design and policy implications that may enhance single family housing values at the subdivision level.

Table 3-1

Value Creation Concepts Related to Single Family Houses

Category	Value Creation Concepts
Product Synergy	Amenity Product Mix
Design Differentials	Sense of Arrival Walkability Circulation System

The conceptual model shows the plausible attributes that influence the single family housing appraisal values (See Figure 3-1).

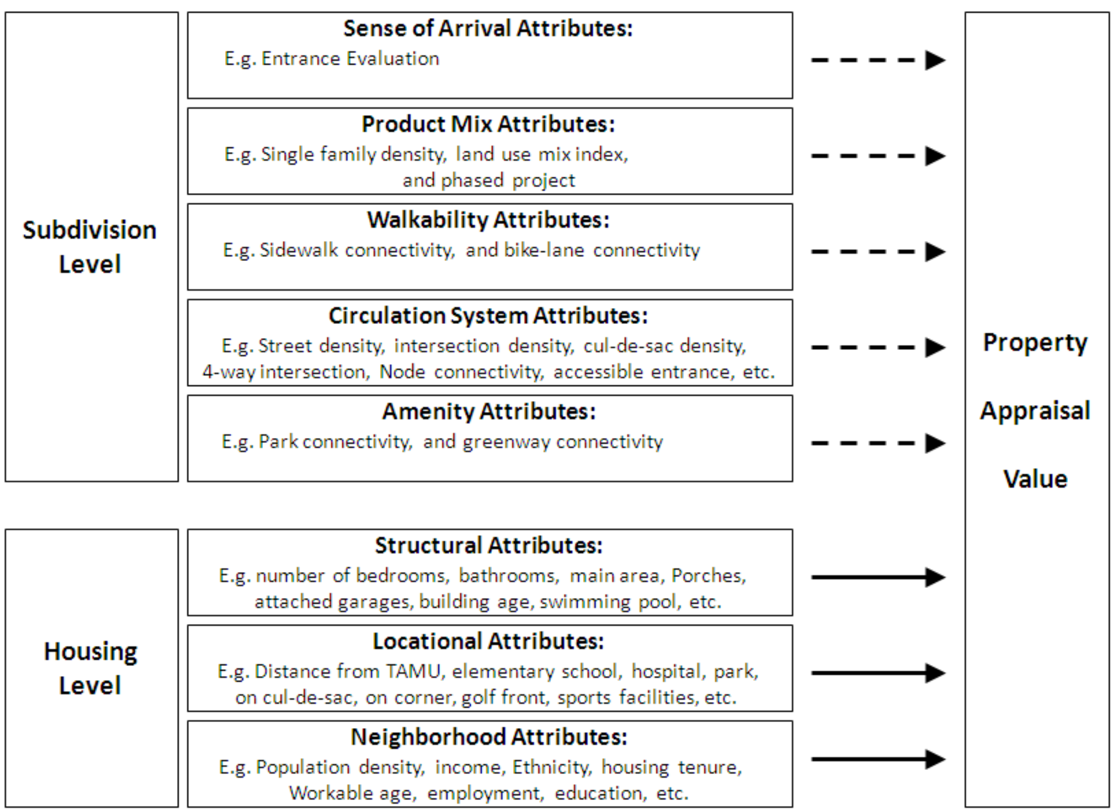


Figure 3-1. Conceptual Model.

3.2 Research Questions and Hypotheses

To achieve the specified objectives, the following questions and hypotheses will be answered (See Table 3-2);

Question 1: Will the value concept of "sense of arrival" create real estate values?

- **Hypothesis 1-1:** The higher the average value of the "Subdivision Entrance Evaluation" measured by architects, landscape architects, urban planners, or land development professionals using picture slides, the higher the value of single family houses within the subdivision.

Question 2: Will the value concept of "product mix" create real estate values?

- **Hypothesis 2-1:** The higher "single family density," which is the ratio of the total number of single family houses to residential area in a subdivision, the lower the value of single family houses within the subdivision.
- **Hypothesis 2-2:** The higher the "land use mix index," which has high value when there are many land uses, the lower the value of single family houses within the subdivision.
- **Hypothesis 2-3:** The more "phased development", the lower the value of single family houses within the subdivision.

Table 3-2

Summaries of Hypotheses

Factor	Concepts	Expected Direction of Effect
Sense of Arrival	Sense of Arrival	+
Product Mix	Single Family Density	-
	Land Use Mix	-
	Phased Development	-
Walkability	Sidewalk Connectivity	+
	Bike-Lane Connectivity	+
	Median Length of Cul-De-Sac	+
	Median Length of Block	-
Circulation System	Accessible Entrance	-
	Street Density	+
	Intersection Density	-
	4-Way Intersection	-
	Node Connectivity	-
	Cul-De-Sac Density	+
Amenity	Park Connectivity	+
	Greenway Connectivity	+

Question 3: Will the value concept of "walkability" create real estate values?

- **Hypothesis 3-1:** The higher the "sidewalk connectivity," which is the pedestrian lane length divided by total road length in a subdivision, the higher the value of single family houses within the subdivision.

- **Hypothesis 3-2:** The higher the "bike-lane connectivity," which is the bicycle lane length divided by total road length in a subdivision, the higher the value of single family houses within the subdivision.
- **Hypothesis 3-3:** The higher the "median length of cul-de-sac," which is the median length of all cul-de-sacs in a subdivision, the higher the value of single family houses within the subdivision.
- **Hypothesis 3-4:** The higher the "median length of blocks," which is the median length of all blocks in a subdivision, the lower the value of single family houses within the subdivision.

Question 4: Will the value concept of "circulation system" create real estate values?

- **Hypothesis 4-1:** The higher the "accessible entrances," the lower the value of single family houses within the subdivision.
- **Hypothesis 4-2:** The higher the "street density," the high the value of single family houses within the subdivision.
- **Hypothesis 4-3:** The higher the "intersection density," the lower the value of single family houses within the subdivision.
- **Hypothesis 4-4:** The higher the number of "4-way intersections," which is the proportion of the number of 4-way intersections to the number of all intersections, the lower the value of single family houses within the subdivision.

- **Hypothesis 4-5:** The higher the "node connectivity," which is the proportion of the number of total intersections to the number of all intersections plus cul-de-sacs, the lower the value of single family houses within the subdivision.
- **Hypothesis 4-6:** The higher the "cul-de-sac density," which is the ratio of the number of cul-de-sacs to street length, the higher the value of single family houses within the subdivision.

Question 5: Will the value concept of "amenity" create real estate values?

- **Hypothesis 5-1:** The value of a house which is accessible to the nearest park is higher than the value of a house which is not accessible to the park.
- **Hypothesis 5-2:** The value of a house which is accessible to the nearest greenway is higher than the value of a house which is not accessible to the greenway.

3.3 Assumptions

Assumptions:

1) The Brazos County Appraisal District's (BCAD) appraisal value of each house is assumed as a proxy for its market value and is assumed to be minimally biased.
2) Possible measurement errors in GIS data, which will be gathered from the city of College Station, Texas, are removed through equal distribution.

CHAPTER IV

METHODS

4.1 Research Design

The research design is a cross-sectional study. The dependent variable is the Brazos County appraisal values of single family houses in the city of College Station in Texas. The independent variables are the following objectively measured factors: product mix, walkability, circulation system, amenity, structural, locational, and neighborhood; and a sense of arrival variable, which was qualitatively measured. Each factor had multiple variables. In this study, it was hypothesized that the appraisal values of single family houses were affected by the characteristics of the housing itself (i.e., housing-level variables) as well as the surrounding features of the houses (i.e., subdivision-level variables).

4.2 Study Site and Population

The study site was the city of College Station, Texas. The city is located in the east central part of the state of Texas (See Figure 4-1,) and is the home of Texas A&M University. The study population was all single family houses in College Station, totaling 10,617 single family parcels. First, 6,669 single family houses nested in 122 subdivisions were selected, because they contained all the necessary information to be analyzed. That is, the parcels lacking information on the number of either bedrooms or bathrooms were excluded in the analyses. Next, among them, only 6,562 single family houses nested in 85 subdivisions were used in this study as they fit the required number of observations for the Hierarchical Linear Model. The primary study outcome will be the appraisal value of each house in 2008, which was obtained from Brazos County Appraisal District (2008).

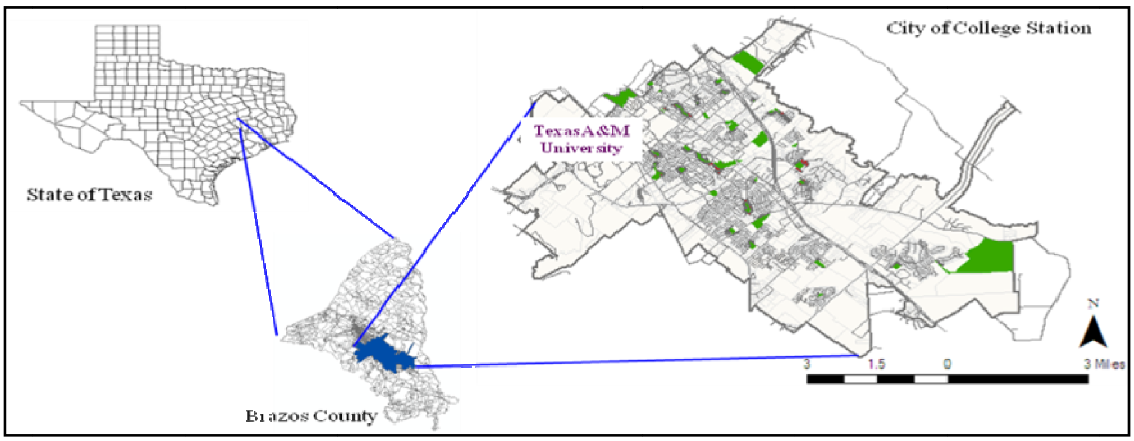


Figure 4-1. Location of the City of College Station, TX.

4.3 Usage of Appraisal Value

4.3.1 The Property Appraisal Process Specific to College Station, Texas

The Brazos County Tax Appraisal District (BCTAD) Office determines the value of all taxable properties in College Station, Texas. The appraisal procedure of the BCTAD office for property valuation starts with the office gathering a list of the taxable properties, which includes the description of the property, and name and address of the owner. The BCTAD office usually repeats the appraisal process for a property at least once every three years. The appraisal process contains mass appraisal in which the properties are classified based on various factors including usage, size, and construction type. Using information gathered from recent property sales, the BCTAD office appraises the value of typical properties in each class. In the valuation process, age and location differences among properties are also considered. After deciding the value of typical properties, individual property appraisals are conducted as well using three common approaches: 1) The cost approach, 2) The capitalization (or Income approach,) and 3) sales comparison approach (or market approach). The BCTAD office uses recent sales/appraised ratio data for adjustment of the individual property appraisals whenever it deems it necessary. The values of the properties are certified by the Appraisal Review Board for College Station, Texas (Kwa, 1996).

4.3.2 Why Will Sales Data Not Be Used in This Research

House Bill No. 2188 was passed by the Texas State House of Representatives in April, 2007, and formally enacted in June, 2007. The law was heavily supported by the real estate industry and lobbyists. Based on H.B. No. 2188, it amended Sec. 552.148 in the Government Code, Chapter 552, Public Information, Subchapter C: "Information Excepted from Required Disclosure" and changed the availability of real estate data (Texas, 2008).

According to Sec. 552.148, public information is available to the public, with several exceptions. Sec. 552.148 mentions an exception regarding records of the comptroller or appraisal district received from a private entity. Sec. 552.148 states that

"Information relating to real property sales prices, descriptions, characteristics, and other related information received from a private entity by the comptroller or the chief appraiser of an appraisal district remains confidential in the possession of the property owner or agent; and may not be disclosed to a person who is not authorized to receive or inspect the information" (See Appendix 4). Because of this legislation, sales data for single family houses cannot be obtained for this research.

At College Station, sales data are only accessible through either the Bryan/College Station Association of Realtors or the Real Estate Center at Texas A&M University and is prohibited to be provided to a person who does not have a real estate license.

4.3.3 Why the Multiple Listing Service (MLS) Cannot Be Used in This Research

The Multiple Listing Service (MLS) is a combined listing service used by many of the realtors to list properties for sale so that all the realtor-members can access listing data and show the properties to prospective buyers. When a listed property is sold the selling price and associated data is added to the listing so that members can utilize that data for market analysis. MLS data is considered a private source and is excluded from open disclosure, as mentioned under Sec. 552.148.

4.3.4 Why a Mail Survey Is Not Adequate Methodology to Obtain Sale Data

Two problems would rise when a mail survey method is used to obtain sales data. First, it would be very difficult to obtain accurate sales prices through the mail survey.

Since the sale price of housing can be used to estimate one's income level, in general, people are reluctant to provide the information in a mail survey. Second, the response rate of a mail survey would become an issue. To achieve a high response rate, the mail survey methodology recommends that potential respondents be contacted four times (Dillman, 2000; Varni et al., 2003). In addition, the methodology suggests sending "thank you cards," prepaid tokens (e.g. a $1 bill), and a stamped return envelope. Despite all these efforts and follow-ups, a 40% response rate is normally considered successful, which is not enough data to be analyzed.

This situation is similar to one of a city government. For example, when the city of Bryan mailed out a survey to new homeowners to find out actual house prices, the response rate in recent years was only about 5%. This clearly indicates that the survey would not be an appropriate and useful methodology for gathering sale prices of single family houses.

4.3.5 Three Drawbacks of Using Appraisal Value

In several papers, the assessed value (or appraised value) of each house was used as a proxy for its market value to identify the marginal effect of a particular characteristic on housing value using the hedonic pricing model (Hendon, 1972; DeSalvo, 1974; Berry and Bednarz, 1975; Kwa, 1996; Seiler et al., 2001). However, three problems could arise when the appraisal value, instead of real sales data, is used for analyses.

4.3.5.1 Problem 1: A time lag between the time of the sales used by the assessor and the date of assessed value causes that appraisal to reflect a past sale price

During the appraisal process, BCTAD officers require a great deal of time: first, to collect a list of the taxable properties; second, to define the characteristics of the properties (e.g. usage, size, and construction type) to calculate assessed value with the three common approaches; and finally to document the assessed value. Fisher et al. (1999) presented information about the two quarter processing lags for a commercial appraisal process. As shown in Table 4-1, due to the time lag, the appraisal value differs from the sale price at the same time point. In the up market (prior to 1986), when property values gradually increased, sale prices exceeded the appraised value by over 10.8%. On the other hand, in the down market (from the beginning of 1988 to the end of 1992), sale prices were higher than previous appraisals by almost 12.5%. Overall, the average difference is about 11%, that is, sale value of commercial property is about 11% higher than the appraised value of the property. Fisher et al. (1999) also concluded that a one year lag existed between the appraised value and the sale price, based on the lagging percentage difference between the sale price and the appraised value.

Table 4-1

Absolute Mean Difference (%) [(Price – Appraised Value) / Appraised Value]

(Source: Fisher et al., 1999)

Combined Index Type	All	Pre-1986	1986-1987	1988-1992	Post- 1992
All Types	10.8	10.8	8.9	12.5	10.6

* All types include apartment, office, retail, and warehouse

4.3.5.2 Problem 2: The assessor does not include housing market information in assessed value

In general, the BCTAD office at College Station repeats the appraisal process for property about once every three years (Kwa, 1996). However, the tax assessors are required to assess real property values at some percentage of market value whenever it deems it necessary. Tax assessors typically apply a regression equation to estimate market value in appraisal methods. That is, when major property characteristics are changed (e.g., split or merged parcels, zoning changes, or adding more rooms,) the assessed value is adjusted in a manner that is consistent with the assessment of similar properties. Nonetheless, the changed value of the property does not reflect price trends since the latest revaluation of all property in College Station. For instance, although the assessed value was calculated in January 2006, the assessed value did not cover changed properties from February 2006 to December 2006.

4.3.5.3 Problem 3: Systematic assessment error can cause underestimation or overestimation of assessed value

As an appraisal model, the tax assessors normally use the hedonic price model (HPM), which is similar to Equation 4-1, to estimate market value (See Figure 4-2). At time 0 (i.e. when all time dummy variables equal 0), property values can be calculated using Equation 4-2. The changed value of the property does not account for price trends since the latest revaluation of all property. Hence, the assessed value of property I at time 0 can be modified by Equation 4-3. The c, a parameter referred to as vertical assessment equity, causes a departure from assessment uniformity. Because the c value effects all assessed value, systematic assessment (measurement) error occurs if the value is not correct. For example, if c = 1.1, all assessed values consistently become about 90% of true market value. The assessment errors (undervaluation and overvaluation) are captured by z (Clapp and Giaccotto, 1992).

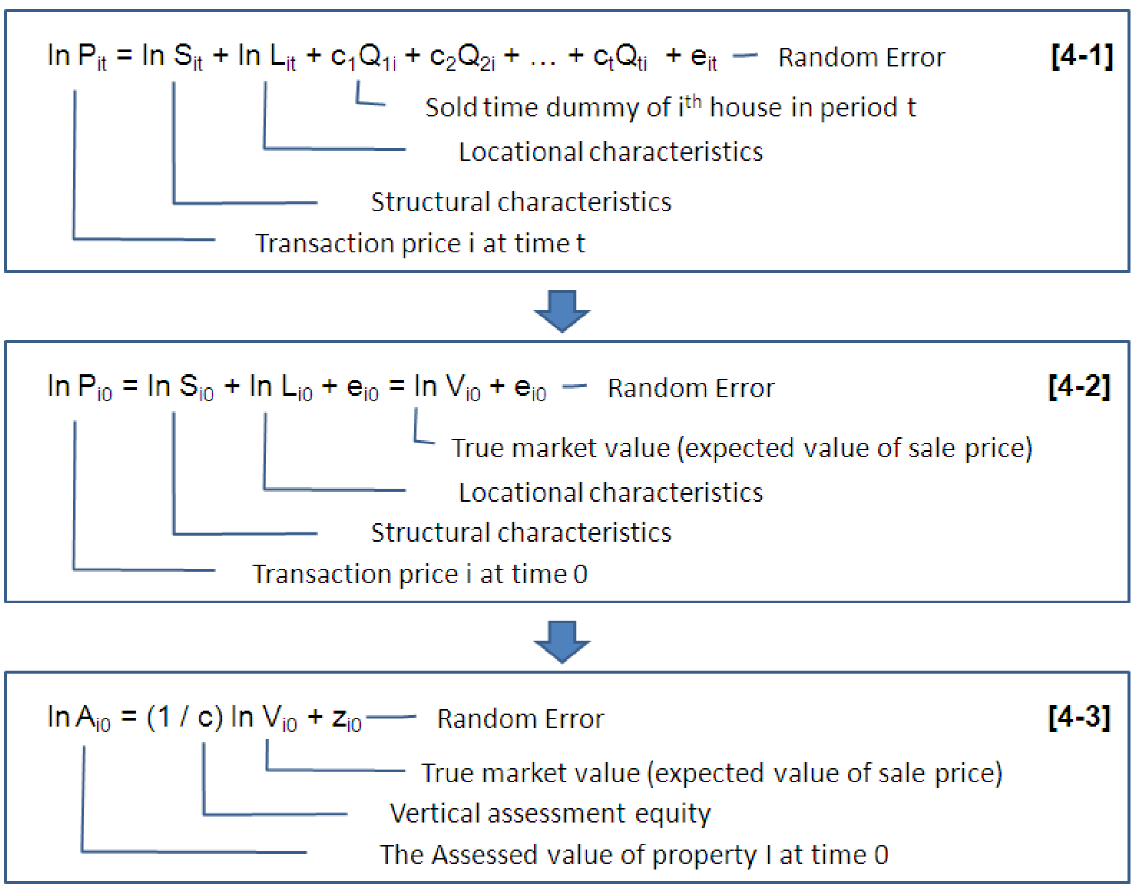


Figure 4-2. The HPM and Assessed Value Model.
(Source: Clapp and Giaccotto, 1992)

4.3.6 Appraisal Value as a Proxy of Sale Data in College Station, Texas

The appraisal value is the best available data for this research for three reasons, in spite of the three problems in using appraisal value. First, appraisal value is about 95% of the sale price and is almost perfectly correlated with sales data. Second, sales data cannot be used in this study because of recently passed legislation. Finally, a large portion of the three problems using appraisal value can be reduced by using a large sample size.

4.3.6.1 Correlation between Sales Data and Appraisal Data

To compare sales data and appraisal data, 37 samples were collected. Among them, seven sales values were gathered from Zillow.com which is an online real estate website. Thirty other sales data samples were provided by anonymous researchers. The researchers did not want to use the sales data in this research; hence, the sales data were only used in comparison with appraisal values.

Table 4-2

Information from Thirty-seven Samples

Sold Year	Number of Sale Data	Corresponding Year of Appraisal Value	Source
2008	5	2008	Zillow.com
2007	2	2007	Zillow.com
2003	30	2003	Anonymous researchers

Table 4-3

Paired Samples Statistics

	Mean	Number	Standard Deviation
Sale Data	$160,048	37	53,350
Appraisal Values	$152,214	37	50,342

The 37 single family houses were sold in 2003, 2007, and 2008. Each sale value was compared with the appraisal value of the sold year (See Table 4-2). The average sale price of the 37 samples was about $160,000, and the average appraisal value was about $152,000 (See Table 4-3). From the statistics of samples, it can be said that appraisal value is about 95% of the sales value of a single family houses in the city of College Station.

Table 4-4

Pearson Correlation Coefficient Table between Sale Price and Appraisal Values

		Appraisal
Sale	Pearson Correlation	.989**
	Sig. (2-tailed)	.000
	N	37

** Correlation is significant at the 0.01 level

Pearson's correlation coefficient measures how two variables are related. The correlation coefficient can be calculated accurately when the data do not have any outliers and have a linear relationship. It was clear that there is no outlier in the data and there is a positive linear relationship. Pearson's correlation coefficient (.989) is significant at the 0.01 level (See Figure 4-3). In Figure 4-3, the line shows perfect correlation. From the correlation, it is clear that sale prices are almost perfectly correlated with appraisal values (See Table 4-4).

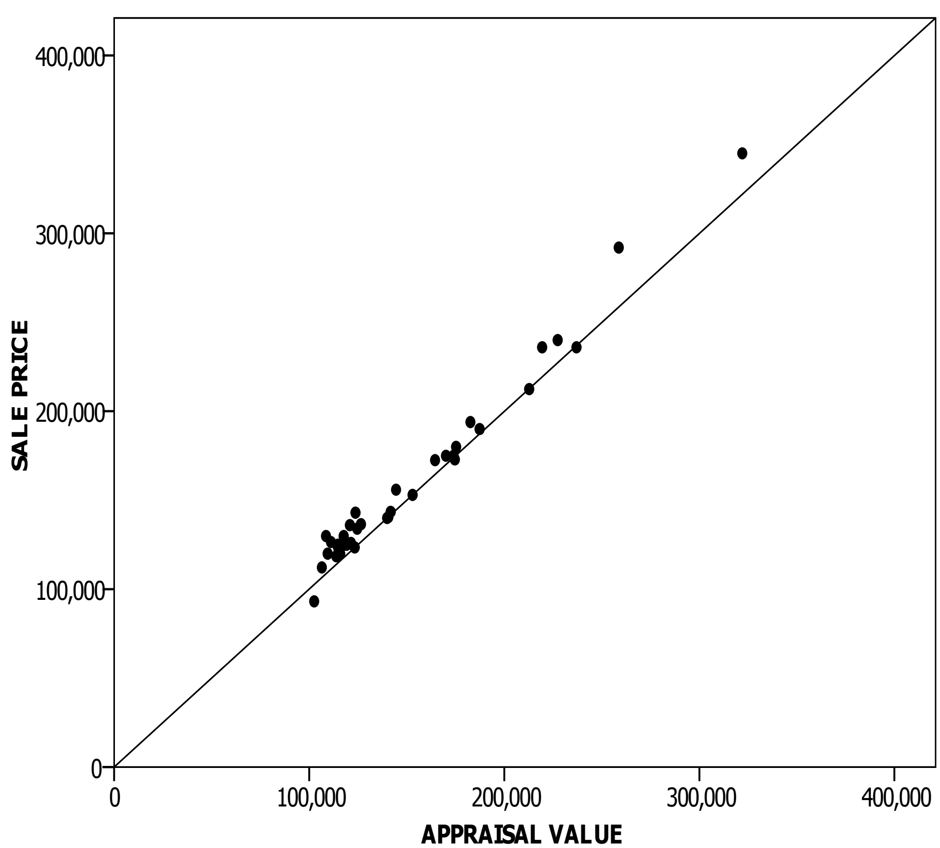


Figure 4-3. A Scatter Plot with Sale Prices and Appraisal Values.

4.4. Solutions for the Three Drawbacks of Using Appraisal Value

Large portions of the three drawbacks of using appraisal value can be reduced by using a large sample size. Hence, in this research to minimize these problems, a large enough sample will be used. The minimum amount of data for this study will be explained in the next section.

4.4.1. Solution for Systematic Measurement Error by Using Appraisal Value

Reliability is defined as "the extent to which it yields consistent results when the characteristic being measured has not changed" (Leedy & Ormrod, 2001). That is, if a measurement instrument is reliable, it is free from measurement errors. However, it is difficult to develop a perfect measurement instrument because error can be created by various factors such as administering different tests, testing conditions, and individual fluctuations (Gall et al, 1999). Thus, it is necessary to make an effort to reduce these measurement errors.

Bias of reliability by using the appraisal value is related to the systematic measurement error. Systematic errors are biases in measurement of a variable across the sample. A systematic error is caused by any factor in the experimental settings or environment (e.g. weather), method of observation, or instrument used and leads to the whole measured value being systemically too high or too low.

Clapp and Giaccotto (1992) argue that the measurement errors associated with assessed value can be reduced to negligible proportions if large samples are available. Even though appraisal value is not the same as assessed value, they have similar measurement error such as time lag between the time of the sale and the date for collecting data for the appraisal value, an appraiser's mistake, and systematic measurement errors. Therefore, the results of Clapp and Giaccotto (1992) can be a solution for the problem of using the appraisal value.

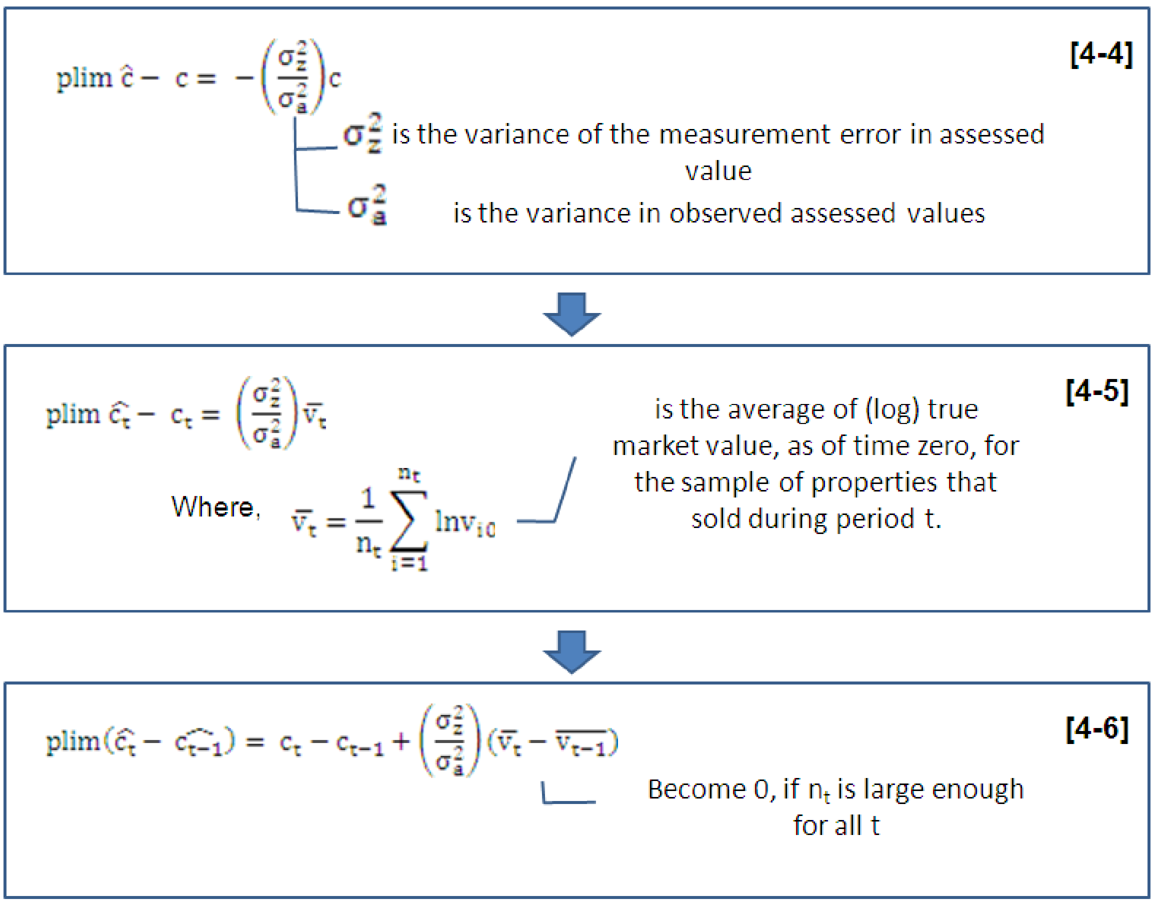


Figure 4-4. Analysis of Errors in Assessed Value.
(Source: Clapp and Giaccotto, 1992)

However, they did not mention that a large sample size is needed. The bias in c hat, the assessment equity parameter, is captured by Equation 4-4 (See Figure 4-4). When each sold time period and true market value are included, Equation 4-4 becomes Equation 4-5. In most situations, the rate of growth representing the rate of real property inflation is more meaningful. Hence, the probability limit for the rate is captured by Equation 4-6, which shows that there will be no bias from measurement error if the change in v bar is 0. More importantly, there can be no change in average true value when n_t becomes large for all t. Because the sample size for this study of 6,562 is much larger than the required sample size of 245, my model is reliable even though I use the appraisal value.

4.4.2. Solution for the Generalizability (External Validity) Threat by Using Appraisal Value

Among several validities, the external validity can be a limitation of the research. The external validity is defined as the extent to which its conclusions are valid to situations beyond the study itself (Leedy and Ormrod, 2001). That is, the extent to which the results drawn can be generalized to other contexts.

External validity relates to both systematic and random sampling errors. Schutt (2001) describes systematic sampling error as “overrepresentation or under-representation of some population parameter by a sample statistic due to the method used to select the sample.” In other words, systematic errors can occur due to any disturbance in selecting samples randomly and this process can cause a bias in the sample. Schutt (2001) explains that random sampling error is “differences between the population parameter and the sample statistic that are due only to chance factors (random error).” As a sampling error may or may not result in an unrepresentative sample, it is important to reduce the size of the sampling error. The magnitude of the sampling error, hopefully, can be estimated by a statistical method. According to mathematical procedures, the larger the number of random samples results in smaller error. For this reason, it is often stated that the results from large random samples is better than those of a small sample size.

The sample size of 6,562 appraisals nested in 85 subdivisions with a minimum sample size of 8 should be large enough to get the power of over .90 are added in this study. In that case, the external validity issue in two models in this study with a dependent variable of appraisal values will be reduced to negligible proportions. In the future, after applying the methods used in this study to other regions or other university towns except in Texas, the external validity problem can be resolved more clearly.

4.5 Required Sample Size

Two methods – the Hedonic Price Model (HPM) and the Hierarchical Linear Model (HLM) – will be used in this research; hence, the sample size for this study should satisfy the minimum required sample size in both models.

4.5.1 Required Sample Size for the Hedonic Price Model

The required sample size for HPM can be calculated using three other variables related to statistical inference: significance criterion (α), population effect size (ES), and statistical power (Cohen, 1988). In general, α is equal to .05 (Cohen, 1990). The statistical power is $1 - \beta$. β is a Type II error, the probability to accept H_0 (null hypothesis) when H_0 is false. A statistical power smaller value than .90 can cause too big a risk of a Type II error. Finally, ES is the probability that H_0 is false by the discrepancy between H_0 and H_1. Cohen (1992) defined medium ES as "an effect likely to be visible to the naked eye of a careful observer". For regression analysis, he found that medium ES is .15.

$V = 42.9/ES - u - 1 = 42.9/.15 - 60 - 1 = 225$

V: the error df

ES: medium effect size = .15

u: the number of IV = 60

$\lambda = 56.3 - (((1/60)-(1/V)) / ((1/60)-(1/120))) * (56.3 - 42.9)$
$= 36.65$

λ: Noncentrality parameter

$N = \lambda / ES = 36.65 / .15 = 245$

N: sample size

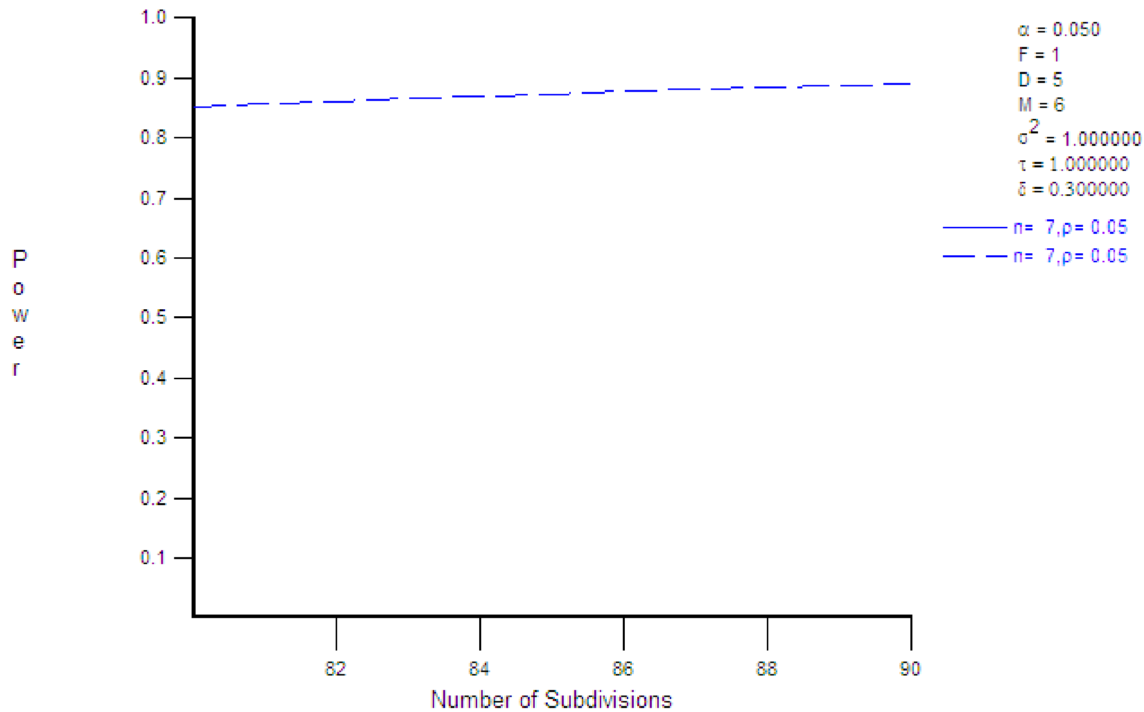
See (Cohen 1988) pp.407-447.

Figure 4-5. Calculation of Required Sample Size.

If it is assumed that 60 independent variables (IV) are statistically significant, the error degree of freedom (V) and noncentrality parameter (λ) can be calculated. The required sample size of 245 is calculated with both the noncentrality parameter (λ) and population effect size (ES) (See Figure 4-5). Hence, the sample size for this study should be at least 245.

4.5.2 Required Sample Size for the Hierarchical Linear Model

Next, to identify the required sample size for the HLM, the Optimal Design software can be used. This software is a freeware program, developed by several researchers to provide general power computations (Spybrook et al., 2006; Spybrook et al., 2008). The required sample size can be calculated using four other variables related to statistical inference: significance criterion (α), standardized effect size (δ), intra-correlation (ρ), and statistical power. The value of α is equal to .05, and the statistical power is .90 (Cohen, 1988; Cohen, 1990). The intra-class correlation (ρ) is captured by a ratio of the variability between clusters to the total variability. For nation-wide use of HLM on U.S. data sets of school achievement, ρ typically ranges between 0.05 and 0.15. Because there is no information of ρ value on subdivisions, the minimum value of ρ (.05) will be used. Finally, a standardized effect size between .50 and .80 is a "large" probability that H_0 is false by the discrepancy between H_0 and H_1; however, the standardized effect sizes between 0.20 and 0.30 are often considered worth detecting. Among "small" effect sizes, .30, which is close to a medium effect size, will be used.



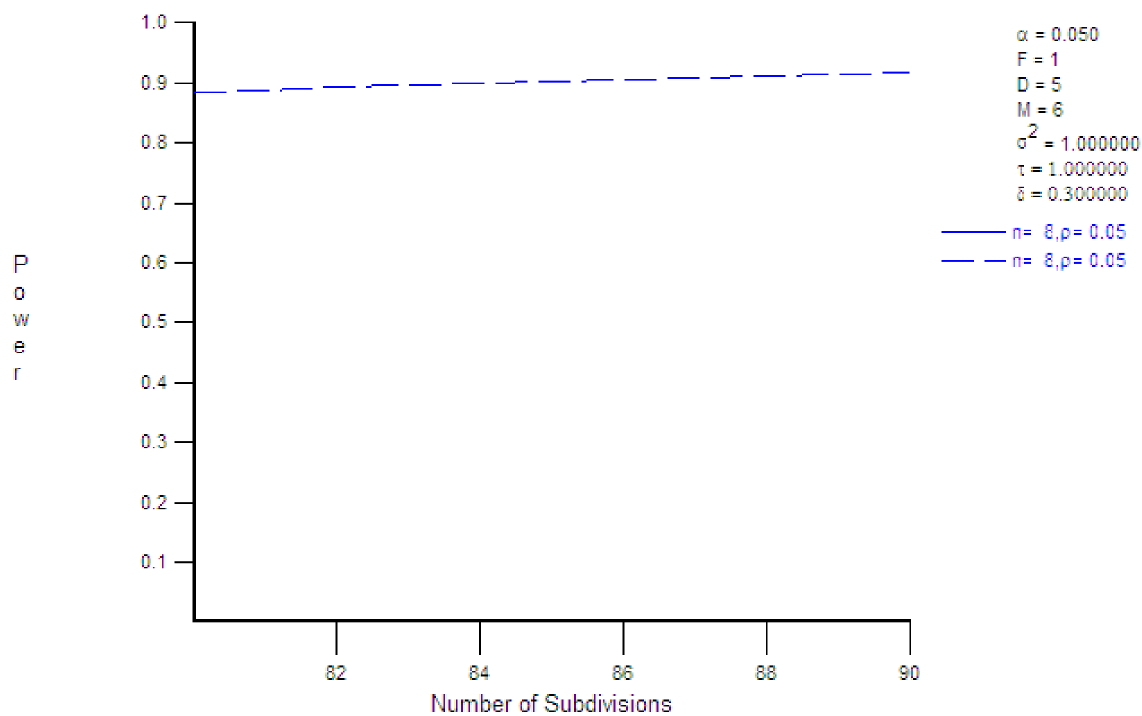
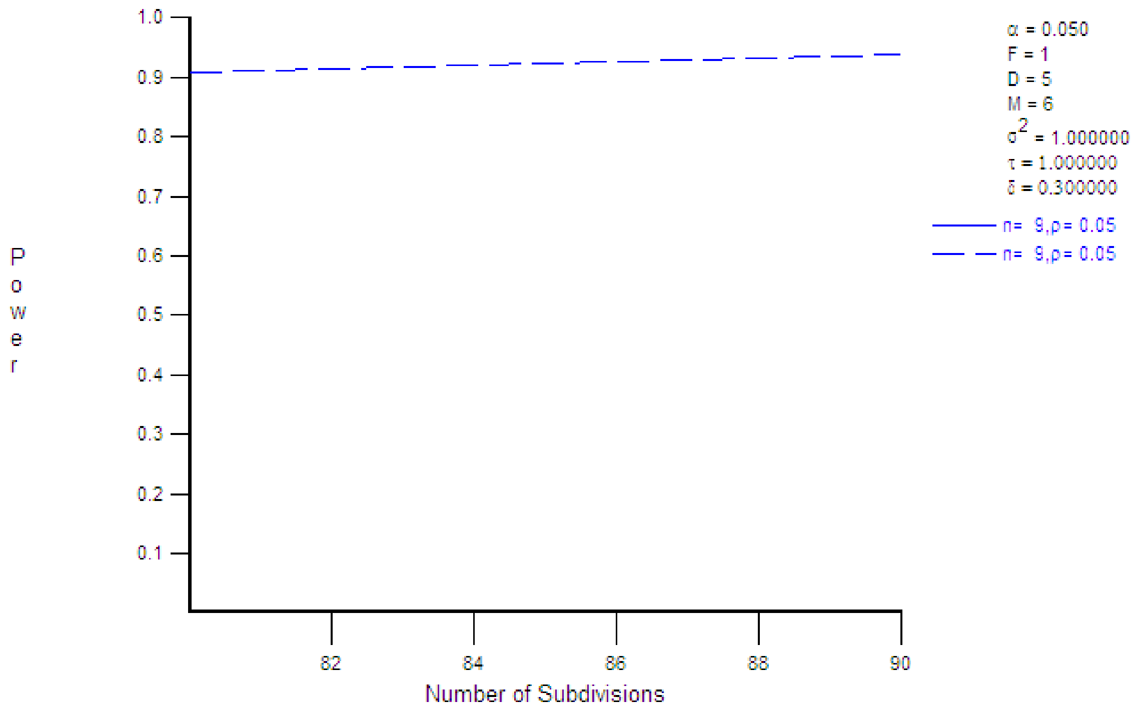


Figure 4-6. Power vs. Number of Subdivision with α=.05, δ=.30, ρ=.05, n=7, 8, 9, and 10.



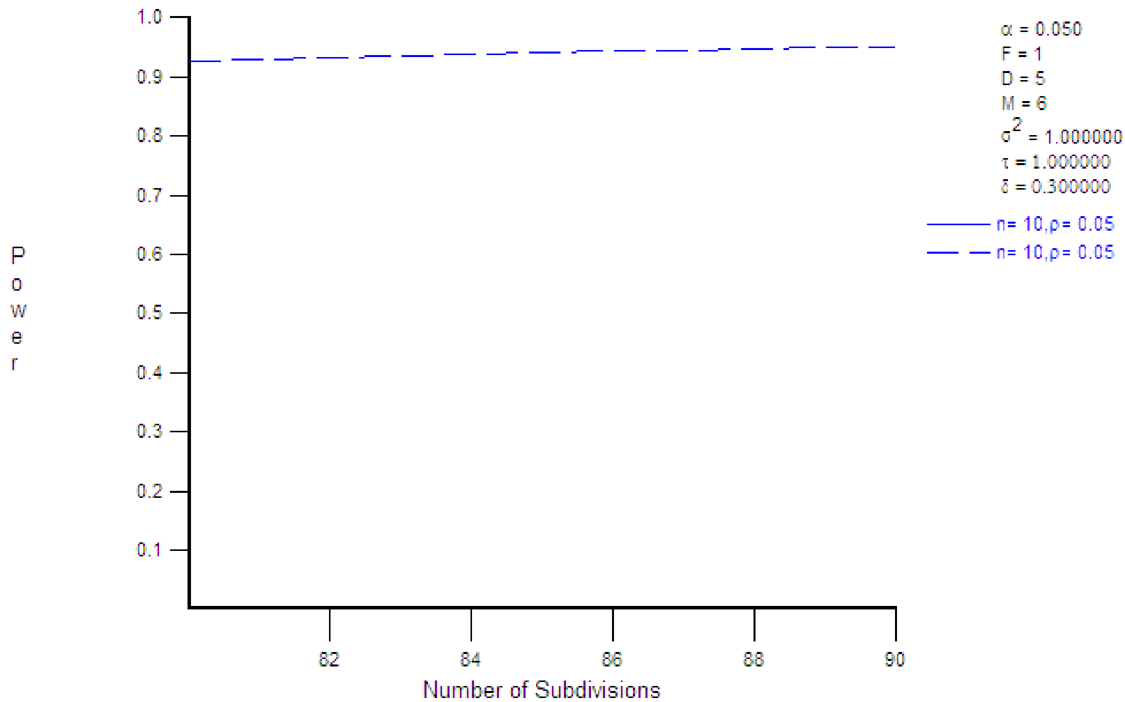


Figure 4-6. (Cont.)

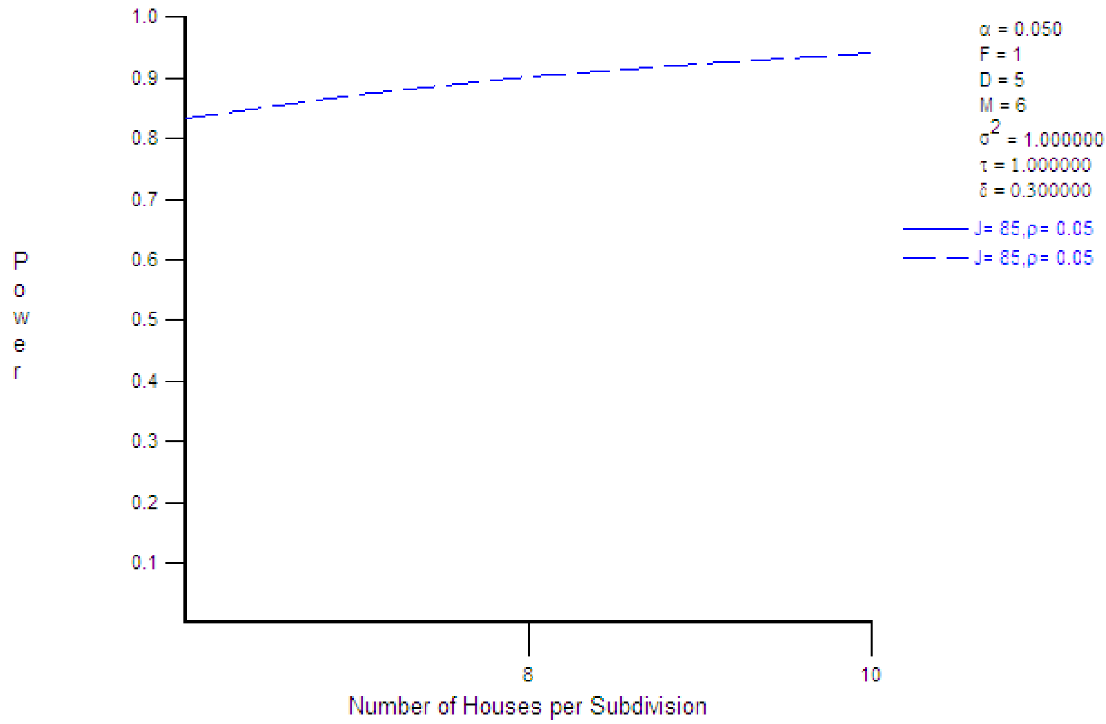


Figure 4-7. Power vs. Number of Houses per Subdivision with α=.05, J=85, δ=.30, ρ=.05.

First, the required number of subdivisions are calculated when the number of houses per subdivision is 7 to 10 (See Figure 4-6). From Figure 4-6, it is clear that at least 85 subdivisions with at least 8 single family houses per subdivision are required to obtain the power of .90. Next, to verify the required number of houses more clearly, the required number of houses per subdivision were calculated when the number of subdivisions (J) is 85 (See Figure 4-7). Figure 4-7 shows that at least 8 single family houses per subdivision are required to get the power of over .90 when there are 85 subdivisions.

There are 123 subdivisions with at least one single family house in College Station, Texas. Among them, the 85 subdivisions with at least 8 houses include a total of 6,562 single family houses. The data set consisting of 6,562 single family houses nested within 85 subdivisions are enough for both HPM and HLM to obtain the required statistical power. Hence, 85 subdivisions with at least 8 single family houses will be used in this research.

4.6 GIS Procedure

Geographic Information System (GIS) is a very efficient tool for identifying the value creation concepts at the subdivision level. Steinberg defined a geographic information system as a system designed to store, manipulate, analyze, and output map-based or spatial, information (Steinberg and Steinberg, 2006). Most value creation concepts such as intersections per hectare, ratio of 3-way intersections, and connected node ratio, are measured with GIS.

Most GIS data, such as parcel, zoning, road, park, and so on, were provided by the city of College Station, Texas. Also, some document-based or web-based information was joined with the GIS data. First, the type and number of facilities in the parks were obtained from the report "Recreation, Park, and Open Space Draft Master Plan 2002-2012 (2002)" which was published by the city of College Station, Texas (College Station, 2002c). The park facility related information is joined to a park GIS layer. Second, appraisal values and structural variables of each house, such as the number of bedrooms, the number of bathrooms, the size of the garage, and so on, were obtained from the Brazos County Appraisal District website. This structural information is also joined to a parcel GIS layer.

4.7 Measures

The dependent variable was the appraisal value of each house located in 85 subdivisions in College Station in 2008. The appraisal values were obtained from the Brazos County Appraisal District (BCAD) website. All independent variables were objectively measured and divided into two different levels; the individual housing level and the subdivision level. In the individual housing level, all variables were obtained from the city of College Station, objectively measured using GIS, or gathered by downloading information from the BCAD website. ArcGIS Version 9.3 was used to objectively measure the four factors in the subdivision level and the sense of arrival factor was subjectively evaluated.

4.7.1 Housing Level

In the housing level, structural, locational, and neighborhood characteristics were measured. Structural characteristics of each house, such as the number of bedrooms and the number of bathrooms, were obtained from BCAD.

Locational characteristics, the distance from each house to major amenities, such as Texas A&M University, elementary schools, and parks, were measured through road distance using network analysis in the ArcGIS program. Nicholls (2002) explained that the network distance from the nearest park to each house better explained the variance of single family housing values than did the direct distance. However, it was not clear whether or not the network distance was a better measurement than the direct distance to other major amenities. The attach golf variable was calculated by a dummy variable which was assigned a “1” value if a single family housing parcel was attached to a golf course directly. Similarly, the attach park variable was measured by a dummy variable which received a “1” value if a single family housing parcel was attached to an adjacent park directly. The across park variable was measured by a dummy variable which had a “1” value if a single family housing parcel was on the opposite side of a park across a street. The corner variable was calculated by a dummy variable which had a value of “1” if a single family housing parcel was on a corner lot. The cul-de-sac variable was measured by a dummy variable which receive a value of “1” if a single family housing parcel was on a cul-de-sac. Six more variables related to the closest park from each house were also measured. The park size variable was measured by the area of the park in acres. The park lots variable was calculated by the number of parking lots. The total facility variable was computed by the number of all facilities in the park, and the total lighted facility variable was measured by the number of all lighted facilities in the park. Similarly, the sport facility variable was calculated by the number of sport related facilities in the park, and the sport lighted facility variable was measured by the number of sport related lighted facilities in the park.

Table 4-5

Summaries of Variables in Housing Level

VARIABLE	DEFINITION
Structural	
Lot Size	Area of parcel (square feet)
Bedroom	The number of bedrooms
Bathroom	The number of Bathrooms
Total Main Area	Area of 1st and 2nd floor (square feet)
Attached Garage	Area of attached garage (square feet)
Detached Garage	Area of detached garage (square feet)
All Porches	Area of open, glassed, and screened porch (square feet)
Sold Year	Recently sold year (year)
Building Age	Age of Single Family House (2008 – Built Year) (year old)
2nd Floor	(Dummy variable) The home is a 2 story house
Swimming Pool	(Dummy variable) The home has a swimming pool
Locational	
Attach Golf	(Dummy variable) The home is adjacent to a golf course
Attach Park	(Dummy variable) The home is adjacent to a park
Across Park	(Dummy variable) The home is the opposite side of a park across a road
Cul-De-Sac	(Dummy variable) The home is on Cul-De-Sac
Corner	(Dummy variable) The home is on corner
Park Size	Area of the closest park (acre)
Park Lots	The number of lots in the closest park
Total Facility	The number of all facilities in the closest park
Total Lighted Facility	The number of all lighted facilities in the closest park
Sport Facility	The number of sport facilities in the closest park
Sport Lighted Facility	The number of lighted sport facilities in the closest park
Net Dist_School	Network distance from the nearest elementary school
Net Dist_TAMU	Network distance from the nearest entrance of Texas A&M University
Net Dist_Park	Network distance from the nearest park
Neighborhood	
Population Density	(Census Block) Population per hectare
Income	(Census Block) Average income in 1999
Ethnicity	(Census Block) Ratio of white alone on population
Tenure	(Census Block) Ratio of rental houses on occupied houses
Workable age	(Census Block) Ratio of over 20 years old on population
Employment	(Census Block Group) Ratio of over 16 year employers on population
Education	(Census Track) Ratio of people with bachelor / grad-professional degree

Neighborhood characteristics were measured based on the 2000 U.S. census data. To calculate neighborhood characteristics in each single family housing parcel, it is assumed that U.S. census block data (e.g. population) are evenly distributed through each U.S. census block. All houses within the same U.S. census unit had the same value of a neighborhood variable. The population density variable is calculated by raw population per hectare in the census block. The income variable is measured as the median income in the census block in 1999. The ethnicity variable is computed by the number of white only divided by the number of raw population in the census block. The tenure variable is measured by the ratio of rental houses to occupied houses. The workable age variable is calculated as the ratio of the number residents of over 20 years to all populations. The education variable is computed as the ratio of the number of people with a bachelor's or graduate-professional degree to all populations in the census unit. Finally, the employment variable is calculated as the ratio of the number of residents over 16 years of age to all populations. The definitions for all variables belonging to the three categories in the housing level are summarized in Table 4-5.

4.7.2 Subdivision Level

At the subdivision level, a number of variables were measured and classified in five categories, which are 1) the sense of arrival; 2) product mix; 3) walkability; 4) circulation system; and 5) amenity.

The sense of arrival was measured by photo evaluation. The scenes in photographic slides were used to evaluate the subdivision entrance's scenic quality

(Scenic America, 1999). The entrance pictures of 85 subdivisions in College Station, Texas, were evaluated by sixty-one graduate students in the College of Architecture at Texas A&M University. The average age of participants was twenty-seven years. Among the sixty-one participants, forty-one were male, twenty-seven were white, and twenty-eight were Asian.

(a) Castle Gate (4.27)

(b) Windwood (4.09)

(c) College Vista (1.82)

(d) Mcculloch (1.87)

Figure 4-8. Comparison of Sense of Arrival Scores of Four Subdivisions.

Each entrance was evaluated by assigning a sense of entrance rating number between 1 and 5 on a Sense of Arrival Rating Response Sheet (See Appendix 3). A rating of "1" indicated a very low level of sense of entrance; and a rating of "5" indicated a very high level of sense of arrival. When a subdivision had more than one entrance, an entrance picture was randomly selected. After collecting evaluation scores from students, the sense of arrival values were calculated as mean values of all scores for each entrance photo. Castle Gate and Windwood subdivisions had high sense of arrival scores. On the other hand, College Vista and Mcculloch subdivisions had a low sense of arrival scores (See Figure 4-8).

The product mix was tested with three variables: *single family density*, *land-use mix index*, and *phased project*. The *single family density* variable was measured by the number of single family houses divided by the residential area of the subdivision. The *land use mix index* variable was computed based on the equation of *land use mix index* (See Table 4-6). The *phased project* variable was encoded as a dummy variable, which means that the phased project variable would have a value of "1" if a subdivision was built through more than one phase.

As walkability variables, *sidewalk connectivity* was quantified by pedestrian lane length divided by road length. *Bike-lane connectivity* was calculated by bike lane length divided by road length. The *Median length of cul-de-sac* was measured by the median length of cul-de-sac, and *median length of a block* was measured by median length of blocks.

Circulation System variables were measured based on Environment and Physical Activity: GIS Protocols Version 2.0 (University of Minnesota, 2005). The *street density* variable was computed as the total length of road per hectare in the subdivision. The *intersection density* variable was measured as the ratio of the number of all intersections to total street length. The *cul-de-sac density* variable was calculated as the ratio of the number of cul-de-sacs to total street length. The *4-way intersection* variable was computed by the ratio of 4-way intersections to all intersections in the subdivision. The *node connectivity* variable was computed by the ratio of the number of intersections to the number of intersections plus cul-de-sacs. Finally, the *accessible entrance* variable was measured by counting the number of accessible points through the boundary of the subdivision.

Amenity refers to *park connectivity* and *greenway connectivity*. The *park connectivity* variable was encoded with a dummy variable where the value “1” meant that a park was located within the subdivision or a park was either attached directly to, or located across from, a subdivision.

Similarly, the *greenway connectivity* variable was encoded with a dummy variable where the value “1” meant that greenways were located within the subdivision or greenways were either attached directly to, or located across from, a subdivision. In this case, greenways did not include any parks. The definitions for all variables belonging to the five categories in the subdivision level are summarized in Table 4-6.

Table 4-6

Summaries of Variables in the Subdivision Level

VARIABLES	DEFINITION	EQUATION
Sense of Arrival		
Sense of Arrival	Average score of the subdivision entrance.	Average score of the subdivision entrance's scenic quality.
Product Mix		
Single Family Density	Ratio of total number of single family houses to residential area in the subdivision.	Total number of single family houses / total residential area in the subdivision (hectare)
Land-Use Mix	Evenness of distribution of hectare of single family, multi family, commercial, exempt, and vacant.	LUM = $(-1)\left(\sum_{i=1}^{n}(\rho_i)(\ln\rho_i)\right)/\ln n$ ρ_i = the proportion of estimated square footage attributed to land use *i*. *n* = the number of land uses (n = 5)
Phased Project	The number of phases in the subdivision development.	(Dummy Variable) Get "1" if the number of phases in the subdivision is more than 1
Walkability		
Sidewalk Connectivity	Average sidewalk system	Total sidewalk length / total street length (miles)
Bike-Lane Connectivity	Average bike lane system	Total bike-lane length / total street length (miles)
Median Length of Cul-De-Sac	Median length of cul-de-sac	Median length of cul-de-sac (miles)
Median Length of Block	Median length of block	Median length of block (miles)
Circulation System		
Street Density	Ratio of street to subdivision area	Total street length (miles) / total area of subdivision (hectare)
Intersection Density	Ratio of intersection to street length	Number of intersections / total street length (miles)
Cul-de-sac Density	Ratio of cul-de-sac to street length	Number of cul-de-sacs / total street length (miles)
4-way intersection	Ratio of 4-way intersection to all intersection	Number of 4-way intersection / number of all intersection
Node connectivity	Ratio of intersections to intersections plus cul-de-sac	Number of all intersections / Number of all intersections plus cul-de-sac
Accessible Entrance	The number of accessible entrances to the subdivision	
Amenities		
Park Connectivity	Accessible to near park	(Dummy Variable) Get "1" if a park is in, attached to, or across a road to the subdivision
Greenway Connectivity	Accessible to near greenways	(Dummy Variable) Get "1" if any greenways are in, attached to, or across a road to the subdivision (Not include parks)

4.8 Reliability Test for the Sense of Arrival Variable

Sixty-one students in the College of Architecture, Texas A&M University participated in evaluating the sense of arrival score using subdivision entrance pictures. Because the subdivision entrance pictures were evaluated by more than two students, the consistency of the evaluations by the students should be verified. To determine the reliability of each assessment of the participants (students,) intraclass (intercoder or interrater) reliability should be checked. The intraclass reliability is defined as "the extent to which two or more individuals evaluating the same product or performance give identical judgments" (Leedy and Ormrod, 2001).

There are two ways to assess the intra-rater reliability: Cohen's Kappa, and the Intraclass Correlation coefficient (ICC). Cohen's Kappa for inter-rater reliability could be used when there are only two raters; hence, an interrater reliability analysis using the ICC statistic was performed to determine consistency among the sixty-one raters. The ICC statistic should be between 0 and 1. An ICC statistic of 1.0 indicates that all raters gave the same rating for each picture; that is, there is perfect inter-rater reliability. As a rule of thumb, Cohen's Kappa statistic of 0.40 to 0.59 is a moderate inter-rater reliability, 0.60 to 0.79 substantial, and 0.80 outstanding (Landis and Koch, 1977). However, there is no exact rule for the ICC. The ICC was calculated in SPSS (Palmer and Hoffman, 2001; Emery et al., 2003). The interrater reliability for the raters was found to be ICC = 0.951 ($p<.001$), 95% CI (0.935, 0.965). The ICC was close to 1.0, and larger than .80. Hence, it can be suggested that the sense of arrival scores of the sixty-one students were statistically reliable.

4.9 Research Methods

Economists have used two methodological approaches to estimate the economic values of market and nonmarket goods and services. These are; 1) stated preference and 2) revealed preference (Geoghegan, 2002). The stated preference approach relies on a survey technique to find values of economic goods and services, and individual preferences. To measure the amount of the Willingness to Pay (WTP) for the goods, the Contingent Valuation Method (CVM) is generally used (Pate and Loomis, 1997; Breffle et al., 1998). On the other hand, the revealed preference approach relies on an individual's observed market choices to estimate their values and to reveal their underlying preferences. The hedonic price models and hierarchical linear models can be used as the revealed preference approach. Since the survey method does not apply, the hedonic price model and hierarchical linear model will be used in this research.

4.9.1 Hedonic Price Model

The Hedonic Price Model (HPM), conceptualized by Grilliches (1971), has been used to facilitate single-family residential property values in the past. Later, the concept was used by many researchers (Rosen, 1974; More et al., 1988; Michaels and Smith, 1990; Garrod and Willis, 1992; Geoghegan et al., 1997). The basic concept of the HPM is that a house is a heterogeneous good composed of a bundle of characteristics, including environmental attributes of the residential parcel, which contribute to the sale price of the good (Geoghegan, 2002). The HPM expresses the relationship between the dependent variable which is the observed real estate value and the independent variable which has the characteristic that are associated with the commodities. As Rosen (1974) defined hedonic prices as the prices of attributes, the hedonic prices could be found from both the market prices of products and the amount of characteristics contained in the products. The HPM is used frequently as a technique to make a price into a variety of attributes of a housing unit in various fields such as urban planning, housing analysis and economy. Almost all previous literature used this hedonic price model to evaluate the effects of open spaces, parks, or golf courses on residential property values.

Generally, the HPM in residential property has the following equation form where the housing value or the rent is expressed with several attributes such as structural, locational, neighborhood, environmental, and time-series (time related) (See Equation 4-7). In addition to these attributes, a hedonic price model has two terms: a constant term and a stochastic error term. The former incorporates the influence of all attributes other than the six attributes. The latter reflect measurement errors or market variations, etc.

$$R = f(S, L, N, E, X, T); \qquad [4\text{-}7]$$

where, R = housing unit market value or rent;

S = structural attributes;

L = location attributes;

N = neighborhood attributes;

E = environmental attributes;

X = other attributes (e.g., tenure);

T = time-series attributes

The HPM was estimated with linear, log-linear, semi-logarithmic (natural logarithm,) and inverse semi-logarithmic functional forms. Among them, log-linear and semi-logarithmic showed significantly better results. Both forms could be used to easily interpret the results. The semi-logarithmic form was used to compare the result with other studies as well. Hence, the two forms were general for the HPM (Palmquist, 1980; Song and Knaap, 2003). The semi-log form (Equation 4-8) and the log-linear form (Equation 4-9) can be expressed as stated below;

ln(Sale_Price or Appraisal_Value) = $\beta_0 + \beta_i x_i + e$, [4-8]

ln(Sale_Price or Appraisal_Value) = $\beta_0 + \beta_i \ln(x_i) + e$; [4-9]

where, β_0 is the constant;

β_i are coefficients;

x_i are variables;

e_i is the disturbance term.

Recently, Artificial Neural Networks (ANN) is used as an alternate method for a multiple regression model; however, the multiple regression models work better than the ANN when a small sample size is used (Nguyen and Cripps, 2001; Palocsay and White, 2004). The hedonic price model with the semi-logarithmic form will be used in this research because the number of subdivisions in our research is less than 100.

4.9.1.1 Model Validation

When a regression analysis is done, several assumptions should be checked to assure that the conclusions are true for a population (Ott and Longnecker, 2001; Field, 2005). First, all independent variables should be quantitative or categorical, and the dependent variable must be quantitative, and continuous. Second, all independent variables should have any variation in value. Third, there is no perfect multicollinearity. That is, there should be no perfect linear relationship among independent variables. Forth, the variance of the residual terms of the independent variable(s) should have the same variance. Fifth, the residual terms of any two observations should be independent. Sixth, residuals in the model are normally distributed with a mean of 0. Finally, each value of the dependent variable is gathered from a separate entity.

Among the assumptions, two assumptions are very important and can be identified by statistical analysis. The first assumption is that perfect multicollinearity should be avoided. Multicollinearity exists when there is a huge correlation among independent variables in a regression model, and makes it difficult to assess the importance of an individual independent variable. There are two commonly used collinearity diagnostics: the variance inflation factor (VIF) and the tolerance. The VIF shows whether or not an independent variable has a strong linear relationship with other independent variable(s). In general, using a VIF of 10 is problematic; however, peer-reviewed literature shows that a VIF greater than 3 can be a cause for concern. A tolerance statistic is the VIF's reciprocal (tolerance = 1 / VIF). The tolerance value below .2 designates a potential problem (Menard, 1995). Second assumption is that the residual terms should be uncorrelated for any two observations. The Durbin-Watson test can be used to test for any severe correlations among errors. As a rule of thumb, values greater than 3 or less than 1 can be problematic (Field, 2005).

4.9.2 Hierarchical Linear Model

Many papers have used the hedonic price model to show the effects of locational or structural characteristics on housing values. However, the hedonic price model does not explain the inherent hierarchy in the variables by which housing value is decided when the independent variables are in hierarchical order. For example, houses are nested in neighborhoods, which are nested in cities and states in turn (Brown and Uyar, 2004). The basic principles underlying the hierarchical order for entry are the removal of confounding (or spurious relationships) and the causal priority of the research factors. Hence, each investigated variable should be entered only after other variables, which may cause a spurious relationship or compounding, have been input (Cohen et al., 2003). In this research, the Hierarchical Linear Model (HLM) will be used as well.

The HLM was coined by education researchers (Raudenbush and Bryk, 2002), and is popularly used in educational psychology fields. Even though the use of HLM is growing in a number of other fields, until now, there is no paper which used a hierarchical linear model to evaluate the effects of various housing or neighborhood related variables on single family housing values. There is just one paper which tried to show how we can apply the HLM to evaluate housing prices with two independent variables. Brown and Uyar (2004) wanted to demonstrate how the HLM could be used to explain the inherent hierarchy in deciding housing prices. They used only one variable for each level: lot size in the housing level and median travel time to work in the neighborhood level. As a result, the HLM model showed that 1) neighborhoods with higher travel times have lower mean housing value, and 2) the change in mean housing value associated with increases in land size is the same across neighborhoods, and 3) neighborhoods with higher travel times have a higher rate of increase in housing values associated with increases in land size. Unlike the traditional HPM, researchers can create a model for each level separately and decide the portions of explained variance that occurs at each level.

4.9.2.1 Centering Procedure

A centering procedure is used to decide the location of variables in the housing level. Because the slopes and intercept in the housing level models are dependent variables at the subdivision level model in HLM, it is important to make the dependent variables be meaningful. Centering is useful for reducing non-essential multicollinearity as well as easily interpreting the results in HLM. Aiken and West (1991) announced two types of multicolleariy. Essential multicollinearity exists when there are substantial correlations among independent variables; on the other hand, non-essential multicollinearity exists when there are higher order terms, such as the interaction term among independent variables. The non-essential multicollinearity among housing level variables and subdivision level variables can be reduced substantially.

There are two major centering procedures in HLM: grand mean centering versus group mean centering. The grand mean centering is used to center the housing level variables around the grand mean. For example, the number of bedrooms variable is centered by subtracting the mean number of bedrooms of all 6,562 houses. In this case, the housing level variables have a form of 4-10.

$$\left(X_{ij} - \overline{X}_{..}\right); \tag{4-10}$$

where i means i^th single family house;

j means j^th subdivision, X_{ij} means housing level variables;

$\overline{X}_{..}$ represents the grand mean.

The group mean centering is used to center the housing level variables around the corresponding subdivision unit mean. For example, the number of bedroom variable is centered by subtracting the mean number of bedrooms from each subdivision. By the group mean centering procedure, the intercept of the level 1 equation in HLM becomes the mean housing value of subdivision j. In this case, the housing level variables have a form of 4-11.

$$\left(X_{ij} - \overline{X}_{.j}\right); \tag{4-11}$$

where $\overline{X}_{.j}$ represents the mean for subdivision j.

To find a better centering procedure, for example, a simple HLM with a housing level variable – total main area - can be considered (See Equation 4-12 and 4-13).

$$\text{Level 1: } Y_{ij} = \beta_{0j} + \beta_{1j}(\ln TMA) + e_{ij} \tag{4-12}$$

$$\text{Level 2: } \beta_{qj} = \gamma_{q0} + u_{qj} \qquad \text{for } q = 0, 1 \tag{4-13}$$

If there are three subdivisions, three regression lines for each subdivision can be developed (See (a) in Figure 4-9). However, an intercept of each regression line does not show any meaningful information. The intercept of subdivision A means the mean housing value of subdivision A when all houses in the subdivision have total main area of 0. No house has a total main area of 0.

To make the intercept be meaningful, grand mean centering procedures are applied (See (b) in Figure 4-9). When the grand mean centered total main area variable is applied, the intercept of each regression line is meaningful. The intercept of subdivision A means the mean housing value of subdivision A, when all houses in the subdivision have a grand mean total main area. A concern with using grand mean centering is that housing variables set to grand mean, even though dependent variable and subdivision variables are set to subdivision mean.

Finally, when the group mean centered total main area variable is applied, the intercept of each regression line is meaningful. The intercept of subdivision A means the mean housing value of subdivision A when all houses in the subdivision have group mean total main area. Now, all variables in the HLM model - dependent variable, housing level variables, and subdivision level variables – are set to Subdivision Mean.

There is no general rule for selecting any centering strategy. The peer-reviewed research recommends that researchers should decide a fit centering procedure based on the purpose of their research (Kreft et al., 1995; Raudenbush and Bryk, 2002). The intercept of each regression line is meaningful when either a grand mean or a group mean centering procedure is applied. On the other hand, when only a group mean centering procedure is applied, all variables in the HLM model are set to a subdivision mean. Because this research is focusing on the subdivision level variables, the group mean centering will be adopted in this research for easy interpretation.

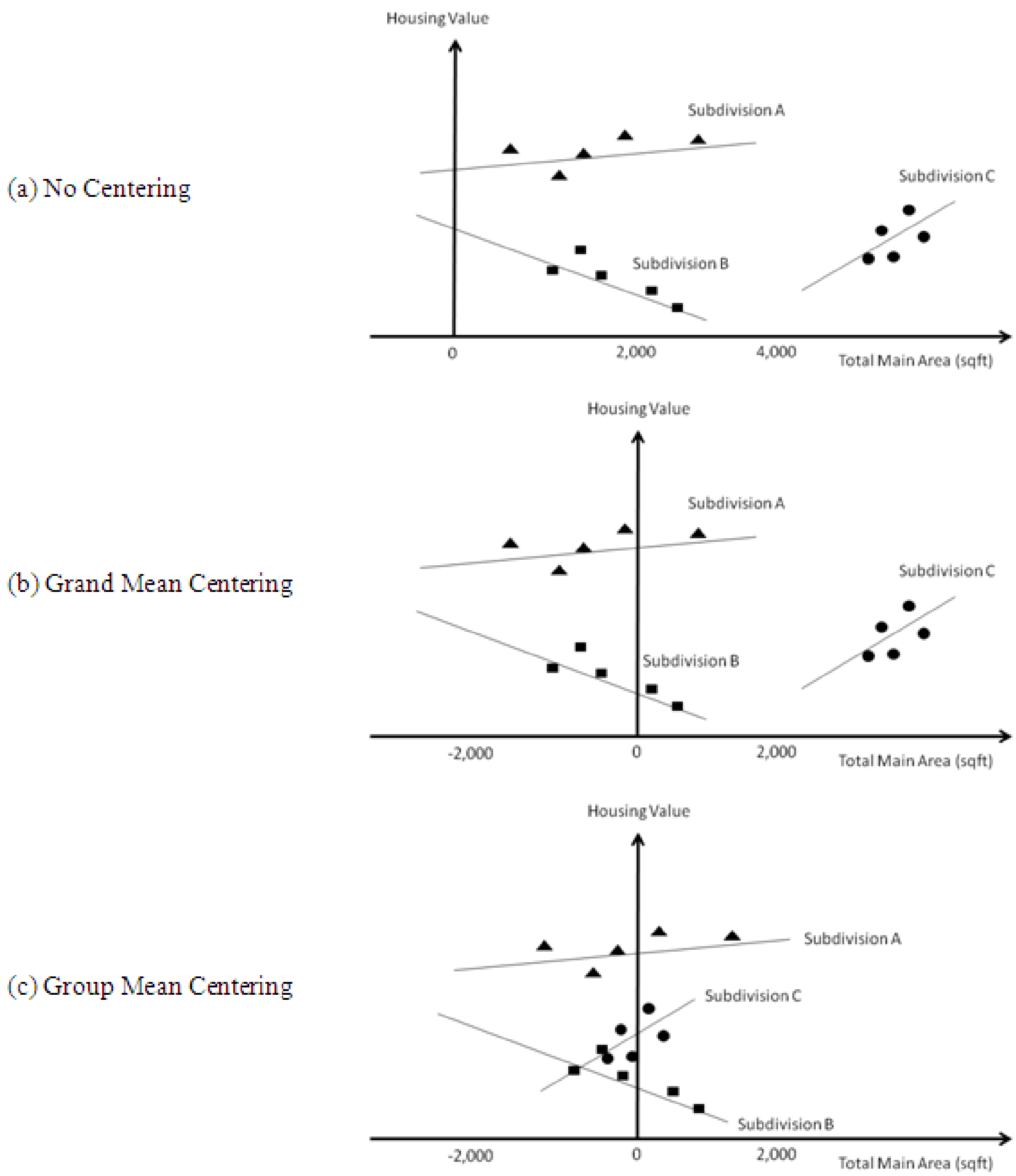


Figure 4-9. Regression Lines of Subdivisions Based on the Centering Procedure.

CHAPTER V

RESULTS

5.1 Descriptive Statistics

5.1.1 Characteristics of the Continuous Variables

Descriptive analyses for all variables were conducted to examine the data characteristics and distribution. The characteristics of the continuous variables at the housing level are summarized in Table 5-1. The mean appraisal value of single family houses was $177,740. On average, single family houses had three bedrooms and two bathrooms, and the age was 19 years. The mean distances from the nearest elementary school and the nearest park to each house were 1.2 mile and 0.4 mile, respectively. The mean number of all facilities and the mean number of sport facilities in the nearest park from each house were ten and five, respectively.

To examine the data's normality, the skewness and kurtosis for each variable were computed. In general, skewness represents how much data distribution was skewed, and kurtosis shows how peak or flat the graph of the data distribution is. A zero value of both the skewness and kurtosis indicate that the distribution was perfectly normal. If the value for skewness or kurtosis of a variable was greater than +3 or less than -3, the variable was not normally distributed (Princeton University, Online-help, regression_intro.htm, 2009).

In this study, the results of skewness and kurtosis indicated that, among the continuous variables at the housing level, nine variables – appraisal value, lot size, total main area, number of bathrooms, detached garage, all porches, network distance from nearest park, population density, and ethnicity – were not normally distributed.

Table 5-1

Descriptive Statistics of Continuous Variables in the Housing level

	Minimum	Maximum	Mean	Std.Dev.	Skewness	Kurtosis
Appraisal Value	31,080.00	778,060.00	177,740.48	74,553.90	2.05	7.26
Lot Size	1874.73	60,000.00	11,827.70	7,416.21	3.90	19.63
Total Main Area	702.00	7,056.00	1,995.51	655.95	1.53	4.30
Number of Bedroom	1.00	6.00	3.48	.59	.07	-.31
Number of Bathroom	1.00	5.50	2.24	.54	1.29	3.03
Building Age	1.00	117.00	18.72	13.65	1.18	1.55
Sold Year	1,971.00	2,008.00	2,002.58	4.65	-1.21	1.22
Attached Garage	.00	1,685.00	411.81	199.85	-.72	1.44
Detached Garage	.00	1,500.00	43.61	153.25	3.54	12.24
All Porches	1.00	2,128.00	144.26	142.73	3.06	21.12
Network Dist. from School	.00	3.26	1.23	.76	.65	-.75
Network Dist. from Park	.01	2.51	.35	.26	1.89	8.30
Network Dist. from TAMU	.13	8.67	3.85	2.11	.52	-.43
Population Density	.01	777.78	16.61	36.46	8.32	101.24
Income	.02	.40	.18	.09	.91	.14
Ethnicity	.00	1.00	.82	.24	-2.77	6.55
Tenure	.00	.99	.20	.25	1.47	1.26
Education	.21	.63	.46	.12	-.36	-1.03
Employment	.03	.27	.10	.05	.86	.05
Workable Age	.30	1.00	.69	.10	.35	2.78
Park Size	1.37	44.70	17.39	14.94	1.14	-.40
Number of Parking Lots	.00	544.00	118.48	215.66	1.42	.09
Total Facilities	.00	24.00	9.55	7.98	.95	-.48
Total Lighted Facilities	.00	20.00	4.69	7.85	1.36	-.02
Sports Facilities	.00	18.00	4.79	6.76	1.34	.00
Lighted Sports Facilities	.00	17.00	3.68	6.72	1.44	.14

Next, the characteristics of the continuous variables at the subdivision level were summarized in Table 5-2. Data showed that the mean number of entrances of subdivisions was four, and, on average, twelve houses were built per hectare. *Median length of cul-de-sac* and *blocks* were 0.01 miles and 0.5 miles, respectively. The mean streets density was 0.07 miles per hectare and the mean number of intersections per mile was five in subdivisions in College Station, Texas. Table 5-2 shows that, among the continuous variables at the subdivision level, six variables – *median length of cul-de-sac*, *median length of blocks*, *single family density*, *cul-de-sac density*, *sidewalk connectivity*, and *bike-lane connectivity* – were either highly skewed or pointy. The nine variables in the housing level and six variables in the subdivision level with no normal distribution should be transformed to be normally distributed. The transformation of the variables will be explained later.

Table 5-2

Descriptive Statistics of Continuous Variables in the Subdivision Level

	Minimum	Maximum	Mean	Std.Dev.	Skewness	Kurtosis
Sense of Arrival	1.82	4.27	3.09	.53	.49	-.23
Accessible Entrance	1.00	10.00	4.38	2.46	.63	-.67
Land Use Mix Index	.00	.93	.46	.24	-.38	-.88
Median Length of Cul-De-Sac	.00	.16	.01	.02	3.03	9.58
Median Length of Blocks	.20	1.88	.51	.17	2.35	14.53
Single Family Density	.80	70.00	11.99	9.72	3.45	14.93
Cul-De-Sac Density	.10	36.10	2.73	2.46	5.85	71.29
Sidewalk Connectivity	.00	.42	.06	.10	2.18	3.52
Bike-Lane Connectivity	.00	6.65	.24	.42	11.80	174.37
Street Density	.00	.14	.07	.02	.37	2.86
Intersection Density	.00	13.00	5.08	1.74	.24	2.85
Connected Node Ratio	.05	1.00	.68	.18	-.57	2.40
Ratio of 4-Way Intersections	.00	1.00	.25	.19	1.00	2.25

5.1.2 Correlation Matrix

The bivariate correlation matrix among appraisal values, variables at the housing level, and variables at the subdivision level are shown in Tables 5-3. A bivariate correlation examines the correlations between two variables without considering other variables; whereas, a partial correlation considers the relationships between two variables and controlling the effects of additional variables. Hence, the bivariate correlation did not show the same relationship in the HPM. However, examining correlations among variables was useful in identifying multicollinearity, which normally represents higher than .90 of the correlation value between two independent variables (Field, 2005). In Table 5-3, six park-related variables (park size, the number of parking lots, total number of park facilities, lighted park facilities, total number of sport facilities, and lighted sport facilities) were very highly correlated. The positive correlation among the six variables could be predicted easily. Because each park-related facility needs enough area, the larger a park is, the more park-related facilities the park has. Next, park-users will want to visit a park with more park facilities. Demand is relative to supply. A larger park will have more parking lots. However, the problem was that there was a very high correlation among the six variables. Hence, only one variable among the six park-related variables could be added in the final models, because of concern that there was a multicollinearity problem among the six variables. Variance Inflation Factor (VIF), and tolerance value of the variables, would be carefully checked to verify the problem exactly in the HPM.

Table 5-3

Correlations among Appraisal Value, Variables in Housing Level, and Variables of Value Creation Concepts in the Subdivision Level

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Appraisal Value	1												
2	Lot Size	.439***	1											
3	Total Main Area	.918***	.521***	1										
4	Num. of Bedrooms	.547***	.242***	.616***	1									
5	Num. of Bathrooms	.726***	.324***	.735***	.549***	1								
6	Building Age	-.338***	.203***	-.163***	-.258***	-.260***	1							
7	Sold Year	-.005	-.164***	-.088***	-.033**	-.064***	-.268***	1						
8	Attached. Garage	.339***	.001	.229***	.196***	.265***	-.377***	.096***	1					
9	Detached Garage	.193***	.266***	.253***	.118***	.154***	.129***	-.128***	-.574***	1				
10	All Porches	.620***	.348***	.561***	.335***	.424***	-.214***	-.013	.158***	.204***	1			
11	Net Dist. School	.094***	.070***	.099***	.079***	.087***	-.282***	.069***	.060***	.052***	.109***	1		
12	Net Dist. Park	.101***	.071***	.044***	.067***	.044***	-.309***	.089***	.091***	-.056***	.082***	.159***	1	
13	Net Dist. TAMU	.496***	-.002	.349***	.314***	.355***	-.675***	.183***	.361***	-.041***	.334***	.274***	.327***	1

Table 5-3 (Cont.)

		1	2	3	4	5	6	7	8	9	10	11	12	13
14	Population Density	-.039**	-.014	-.016	-.007	-.003	.120***	-.077***	-.049***	.022	-.040***	-.105***	-.098***	-.153***
15	Income	.503***	.214***	.464***	.315***	.377***	-.343***	.010	.195***	.132***	.356***	.388***	.200***	.586***
16	Ethnicity	-.070***	.122***	.013	-.024	.013	.282***	-.134***	-.069***	.101***	-.038**	.094***	-.187***	-.374***
17	Tenure	-.408***	-.169***	-.400***	-.364***	-.331***	.341***	-.004	-.252***	-.087***	-.263***	-.252***	-.192***	-.391***
18	Education	.345***	.039**	.287***	.271***	.263***	-.567***	.114***	.287***	.045***	.262***	.622***	.169***	.665***
19	Employment	.127***	.170***	.162***	.032**	.143***	.115***	-.146***	.041***	.155***	.058***	.152***	-.075***	-.106***
20	Workable Age	-.180***	-.075***	-.154***	-.196***	-.150***	.251***	-.028*	-.124***	-.009	-.157***	-.139***	-.061***	-.309***
21	Park Size	-.200***	.038**	-.180***	-.152***	-.110***	.279***	-.084***	-.071***	.021	-.166***	-.362***	-.008	-.281***
22	Num. of Parking lots	-.184***	.035**	-.165***	-.160***	-.110***	.319***	-.090***	-.087***	.033**	-.158***	-.372***	-.025*	-.293***
23	Total Facilities	-.106***	.054***	-.099***	-.128***	-.057***	.330***	-.106***	-.052***	.035*	-.114***	-.495***	-.058***	-.266***
24	Lighted Tot. facility	-.193***	.015	-.170***	-.169***	-.116***	.334***	-.100***	-.096***	.037*	-.168***	-.340***	-.048***	-.318***
25	Sport Facilities	-.176***	.011	-.168***	-.158***	-.108***	.297***	-.073***	-.070***	.019	-.152***	-.414***	-.028*	-.272***
26	Lighted Spo. facility	-.173***	.020	-.155***	-.151***	-.101***	.311***	-.090***	-.079***	.034**	-.153***	-.352***	-.028*	-.281***
27	Sense of Arrival	.494***	.057***	.404***	.269***	.309***	-.304***	.065***	.237***	.055***	.305***	.083***	.118***	.668***
28	Accessible Entrance	-.135***	.074***	-.064***	-.161***	-.118***	.527***	-.165***	-.178***	.080***	-.120***	-.414***	-.238***	-.411***
29	Land Use Mix Index	-.064***	-.076***	-.109***	-.095***	-.023	.038**	-.010	.062***	-.053***	-.077***	-.305***	-.184***	.077***
30	Median Cul-De-Sac	-.044***	.080***	-.032**	.002	-.017	.063***	-.034**	-.055***	.003	-.039***	-.140***	.072***	-.244***
31	Median Blocks	.139***	.544***	.209***	.094***	.124***	.172***	-.119***	.021	.110***	.119***	-.048***	.101***	.069***
32	Single Family Dens.	-.048***	-.259***	-.133***	-.008	-.071***	-.362***	.199***	.043***	-.122***	-.013	.063***	.260***	.276***
33	Cul-De-Sac Dens.	.049***	-.016	.048***	.087***	.033**	-.147***	.001	.050***	.016	.034**	.244***	.059***	.129***
34	Sidewalk Connect.	.003	.050***	-.018	-.046***	-.026*	.061***	-.007	.018	-.018	-.025*	-.186***	-.116***	.109***
35	Bike-Lane Connect.	-.086***	.027*	-.059***	-.079***	-.048***	.162***	-.038**	-.012	.008	-.075***	-.097***	-.125***	-.091***
36	Street Density	-.110***	-.335***	-.150***	-.058***	-.091***	-.204***	.110***	-.020	-.107***	-.065***	.228***	-.014	.147***
37	Intersection Dens.	.021	-.121***	.016	.033**	.018	-.032**	.029*	.005	.023	.029*	.333***	-.017	.126***
38	Connect. Node Ratio	-.135***	-.082***	-.134***	-.157***	-.130***	.257***	.001	-.149***	-.025*	-.066***	-.167***	-.117***	-.215***
39	4way Intersects	-.164***	-.056***	-.135***	-.073***	-.118***	.114***	.009	-.044***	-.011	-.113***	.143***	-.066***	-.100***

Table 5-3 (Cont.)

		14	15	16	17	18	19	20	21	22	23	24	25	26
14	Population Density	1												
15	Income	-.073***	1											
16	Ethnicity	.075***	.053***	1										
17	Tenure	.138***	-.535***	-.136***	1									
18	Education	-.127***	.661***	-.086***	-.486***	1								
19	Employment	.089***	.225***	.210***	-.005	.085***	1							
20	Workable Age	.067***	-.176***	.151***	.395***	-.320***	.027*	1						
21	Park Size	.069***	-.285***	.213***	.113***	-.360***	.142***	.077***	1					
22	Num. of Parking lots	.075***	-.279***	.170***	.141***	-.344***	.212***	.062***	.959***	1				
23	Total Facilities	.087***	-.246***	.108***	.158***	-.388***	.228***	.101***	.921***	.941***	1			
24	Lighted Tot. facility	.082***	-.270***	.176***	.157***	-.352***	.256***	.086***	.954***	.994***	.945***	1		
25	Sport Facilities	.078***	-.276***	.122***	.149***	-.329***	.175***	.051***	.933***	.984***	.950***	.974***	1	
26	Lighted Spo. facility	.076***	-.249***	.171***	.127***	-.316***	.238***	.058***	.945***	.997***	.933***	.993***	.981***	1
27	Entrance Evaluation	-.099***	.444***	-.361***	-.250***	.515***	.000	-.196***	-.191***	-.130***	-.071***	-.142***	-.104***	-.117***
28	Accessible Entrance	.116***	-.200***	.177***	.219***	-.432***	.257***	.123***	.579***	.618***	.635***	.636***	.613***	.612***
29	Land Use Mix Index	.045***	-.206***	.063***	.106***	-.192***	.156***	-.027*	.514***	.457***	.482***	.451***	.444***	.438***
30	Median Cul-De-Sac	.056***	-.169***	-.013	.004	-.232***	.005	-.003	-.176***	-.169***	-.129***	-.182***	-.167***	-.170***
31	Median Blocks	-.031*	.053***	-.045***	-.025*	-.090***	.123***	.039**	.196***	.116***	.186***	.105***	.089***	.092***
32	Single Family Dens.	-.094***	.096***	-.218***	-.094***	.192***	-.290***	-.014	-.194***	-.216***	-.252***	-.233***	-.202***	-.214***
33	Cul-De-Sac Dens.	-.042***	.025*	-.051***	-.050***	.157***	-.033**	.022	-.202***	-.244***	-.250***	-.240***	-.269***	-.244***
34	Sidewalk Connect.	-.030*	-.126***	-.376***	.135***	-.099***	-.086***	-.061***	.069***	.022	.120***	.017	.042***	.007
35	Bike-Lane Connect.	.009	-.103***	-.083***	.219***	-.159***	.020	.077***	.068***	.046***	.099***	.055***	.041***	.045***
36	Street Density	-.051***	.165***	-.043***	-.010	.228***	-.151***	-.117***	-.143***	-.116***	-.203***	-.100***	-.112***	-.095***
37	Intersection Dens.	-.032**	.242***	-.008	-.035**	.204***	.099***	.062***	-.239***	-.221***	-.227***	-.192***	-.223***	-.200***
38	Connect. Node Ratio	.040***	-.057***	.066***	.110***	-.187***	.014	.023	.095***	.153***	.161***	.158***	.181***	.159***
39	4way Intersects	-.013	-.159***	.169***	.011	.038**	.127***	-.098***	.265***	.315***	.147***	.310***	.272***	.319***

Table 5-3 (Cont.)

		27	28	29	30	31	32	33	34	35	36	37	38	39
27	Entrance Evaluation	1												
28	Accessible Entrance	-.089***	1											
29	Land Use Mix Index	.005	.420***	1										
30	Median Cul-De-Sac	-.252***	-.234***	-.260***	1									
31	Median Blocks	.015	.035**	.192***	.062***	1								
32	Single Family Dens.	.178***	-.348***	-.144***	-.009	-.254***	1							
33	Cul-De-Sac Dens.	.084***	-.411***	-.169***	.004	.052***	.153***	1						
34	Sidewalk Connect.	.214***	.118***	.220***	.126***	.296***	-.134***	-.008	1					
35	Bike-Lane Connect.	.017	.076***	.021	-.025*	.129***	-.177***	-.048***	.255***	1				
36	Street Density	-.031*	-.090***	-.061***	-.213***	-.451***	.164***	-.167***	-.171***	-.237***	1			
37	Intersection Dens.	.132***	-.137***	-.162***	-.115***	-.269***	.153***	.177***	-.143***	.166***	.078***	1		
38	Connect. Node Ratio	-.112***	.433***	.042***	-.106***	-.245***	-.058***	-.622***	-.045***	.006	.166***	.270***	1	
39	4way Intersects	-.067***	.240***	.370***	-.306***	-.043***	-.164***	-.062***	-.055***	-.079***	.101***	-.128***	.061***	1

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

5.1.3 Log Transformation

There were several ways of data transformation such as log, square root, or reciprocal transformation. In general, a number of papers in regard to analyzing property values had most commonly used a log transformation when data were not normally distributed (Palmquist, 1980; Song and Knaap, 2003). The log transformation is performed by taking the logarithm of dependent variable or the logarithm of both independent and dependent variables.

Table 5-4

Descriptive Statistics of the Transformed Variables

	Minimum	Maximum	Mean	Std.Dev.	Skewness	Kurtosis
LN (Appraisal)	10.34	13.56	12.02	.37	.46	.83
LN (Number of Bathrooms)	.10	1.72	.82	.22	.01	2.76
LN (Total Main Area)	6.55	8.86	7.55	.30	.40	.29
LN (Detached Garage)	.00	7.31	.50	1.70	3.11	7.70
LN (Lot Size)	7.54	12.41	9.27	.46	1.34	5.77
LN (All Porches)	.00	7.66	4.42	1.31	-1.45	2.84
LN (Network dist. from Park)	-4.95	.92	-1.37	.95	-1.37	2.73
LN (Population Density)	-4.61	6.66	1.59	2.01	-1.22	1.65
LN (Ethnicity)	-4.61	.01	-.45	1.17	-3.24	8.64
LN (Median Length of Cul-De-Sac)	-6.91	-1.80	-5.22	1.23	.83	.05
LN (Median Length of Blocks)	-1.61	.63	-.73	.31	-.47	2.60
LN (Single Family Density)	-.22	4.25	2.28	.61	.00	2.84
LN (Sidewalk connectivity)	-4.61	-1.05	-3.59	1.11	.79	-.39
LN (Bike-Lane Connectivity)	-6.21	1.89	-2.48	2.02	-1.08	-.32
LN (Cul-De-Sac Density)	-2.30	3.59	.58	1.16	-1.41	1.47

Table 5-4 shows the changed values of skewness and kurtosis of the dependent variable and fourteen independent variables after applying the log on the variables. The dependent variable (appraisal value) presenting high kurtosis value was log-transformed, just as in other papers, to fit to normal distribution and to be easily interpreted (See Table 5-1). Also, among all independent variables, eight continuous variables at the housing level and six continuous variables at the subdivision level, which were not normally distributed (See Table 5-1 and Table 5-2), were log–transformed.

Compared to the skewness and kurtosis of the original data, the log-transformed variables showed much lower values of skewness and kurtosis. Among the fourteen variables, 11 variables fell into the value between -3 and +3 for skewness and kurtosis. However, three variables including detached garage, lot size, and ethnicity still showed higher skewness and kurtosis.

The transformation of the data is helpful to reduce the impact of outliers, and convert not normally distributed data to normally distributed data; however, it is not a panacea. If the variables which cannot be normally distributed by transformation should be added in the analysis, using a method that does not depend on the assumption of normal distribution should be considered (Field, 2005). However, both the Hedonic Price Model and the Hierarchical Linear Model assume the normal distribution of the data. Therefore, these three variables - Detached Garage, Lot Size, and Ethnicity - were not included in both models in this study.

5.1.4 Characteristics of the Dummy Variables

Ten dummy variables at both the housing level and the subdivision level are summarized in Table 5-5. Dummy variables were encoded either “0” or “1” in the dataset; that is, if a value of “0” was given, it meant a certain feature did not include a house or a subdivision.

Table 5-5

Dummy Variables

	Minimum	Maximum	Mean	Std.Dev.
2^{nd} Floor	0	1	.08	.276
Swimming Pool	0	1	.05	.225
Attach to Golf Course	0	1	.01	.077
Cul-De-Sac	0	1	.13	.337
Corner	0	1	.15	.361
Attach to a Park	0	1	.02	.139
Across to a Park	0	1	.02	.133
Phased Project	0	1	.80	.402
Park Connectivity	0	1	.82	.385
Greenway Connectivity	0	1	.60	.490

In the study, at the housing level, seven variables – 2^{nd} floor, swimming pool, attached to a golf course, on cul-de-sac, on the corner, attach to a park, and across a road to a park – were defined as dummy variables. Also, three dummy variables including phased project, park connectivity, and greenway connectivity were defined at the subdivision level.

The characteristics of dummy variables show that a lot of subdivisions were built through more than one phase, and were connected to park and greenway. On the other hand, most houses did not have a 2nd floor a swimming pool, were not attached to a golf course, not located on a cul-de-sac, on a corner, were not attached to a park, or were not across a road to a park.

5.2 Hedonic Price Model

5.2.1 Model Validation

Normal distribution of all variables was examined in the previous section. In this section, the second assumption regarding independent errors is examined. The HPM assumes that the error terms should be independent and uncorrelated. The size of errors for one case should not have an impact on the size of errors for the next case. In this case, the errors mean the difference between the actual score of a case and the estimated score in a Hedonic Price Model. The HPM was made with SPSS Version 16.

To check the serious correlation among errors, the Durbin-Watson statistic was generally applied and the value ranged from 0 to 4. As a general rule, the acceptable range of the statistic is between 1 and 3 (Field, 2005). In this study, the Durbin-Watson statistic for the HPM was 1.073 which fell in the acceptable range. Therefore, the results show that errors in prediction would not follow a pattern from case to case.

5.2.2 Results of the Hedonic Price Model

The Hedonic Price Model for this research could be specified as follow:

$$P_i = f(S_i, L_i, N_i, O_i, M_i, W_i, C_i, A_i); \quad [5\text{-}1]$$

where P_i represents the appraisal value of the i^{th} single family home,

S_i is a vector of structural characteristics,

L_i is a vector of locational characteristics,

N_i is a vector of neighborhood characteristics,

O_i is a vector of sense of arrival characteristics,

M_i is a vector of Product Mix characteristics,

W_i is a vector of walkability characteristics

C_i is a vector of circulation system characteristics, and

A_i is a vector of amenity characteristics.

In Equation 5-1, the last five vectors (i.e., O_i, M_i, W_i, C_i, A_i) were the value creation concepts to be estimated.

Overall, the HPM explained about 93% of the variance of the single family housing appraisal values in College Station. The HPM selected statistically useful variables based on the stepwise variable selection method.

The variables included in the model are summarized in Table 5-6. Among forty-four independent variables which were normally distributed, twenty independent variables are statistically significant at a .05 level in the HPM. Table 5-6 shows that all VIF values were lower than 3 and all tolerance statistics were higher than .2. Therefore, variables were not engaged in any significant multicollinearity problem in this model.

Table 5-6

Coefficients of the Hedonic Price Model

	Unstandardized Coefficients		Standardized Coefficient			Collinearity Statistics	
	B	Std.Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	5.0260	.046		109.07	.000		
LN(Total Main Area)	.9105	.006	.750	153.20	.000	.477	2.097
Attached Garage	.0001	.000	.058	15.11	.000	.788	1.270
LN(All Porches)	.0146	.001	.053	13.07	.000	.707	1.414
Swimming Pool	.0689	.006	.043	12.11	.000	.928	1.077
Building Age	-.0059	.000	-.220	-41.13	.000	.402	2.490
Network Dist. from School	-.0264	.002	-.055	-12.31	.000	.579	1.728
Attach to a Golf Course	.1763	.016	.37	10.77	.000	.964	1.038
Sports Facilities	.0012	.000	.022	4.59	.000	.515	1.943
LN(Population Density)	-.0025	.001	-.014	-3.24	.001	.627	1.595
Income	.2461	.020	.064	12.28	.000	.423	2.366
Tenure	-.0371	.007	-.025	-5.24	.000	.504	1.983
Employment	.2454	.033	.031	7.44	.000	.655	1.526
Workable Age	.0631	.014	.018	4.54	.000	.760	1.315
Sense of Arrival	.0571	.003	.083	16.72	.000	.469	2.132
LN(Single Family Density)	-.0255	.003	-.043	-9.41	.000	.558	1.794
Phased Project	-.0414	.004	-.046	-9.98	.000	.548	1.825
LN(Sidewalk Connectivity)	.0116	.002	.035	7.15	.000	.467	2.141
LN(Median Length of Blocks)	-.0474	.005	-.041	-9.14	.000	.575	1.738
Accessible Entrance	-.0024	.001	-.016	-2.94	.003	.369	2.713
Street Density	-.4189	.089	-.020	-4.70	.000	.636	1.573

In the Hedonic Price Model, thirteen variables at the housing level were found to have significant effects on appraisal values and their direction were as expected in prior correlation results. Among the thirteen variables, *total main area, attached garage, all porches, swimming pool, attach to a golf course, sports facilities, income, employment*, and *workable age* variables were positively related and statistically significant; whereas *building age, network distance from school, population density,* and *tenure* variables showed negative directions and were statistically significant with .05 of p-value.

At the subdivision level, seven variables were found and the directions of most variables were consistent with prior correlation results as expected. However, *street density* variable showed a different result. Among the seven variables, *sense of arrival* and *sidewalk connectivity* variables presented positive directions and were statistically significant, while the other five variables – *single family density, phased project, median length of blocks, accessible entrance,* and *street density* – had negative directions and were statistically significant.

5.2.3 Interpretations of the Hedonic Price Model

Based on Table 5-6, the final HPM is explained as:

MODEL: ln(Appraisal Value) = [5-2]

ln(TotMain) + AttachGarage + ln(AllPorches) + BuiltAge + SwimPool + *[Structural Characteristics]*

ND_School + AttaGolf + SportsFaci + *[Locational Characteristics]*

ln(PopDen) + Income + Tenure + Employment + WorkableAge + *[Neighborhood Characteristics]*

SenseofArrival + *[Sense of Arrival Characteristics]*

ln(SingleDen) + PhasedProject + *[Product Mix Characteristics]*

ln(Sidewalk) + ln(MedBlocks) + *[Walkability Charactersitics]*

AccessibleEntrance + StreetDen *[Circulation System Characteristics]*

Because the dependent variable was log transformed, coefficients on the independent variables would be interpreted differently based on the form of the variables (Asteriou and Hall, 2007). First, when the independent variable was log transformed as well, the coefficient of the variable should be interpreted as elasticity. For instance, in the case of the total main area variable, a 1% increase of the total main area of a single family house led to an average appraisal value increase by 0.9%. Second, when the independent variable was not transformed, the coefficient of the variable should be interpreted as a relative change in dependent variables on an absolute change in the dependent variable. For example, in the case of the Attached Garage variable, a square foot rise in the attached garage resulted in a 0.01% rise of the appraisal value. Finally, when the independent variable was an untransformed dummy variable, the true proportional change in the dependent variable resulting from a unit change in a dependent variable should be calculated with the equation of "100(exp(b1)-1)" (Halvorsen and Palmquist, 1980; Hardy, 1993). In the case of the swimming pool variable, the true portion change would be 7.10% (100 * (exp(0.0689) -1) = 7.13291). Hence, the expected appraisal value for a house with a swimming pool was 0.071 (7.13%) higher than the appraisal value for a house without a swimming pool.

Based on three different ways of interpretation, variables at the housing level are interpreted as follows. As log-transformed continuous variables, for a 1% increase of porches of the single family house, the average appraisal value of the houses increased by 0.02%. On the other hand, for a 1% increase of population density of a census block including the single family house, the average appraisal value of the houses decreased by

0.003%. Next, as non-transformed continuous variables, for a year rise in building age, a mile rise in network distance from the nearest elementary school, and a percentage rise in tenure, the appraisal value dropped by 0.6%, 2.6%, and 3.7%, respectively. For a unit rise in sport facilities in the nearest park, a million dollar rise in income, a percentage rise in employment, and a percentage rise in workable age, the appraisal value increased by 0.1%, 24.6%, 24.5%, and 6.3%, respectively. Finally, as a dummy variable, the expected appraisal value for a house abutting a golf course was 17.6% higher than the appraisal value for a house which is separated from any golf courses.

Seven coefficients on the variables in the subdivision level were as expected and were consistent with prior results, except street density. *Sense of arrival* and *sidewalk connectivity* variables were positive and statistically significant. The other five variables were negative and statistically significant. As log-transformed continuous variables, for a 1% increase of *sidewalk connectivity* ratio of the subdivision including the single family house, the average appraisal value of the houses increased by 0.01%. On the other hand, for a 1% increase of *single family density* and *median length of blocks*, the average appraisal value of the houses decreased by 0.01% and 0.05%, respectively. Next, as a non-transformed continuous variable, for a 1% rise in the *sense of arrival* score on a five point Likert scale (very low = 1, very high = 5), the appraisal values increased by 5.7%; whereas, for a 1% rise in street density and the *number of accessible entrances* to a subdivision, the appraisal values dropped by 41.8% and 0.3%, respectively. Finally, as a dummy variable, the expected appraisal value for a house in the subdivision with more than one phase was 4.2% lower than the appraisal value for a house in the subdivision with only one phase.

5.3 Hierarchical Linear Model

For this study, three Hierarchical Linear Models were applied. The first two models were necessary to make the final model. The models were made with HLM Version 6.06 and SPSS Version 16 using MIXED procedure (See Appendix 5). The results of the HLM Version 6.06 were mainly used. The results of SPSS Version 16 were used to identify the statistical significance of variances and covariances between housing level variables. The first HLM was the Random-Effect ANOVA model, which consists of a dependent variable. The Random-Effect ANOVA model showed whether or not the HLM was necessary for analyzing the data in this study or if only the Hedonic Price Model was enough. The second HLM was the Random-Coefficient Regression Model, which was useful in identifying statistically significant variables in the housing level. The variables in the Random-Coefficient Regression Model should be added in the final HLM. The final HLM was the Intercepts- and Slopes-as-Outcomes Model, which included all statistically significant variables in both the housing level and the subdivision level.

5.3.1 The Random-Effect ANOVA Model

The analysis started with fitting a random-effect ANOVA model to determine the total amount of variability in the appraisal values within and between subdivisions. The random-effect ANOVA model is the simplest possible hierarchical linear model and can be explained as:

Level 1: $\mathrm{Ln(Appraisal)}_{ij} = \beta_{0j} + e_{ij}$ [5-3]

Level2: $\beta_{0j} = \gamma_{00} + u_{0j}$ [5-4]

Combined Model: $\mathrm{Ln(Appraisal)} = \gamma_{00} + u_{0j} + e_{ij}$; [5-5]

where i is the i^{th} single family house;
j is the j^{th} subdivision;
β_{0j} represents the mean appraisal value of the j^{th} subdivision;
γ_{00} represents the mean appraisal value of all single family houses in College Station;
u_{0j} represents a subdivision (level-2) effect;
e_{ij} represents a house (level-1) effect.

The variance of the dependent variable can be explained as:

$$\mathrm{Var}\left(\mathrm{Ln}\left(\mathrm{Appraisal}_{ij}\right)\right) = \mathrm{Var}\left(u_{0j} + e_{ij}\right) = \mathrm{Var}\left(u_{0j}\right) + \mathrm{Var}\left(e_{ij}\right) = \tau_{00} + \sigma^2; \quad [5\text{-}6]$$

where σ^2 is the within-group variability, and τ_{00} represents the between-group variability.

A useful parameter associated with the random-effect ANOVA model is the interclass correlation coefficient (ICC). The ICC can be expressed by equation 5-7.

$$\rho = \tau_{00}/(\tau_{00} + \sigma^2) \quad [5\text{-}7]$$

The ICC evaluates the proportion of the variance in the dependent variable (ln(appraisal value)) that was between the level-2 units (subdivision.) In Table 5-7, the estimate of residual was the within-subdivision variability (σ^2) and the estimate of the intercept was the between-subdivision variability (τ_{00}). The ICC can be calculated by equation 5-7 as shown below;

$$\rho = \frac{\tau_{00}}{(\tau_{00} + \sigma^2)} = \frac{0.128}{(0.128 + 0.044)} = 0.744$$

Table 5-7

Estimated Random Effects on the Random-Effect ANOVA Model

Parameter	Variance Component	D.F.	Chi-Square	Sig.
Intercept	.12803	84	14981.16671	.000
Residual	.04413			

Muthen and Satorra (1995) suggest the design effect is the ratio of the total number of houses required using subdivision level randomization to the number required using housing level randomization. The design effect was calculated by equation 5-8.

Design Effect = 1 + (average cluster size - 1) * ICC = 1 + (77-1)*0.744 = 57.5 [5-8]

The average cluster size in my research was 77 (= the number of total houses / the number of subdivisions = 6,562 / 85 = 77), and the design effect was 57.5. Maas and Hox (2002) mentioned that using single level analysis is likely to lead to biased results if the design effect was larger than 2. Because the design effect of the data (57.5) was larger than 2, the HLM would give unbiased results instead of a single level model.

5.3.2 The Random-Coefficient Regression Model

The next step in this research was to make the random-coefficient Model. The model represents the structural, locational, and neighborhood distribution of the appraisal value in each of the 85 subdivisions. It is an important early step in a Hierarchical Linear Model in identifying a range of useful housing level variables for the sequentially final model including both housing level and subdivision level. The statistically significant housing level variables in this model should be used in the next model. The final random-coefficient regression model was developed using statistically significant variables among all the possible housing level variables. As a result, the appraisal value for single family housing i in subdivision j was regressed on l*n(total main area), ln(the number of bathrooms), ln(all porches),attached garage, building age, attach to a golf course,* and *swimming pool*. The five continuous variables - ln(total main area), ln(the number of bathrooms), ln(all porches), attached garage, and building age – were all group mean centered with the form of $\ln(X_{ij}) - \ln(\overline{X}_{.j})$. The random-coefficient regression model was consistent with two levels (Equation 5-9 and 5-10).

Table 5-8

Estimated Fixed Effects on the Random-Coefficient Regression Model

	Estimate	Std.Error	D.F.	t Ratio	Sig.
Intercept	11.9238	.039	84	304.783	.000
LN (Total Main Area_Centered)	.7117	.020	84	35.988	.000
LN (Bathroom_Centered)	.0499	.011	84	4.623	.000
LN (All Porches_Centered)	.0092	.001	84	7.322	.000
(Building Age_Centered)	-.0066	.001	84	-7.516	.000
(Attached Garage_Centered)	.0001	.000	6554	10.273	.000
(Attach to a Golf Course)	.1495	.013	6554	11.123	.000
(Swimming Pool)	.0608	.004	6554	14.190	.000

The first four coefficients in Equation 5-9 were specified as random in the subdivision level model; on the other hand, the last three coefficients had only a fixed effect. It just indicated that the effect of building age, attach to a golf course, and swimming pool variables on housing value did not vary across the 85 subdivisions.

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}(\text{lnTMA\_C}) + \beta_{2j}(\text{lnBATH\_C}) + \beta_{3j}(\text{lnAP\_C}) +$

$\beta_{4j}(\text{BA\_C}) + \beta_{5j}(\text{AG\_C}) + \beta_{6j}(\text{GOLF}) + \beta_{7j}(\text{POOL}) + e_{ij}$ [5-9]

Level 2: $\beta_{qj} = \gamma_{q0} + u_{qj}$ for q = 0, 1, 2, 3, 4,

$\beta_{qj} = \gamma_{q0}$ for q = 5, 6, 7; [5-10]

where lnTMA_C was the group-mean centered ln(total main area);
lnBATH_C was the group-mean centered ln(the number of bathrooms);
lnAP_C was the group-mean centered ln(all porches);
BA_C was the group-mean centered building age;
AG_C was the group-mean centered attached garage;
GOLF was a dummy variable for attachment to a golf course;
POOL was a dummy variable for the existence of a swimming pool;
γ_{q0} was the mean value for each subdivision effect;
σ^2, the variance of e_{ij}, represented the residual variance at level one that remained unexplained after considering the homes' total main area, the number of bathrooms, all porches, building age, attached garage, attachment to a golf course, and swimming pool (See Table 5-8).

Because there are five level-2 random effects (u_{qj} in Equation 5-10), the variances and covariances among them now form a 5 by 5 matrix (See Table 5-9). Table 5-9 shows four important results of the relationship among dependent variables and four independent variables – lnTMA_C, lnBATH_C, lnAP_C, and BA_C.

First, the within-subdivision variability (σ^2) tests the difference between the appraisal value of i^{th} house and the mean appraisal value of a subdivision including the i^{th} house. In Table 5-9 and Equation 5-11, σ^2 (= 0.0054) is statistically significant with .05 of p-value. Hence, it could be concluded that the appraisal values of houses nested in a subdivision are not the same with the mean appraisal value of the corresponding subdivision.

$$T = \begin{bmatrix} \mathrm{Var}(u_{0j}) & & & & \\ \mathrm{Cov}(u_{1j}, u_{0j}) & \mathrm{Var}(u_{1j}) & & & \\ \mathrm{Cov}(u_{2j}, u_{0j}) & \mathrm{Cov}(u_{2j}, u_{1j}) & \mathrm{Var}(u_{2j}) & & \\ \mathrm{Cov}(u_{3j}, u_{0j}) & \mathrm{Cov}(u_{3j}, u_{1j}) & \mathrm{Cov}(u_{3j}, u_{2j}) & \mathrm{Var}(u_{3j}) & \\ \mathrm{Cov}(u_{4j}, u_{0j}) & \mathrm{Cov}(u_{4j}, u_{1j}) & \mathrm{Cov}(u_{4j}, u_{2j}) & \mathrm{Cov}(u_{4j}, u_{3j}) & \mathrm{Var}(u_{4j}) \end{bmatrix} \quad [5\text{-}11]$$

$$= \begin{bmatrix} \tau_{00} & & & & \\ \tau_{10} & \tau_{11} & & & \\ \tau_{20} & \tau_{21} & \tau_{22} & & \\ \tau_{30} & \tau_{31} & \tau_{32} & \tau_{33} & \\ \tau_{40} & \tau_{41} & \tau_{42} & \tau_{43} & \tau_{44} \end{bmatrix} = \begin{bmatrix} 0.130 & & & & \\ 0.014 & 0.021 & & & \\ 0.003 & -0.001 & 0.003 & & \\ 0.001 & 0.000 & -0.000 & 0.000 & \\ 0.000 & -0.000 & 0.000 & -0.000 & 0.000 \end{bmatrix}$$

Second, in the variance-covariance matrix (T), τ_{00} tests the difference between the intercept value of the regression line of j^{th} subdivision and the intercept value of the regression line of the overall model (See Equation 5-11). Because there are 85 subdivisions, 85 regression lines could be made. In Table 5-9, τ_{00} (= 0.130) is statistically significant with a p-value of .05. Hence, it could be concluded that the intercepts of regression lines of 85 subdivisions are not the same as the intercept value of the regression line of the overall model (See (b) in Figure 5-1).

Table 5-9

Estimated Random Effects on the Random-Coefficient Regression Model

	Variance Component	D.F.	Chi-Square	Sig.
Mean Housing Value, τ_{00}	.1298***	75	98572.68451	.000
LN (Total Main Area_Centered) , τ_{11}	.0210***	75	761.52037	.000
LN (Bathroom_Centered) , τ_{22}	.0031***	75	124.69933	.000
LN (All Porches_Centered) , τ_{33}	.0000**	75	107.08080	.009
(Building Age_Centered) , τ_{44}	.0000***	75	666.96180	.000
Level-1 effect, σ^2	.0054***			

Correlation Among Subdivision Effects	Mean Housing Value	LN (Total Main Area_Centered)	LN (Bathroom_ Centered)	(All Porches_ Centered)
LN (Total Main Area_Centered)	τ_{10} = .0142			
LN (Bathroom_Centered)	τ_{20} = .0032	τ_{21} = -.0005		
LN (All Porches_Centered)	τ_{30} = .0014**	τ_{31} = .0003	τ_{32} =- .0001	
(Building Age_Centered)	τ_{40} = .0001	τ_{41} = -.0002	τ_{42} = .0001	τ_{43} = -.0000

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Third, τ_{11} tests the difference between the slope of the regression line of the j^th^ subdivision and the slope of the regression line of the overall model when the appraisal value is on the y-axis and *total main area* is on the x-axis. In Table 5-9, τ_{11} (= 0.021) is statistically significant with .05 of p-value. Hence, it could be concluded that the slopes of regression lines of 85 subdivisions are not the same as the slope of the regression line of the overall model (See (d) in Figure 5-1). τ_{22}, τ_{33}, and τ_{44} could be interpreted with the same procedure with the *number of bathrooms, all porches*, and *building age* variables on the x-axis, respectively.

Finally, τ_{30} tests the correlation between intercepts and slopes of regression lines of all subdivisions when the *appraisal value* is on the y-axis and *all porches* is on the x-axis. In Table 5-9, τ_{30} (= 0.0014) is statistically significant with .05 of p-value. Because τ_{30} is larger than 0, it could be concluded that there is a positive relationship between intercepts and slopes; that is, the higher the intercept value on a regression line of a subdivision, the more steep a slope the regression line has, and vice versa. For example, houses nested in subdivision A increased their housing value by increasing a unit of *all porches* at a faster pace than houses nested in subdivision D (See (e) of Figure 5-1).

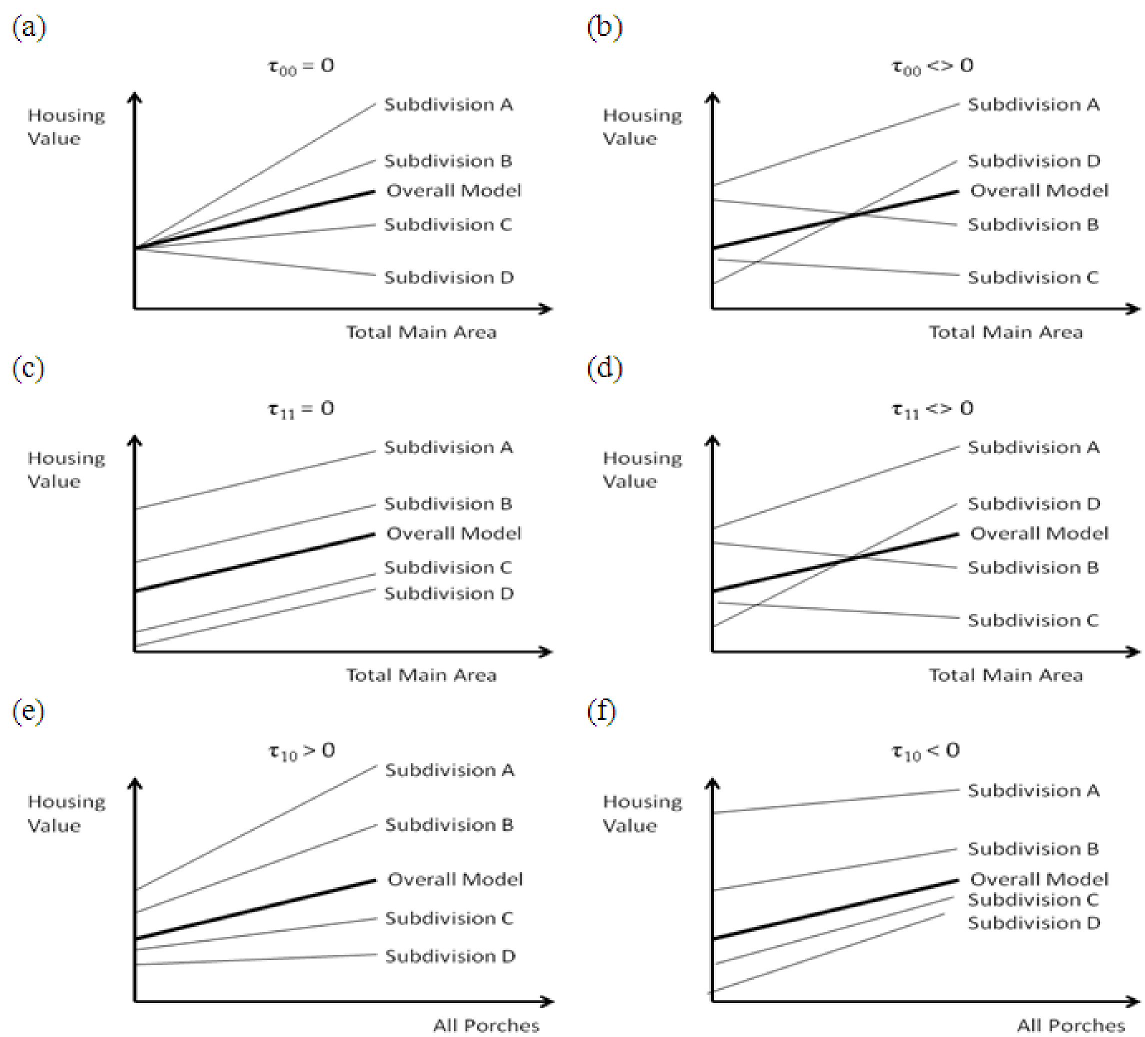


Figure 5-1. Meaning of Random Effects.

5.3.3 The Intercepts- and Slopes-as-Outcomes Model

The previous random-coefficient regression model shows that seven housing level variables had a significant relationship with appraisal values. All statistically significant level-1 variables in the random-coefficient regression model should remain at least at a fixed effect in the housing-level model of the intercepts- and slopes-as-outcomes model (Raudenbush and Bryk, 2002). Hence, lnTMA_C, lnBATH_C, lnAP_C, BA_C, AG_C, GOLF, and POOL variables were added in the housing level model (See Equation 5-12).

Kreft et al. (1995) recommended that the group means of level-1 variables needed to be reintroduced into the macro level model when the group-mean centering procedure was used. The reason was that this action compensated the removed group mean effects caused by the group mean centering of the level-1 variables. Hence, three group means – lnTMA_GM, lnBATH_GM, and AG_GM – were added in the subdivision level model (Equation 5-13). However, the group means of all porch and building age variables were not included, because the two group mean variables were not statistically significant.

In the subdivision level model in the final model, five variables were added. The variables were sense of arrival (SENOFARR), median length of block (lnMEDBLO), median length of cul-de-sac (lnMEDCUL), number of accessible entrances (ACCENT), and greenway connectivity (GRECON). The joint effects of three subdivision level variables – sense of arrival, number of accessible entrances, and group mean of total main area – on two housing level variables – lnTMA_C and AG_C – were modeled.

Statistically significant interactions among subdivision level variables were also added. The intercepts- and slopes-as-outcomes model can be explained as:

Level 1: $Y_{ij} = \beta_{0j} + \beta_{1j}(\text{lnTMA\_C}) + \beta_{2j}(\text{lnBATH\_C}) + \beta_{3j}(\text{lnAP\_C}) + \beta_{4j}(\text{BA\_C}) + \beta_{5j}(\text{AG\_C}) + \beta_{6j}(\text{GOLF}) + \beta_{7j}(\text{POOL}) + e_{ij}$ [5-12]

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{SENOFARR}) + \gamma_{02}(\text{lnMEDCUL}) + \gamma_{03}(\text{lnMEDBLO}) + \gamma_{04}(\text{ACCENT}) + \gamma_{05}(\text{ACCGRE}) + \gamma_{06}(\text{lnTMA\_GM}) + \gamma_{07}(\text{lnBATH\_GM}) + \gamma_{08}(\text{AG\_GM}) + \gamma_{09}(\text{lnTMA\_GM} * \text{GRECON}) + \gamma_{010}(\text{lnMEDCUL} * \text{ACCENT}) + \gamma_{011}(\text{lnMEDBLO} * \text{GRECON}) + u_{0j}$

$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{SENOFARR}) + \gamma_{12}(\text{ACCENT}) + u_{1j}$

$\beta_{qj} = \gamma_{q0} + u_{qj}$ for q = 2, 3, 4,

$\beta_{5j} = \gamma_{50} + \gamma_{51}(\text{SENOFARR}) + \gamma_{52}(\text{TMA\_GM})$

$\beta_{qj} = \gamma_{q0}$ for q = 6, 7 [5-13]

Combined [Fixed Part]: $Y_{ij} = \gamma_{00} + \gamma_{01}(\text{SENOFARR}) + \gamma_{02}(\text{lnMEDCUL}) + \gamma_{03}(\text{lnMEDBLO}) + \gamma_{04}(\text{ACCENT}) + \gamma_{05}(\text{ACCGRE}) + \gamma_{06}(\text{lnTMA\_GM}) + \gamma_{07}(\text{lnBATH\_GM}) + \gamma_{08}(\text{AG\_GM}) + \gamma_{09}(\text{lnTMA\_GM} * \text{GRECON}) + \gamma_{010}(\text{lnMEDCUL} * \text{ACCENT}) + \gamma_{011}(\text{lnMEDBLO} * \text{GRECON}) + \gamma_{10}(\text{lnTMA\_C}) + \gamma_{11}(\text{SENOFARR}) * (\text{lnTMA\_C}) + \gamma_{12}(\text{ACCENT}) * (\text{lnTMA\_C}) + \gamma_{20}(\text{lnBATH\_C}) + \gamma_{30}(\text{lnAP\_C}) + \gamma_{40}(\text{BA\_C}) + \gamma_{50}(\text{AG\_C}) + \gamma_{51}(\text{AG\_C}) * (\text{SENOFARR}) + \gamma_{52}(\text{AG\_C}) * (\text{TMA\_GM}) + \gamma_{60}(\text{GOLF}) + \gamma_{70}(\text{POOL})$ [5-14]

The results for the intercepts- and slopes-as-outcomes model are presented in Table 5-10. Coefficients on the seven variables (*total main area, the number of bathrooms, all porches, building age, attached garage, attach to a golf course,* and *swimming pool*) in the housing level in HLM were positive as expected except the building age variable, and were consistent with prior HPM results. The number of bathrooms, all porch, building age, attach to a golf course, and swimming pool variables were interpreted easily because there was no interaction terms with the subdivision level variables.

For a 1% increase in the number of bathrooms of a single family house which was nested in a subdivision and had the mean value of the subdivision, the appraisal value of the house increased by 0.054%. For a 1% increase of the porch size of a single family house, the appraisal value of the house increased by 0.01%. In the case of the attach to a golf course variable, as a dummy variable, the true portion change would be 16.25% (= 100 * (exp (0.1506) -1) = 16.25). Hence, if a house was on a golf course, the expected appraisal value for the house increased by 16.25%. In the case of the Swimming Pool variable, as a dummy variable, if the house had a swimming pool, the expected appraisal value for the house increased by 6.35% (= 100 * (exp (0.0616) -1) = 6.35). On the other hand, for a year rise in building age, the appraisal value dropped by 0.66%.

Table 5-10

Estimated Fixed Effects on the Intercepts- and Slopes-as-Outcomes Model

Fixed Effect	Coefficient	Std.Error	t Ratio	d.f.	Sig.
Subdivision Mean Housing Value					
BASE, γ_{00}	4.2465	0.4616	9.200	73	0.000
Sense of Arrival, γ_{01}	0.0518	0.0198	2.614	73	0.011
Ln(median length of Cul-De-Sac), γ_{02}	0.0444	0.0101	4.393	73	0.000
Ln(median length of block), γ_{03}	-0.1364	0.0326	-4.190	73	0.000
Number of Accessible Entrance, γ_{04}	-0.0536	0.0137	-3.907	73	0.000
Greenway Connectivity, γ_{05}	1.7052	0.7116	2.396	73	0.019
Ln(total main area group mean), γ_{06}	0.9643	0.0664	14.514	73	0.000
Ln(number of bathroom group mean), γ_{07}	0.3937	0.0976	4.032	73	0.000
Attached garage group mean, γ_{08}	0.0003	0.0001	4.082	73	0.000
Ln(total main area group mean)* Greenway Connectivity, γ_{09}	-0.1999	0.0932	-2.145	73	0.035
Ln(median length of Cul-De-Sac)* Number of Accessible Entrance, γ_{010}	-0.0099	0.0025	-4.022	73	0.000
Ln(median length of block)* Greenway Connectivity, γ_{011}	0.1952	0.067	2.914	73	0.005
Total Main Area					
BASE, γ_{10}	0.3529	0.0963	3.663	82	0.001
Sense of Arrival, γ_{11}	0.1001	0.0303	3.306	82	0.002
Number of Accessible Entrance, γ_{12}	0.0210	0.0066	3.168	82	0.003
The Number of Bathrooms					
BASE, γ_{20}	0.0537	0.0104	5.150	84	0.000
Porches					
BASE, γ_{30}	0.0090	0.0013	7.071	84	0.000
Building Age					
BASE, γ_{40}	-0.0066	0.0009	-7.775	84	0.000
Attached Garage					
BASE, γ_{50}	0.00133	0.0002	7.037	6,539	0.000
Sense of Arrival, γ_{51}	0.00004	0.0000	2.816	6,539	0.005
ln(Total Main Area group mean), γ_{52}	-0.00018	0.0000	-6.639	6,539	0.000
Attach to a Golf Course					
BASE, γ_{60}	0.1506	0.0134	11.242	6,539	0.000
Swimming Pool					
BASE, γ_{70}	0.0616	0.0043	14.414	6,539	0.000

The interpretation of both total main area and attached garage variables was complicated because of interaction terms. The ln(total main area group mean centered) variable should be interpreted with sense of arrival and number of accessible entrances variables [i.e., $\hat{\gamma}_{10} + \hat{\gamma}_{11}(\text{sense of arrival}) + \hat{\gamma}_{12}(\text{number of accessible entrances})$ = 0.353 + 0.100*sense of arrival + 0.021*number of accessible entrances]. The attached garage group mean centered variable should be interpreted with sense of arrival and ln(total main area group mean) variables [i.e., $\hat{\gamma}_{50} + \hat{\gamma}_{51}(\text{sense of arrival}) + \hat{\gamma}_{52}(\text{lnTMA\_GM})$ = 0.0013 + 0.00004*sense of arrival - 0.0002*ln (total main area group mean)]. For a 1% increase of the total main area of a single family house which was nested in a subdivision and had the mean value of the subdivision, if the subdivision had the sense of arrival value of 3 and had only one accessible entrance, the appraisal value of the house increased by 0.68% (= 0.353 + 0.100 * 3 + 0.021 * 1). For a square foot rise in the attached garage of a single family house which was nested in a subdivision and had the mean value of the subdivision, if the subdivision had the sense of arrival value of 3 and the mean total main area of 2,000 sqft, the appraisal value rose by 0.01% (= 0.00133 + 0.00004 * 3 - 0.00018 * ln(2,000) = 0.00133 + 0.00012 – 0.00137 = 0.00008).

Coefficients on the subdivision level variables in HLM were as expected. If a variable was related to intersection terms, the variable should be interpreted considering the intersection terms. The ln(median length of cul-de-sac) variable was related to the number of accessible entrances variable [i.e., $\hat{\gamma}_{02} + \hat{\gamma}_{010}(\text{the number of accessible entrances})$ = 0.0444 - 0.0099 * the number of accessible entrances]. The ln(median length of block) variable should be interpreted with the greenway connectivity variable [i.e., $\hat{\gamma}_{03} + \hat{\gamma}_{011}(\text{greenway connectivity})$ = -0.1364 + 0.1952 * greenway connectivity], and the number of accessible entrances variable was related to ln(median length of cul-de-sac) variable [i.e., $\hat{\gamma}_{04} + \hat{\gamma}_{010}(\text{Ln (median length of cul} - \text{de} - \text{sac}))$ = -0.0536 - 0.0099 * ln(median length of cul-de-sac)]. The greenway connectivity variable should be interpreted with both ln(total main area group mean) and ln(median length of block) variables [i.e., $\hat{\gamma}_{05} + \hat{\gamma}_{09}(\text{Ln (total main area group mean)}) + \hat{\gamma}_{011}(\text{Ln(median length of block)})$ = 1.7052 - 0.1999* ln(total main area group mean) + 0.1952* ln(median length of block),] and the ln(total main area group mean) variable was related to greenway connectivity variable [i.e., $\hat{\gamma}_{06} + \hat{\gamma}_{09}(\text{greenway connectivity})$ = 0.9643 - 0.1999 * greenway connectivity].

Let's imagine that a single family house was nested in a subdivision and had the mean value of the subdivision. For a unit rise in sense of arrival score on the 1 to 5 Likert scale (very low = 1, very high = 5) of the subdivision, the appraisal value of the house increased by 5.18%. For a 1% increase of the length of the median cul-de-sac of the subdivision, if the subdivision had three accessible entrances, the appraisal value of the house increased by 0.015% (= 0.0444 - 0.0099 * 3 = 0.015). For a 1% increase of the length of the median block of the subdivision, if the subdivision was not to be connected to any greenway trails, the appraisal value of the house decreased by 0.1364% (= -0.1364 + 0.1952 * 0). For a unit rise in the number of accessible entrances to the subdivision, if the subdivision had a length of median cul-de-sac of 0.01 miles, the appraisal value of the house decreased by 0.80% (= -0.0536 - 0.0099 * ln(0.01) = -0.0536 -0.0099 * -4.605 = -0.0080). If the subdivision was connected to any greenway trails and had a mean total main area of 2,000 square feet and a mean length of median block of 0.5 miles, the appraisal value of the house increased by 5.224% (= 100*(exp (1.7052-0.1999*ln(2000) + 0.1952 * ln(0.5))-1) = 5.177). For a 1% increase in the mean total main area of the subdivision, if the subdivision was connected to any greenway trails, the appraisal value of the house increased by 0.7644% (= 0.9643 – 0.1999 * 1). For a 1% increase in the mean number of bathrooms in the subdivision, the appraisal value of the house increased by 0.3937%. For a square feet rise of the mean attached garage of the subdivision, the appraisal value of the house increased by 0.03%.

$$T = \begin{bmatrix} Var(u_{0j}) & & & & \\ Cov(u_{1j}, u_{0j}) & Var(u_{1j}) & & & \\ Cov(u_{2j}, u_{0j}) & Cov(u_{2j}, u_{1j}) & Var(u_{2j}) & & \\ Cov(u_{3j}, u_{0j}) & Cov(u_{3j}, u_{1j}) & Cov(u_{3j}, u_{2j}) & Var(u_{3j}) & \\ Cov(u_{4j}, u_{0j}) & Cov(u_{4j}, u_{1j}) & Cov(u_{4j}, u_{2j}) & Cov(u_{4j}, u_{3j}) & Var(u_{4j}) \end{bmatrix} \quad [5\text{-}15]$$

$$= \begin{bmatrix} \tau_{00} & & & & \\ \tau_{10} & \tau_{11} & & & \\ \tau_{20} & \tau_{21} & \tau_{22} & & \\ \tau_{30} & \tau_{31} & \tau_{32} & \tau_{33} & \\ \tau_{40} & \tau_{41} & \tau_{42} & \tau_{43} & \tau_{44} \end{bmatrix} = \begin{bmatrix} 0.007 & & & & \\ 0.003 & 0.015 & & & \\ -0.001 & -0.001 & 0.003 & & \\ -0.000 & 0.000 & -0.000 & 0.000 & \\ -0.000 & -0.000 & -0.000 & -0.000 & 0.000 \end{bmatrix}$$

Due to the five level-2 random effects (u_{qj} in Equation 5-13,) the variances and covariances matrix can be measured (See Table 5-11). The matrix shows important information on the relationship among dependent variables and four independent variables - total main area, the number of bathrooms, porches, and building age - in the Intercepts- and Slopes-as-Outcomes Model.

First, the within-subdivision variability (σ^2) shows that the appraisal values of houses nested in a subdivision are not the same as the mean appraisal value of the subdivision. Second, τ_{00} shows that the intercepts of regression lines of 85 subdivisions are not the same as the intercept value of regression line of the overall model. Third, τ_{11}, τ_{22}, τ_{33}, and τ_{44} shows that the slopes of regression lines of 85 subdivisions are not the same as the slope of regression line of the overall model when the *appraisal value* was on the y-axis and *total main area, the number of bathrooms,* and *building age* were on the x-axis. Finally, τ_{10} shows that there is no correlation between intercepts and slopes of regression lines of all subdivisions when the appraisal value is on the y-axis and *total main area* is on the x-axis (See Table 5-11).

Table 5-11

Estimated Random Effects on the Intercepts- and Slopes-as-Outcomes Model

	Variance Component	D.F.	Chi-Square	Sig.
Mean Housing Value, τ_{00}	.0065***	64	4657.17396	.000
LN (Total Main Area_Centered) , τ_{11}	.0152***	73	447.78723	.000
LN (Bathroom_Centered) , τ_{22}	.0027***	75	118.47431	.001
LN (All Porches_Centered) , τ_{33}	.0000*	75	102.48997	.019
(Building Age_Centered) , τ_{44}	.0000***	75	677.39710	.000
Level-1 effect, σ^2	.0054***			

Correlation Among Subdivision Effects	Mean Housing Value	LN (Total Main Area_Centered)	LN (Bathroom_ Centered)	(All Porches_ Centered)
LN (Total Main Area_Centered)	τ_{10} = .0026			
LN (Bathroom_Centered)	τ_{20} = -.0013	τ_{21} = -.0012		
LN (All Porches_Centered)	τ_{30} = -.0001	τ_{31} = .0004	τ_{32} = -.0001	
(Building Age_Centered)	τ_{40} = -.0001	τ_{41} = -.0002	τ_{42} = -.0001	τ_{43} = -.0000

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

CHAPTER VI

DISCUSSION AND CONCLUSION

6.1 Discussion

6.1.1 Value Creation Concepts

The primary purpose of this study is to examine the effects of variables in the subdivision level, value creation concepts, on single family housing appraisal values. To achieve the purpose, two models – the Hedonic Price Model (HPM) and the Hierarchical Linear Model (HLM) - were used. Variables in the subdivision level as well as variables in the housing level are evaluated based on the results of both methodologies.

6.1.1.1 Sense of Arrival

It is hard to find research about the effects of the *sense of arrival* on single family housing values. To evaluate the average score of the subdivision entrance's scenic quality, the scenes in photographic slides were used. Scores for each scene, which were obtained from participants, were used for examination of the sites (Buhyoff et al., 1982; Yamashita, 2002; Tunstall et al., 2004).

Sixty-one graduate students in the College of Architecture at Texas A&M University participated in evaluating photographs of 85 subdivision entrances. The students scored each entrance scene by assigning a sense of entrance rating number between 1 and 5. The *sense of arrival* variable consisted of the mean values of sixty-one students' scores on each picture, and the variable was included in both HPM and HLM. Ninety percent of the participants are white (twenty-seven students) or Asian (twenty-eight students).

Table 6-1

Coefficient of Sense of Arrival Characteristics

Variable	Race	HPM	HLM
Sense of Arrival	**All (61 students)**	**.0571*****	**.0518***
	White (27 students)	**.0420*****	**.0410***

Note. * p<.05, ** p<.01, *** p<.001

The *sense of arrival* variable shows a positive relationship with the housing appraisal value as expected, and was statistically significant in both models.

For a unit increase in the *Sense of Arrival* score, the average appraisal value of houses increased by 5.7% in HPM and 5.2% in HLM, respectively. The mean appraisal value of all 6,562 single family houses was $177,800. For example, a house valued at $177,800 was in a subdivision whose value of *sense of arrival* score was 3. If the subdivision had the value of a *sense of arrival* score of 4, the housing value would increase by $9,250 (= 177,800 * 0.052), other things being constant.

According to the "College Station Demographic Report, 2002", about three fourths of the population in College Station in 2000 was white; on the other hand, only about 6% of the population was Asian (College Station, 2002b). However, a large portion of sixty-one students who participated in the survey were Asian as well as white. From Table 6-2, white students gave lower scores for entrance scenes than all students. To compare the means of *sense of arrival* scores for two groups--all students and white students--the paired-samples t-test procedure was conducted (See Table 6-3). The result of the t-test shows that the mean score of white students was lower than the mean score of all students.

Table 6-2

Comparison Means of Sense of Arrival Scores of White and All Students

	Minimum	Maximum	Mean	Std.Dev.
White (27 students)	1.54	4.98	2.66	.664
All (61 students)	1.82	4.27	2.80	.540

When the mean value of white students was used for the *sense of arrival* variable, the coefficients of the *sense of arrival* variable in HPM and HLM became lower (See Table 6-1). For a unit increase of the *sense of arrival* score of white students, the average appraisal value of houses increased by 4.2% in HPM and 4.1% in HLM, respectively. For example, a house valued at $177,800 in a subdivision with a value of a *sense of arrival* score of 3, if the subdivision had a value of *sense of arrival* score of 4, the housing value would increase by $7,300 (= 177,800 * 0.041), other things being constant.

Table 6-3

Paired-samples t-test with Sense of Arrival Scores of White and All Students

				95% Confidence Interval				
Pair	Mean	Std.Dev.	Std.Err.	Lower	Upper	t	d.f.	Sig.
White – All	-.146	.194	.021	-.188	-.104	-6.949	84	.000

6.1.1.2 Product Mix

Song and Knaap (2003) argue that negative relationships exist between the single family housing values and the *Land Use Mix* when the land use mix includes single-family residential as well as other land uses (multi-family residential, industrial, public, and commercial uses.) Next, low single family density means each single family house has a large space; hence, there will be a negative relationship between the single family density and housing value. Finally, there will be a negative relationship between phased development and housing value. Forty five subdivisions of 85 subdivisions in College Station, Texas, are developed in only one phase. The average size of one phase developed subdivisions (50.3 hectares) is much larger than the average size of more than 2 phased developed subdivisions (13.6 hectares). The size of recently developed subdivisions is larger than the size of older subdivisions, and the recently developed subdivisions are located on the south-east side of College Station.

Table 6-4
Coefficients of Product Mix Characteristics

Variable	HPM	HLM
LN (Single Family Density)	**-.0255*** **	Not Significant
Land Use Mix Index	Not Significant	Not Significant
Phased Project	**-.0414*** **	Not Significant

Note. * p<.05, ** p<.01, *** p<.001

Single family density and phased project variables in product mix characteristics were statistically significant in HPM. The two variables showed a negative relationship with housing appraisal values as expected (See Table 6-4). On the other hand, no variables in product mix characteristics were statistically significant in HLM.

For a 1% increase in *single family density*, the average appraisal value of houses decreased by 0.03%. For example, a house of $177,800 was in a subdivision with 100 single family houses per hectare in a residential area. If the subdivision had one more house, the housing value would decrease by $54 (= 177,800 * 0.0003), other things being constant. This result can be explained by the fact that the more single family houses in a subdivision, the smaller size lot each house had.

Table 6-5

Correlation between Appraisal Value and Continuous Phased Projects

		Appraisal
Sale	Pearson Correlation	-.090**
	Sig. (2-tailed)	.000
	N	6562

** Correlation is significant at the 0.01 level

The *phased project* variable in this research was a dummy variable. Because this dummy variable was statistically significant in HPM, the dummy variable was used instead of original continuous variable. It is not meaningful to measure the correlation coefficient between a dependent variable and a dummy variable. Hence, to calculate the correlation coefficient between appraisal value and the phased project, the original continuous phased project variable was used. In Table 6-5, there was negative relationship between the appraisal value and the continuous phased project variable. The correlation coefficient (-0.090) was statistically significant with .05 of p-value. In Table 6-6 and Figure 6-1, it was clear that the negative relationship was caused by subdivisions with more than sixteen phases. Mean housing appraisal values in subdivisions with two to fifteen phases were larger than the mean values in subdivisions with only one phase. Even though mean values in subdivisions with six, eight, and twelve phases showed low, it could not be important because of the small number of houses in these subdivisions (See Table 6-6). The number of houses in subdivisions with more than sixteen was about a quarter of the number of total single family houses.

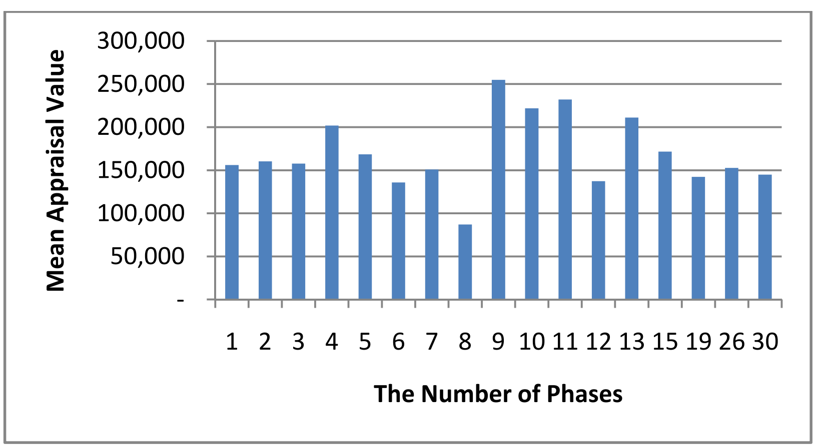


Figure 6-1. Mean Appraisal Values versus the Number of Phases.

Table 6-6

Mean Appraisal Values in Subdivision with the Number of Phases and Total Number of Houses in the Subdivisions

Phase	Mean Appraisal Value	The Number of Houses
1	**156,007**	**1,329**
2	160,339	345
3	157,787	423
4	201,840	106
5	168,455	441
6	**135,727**	**58**
7	150,848	148
8	**87,070**	**13**
9	254,842	857
10	221,901	299
11	232,077	290
12	**137,302**	**34**
13	211,098	286
15	171,538	474
19	**142,277**	**405**
26	**152,718**	**146**
30	**144,939**	**908**

The expected appraisal value for a house in a subdivision with more than one phase was 4.1% lower than the appraisal value for a house in a subdivision with only one phase. For example, if a house valued at $177,800 was in the Woodland Hills subdivision with only one phase, the value of another house in the Westfield subdivision with two or more phases would be $7,300 lower than the house in the Woodland Hills subdivision, other things being constant.

6.1.1.3 Walkability

It was hard to find any literature about the relationships between walkability factors and single family housing values; however, several papers showed walkability variables to encourage more physical activities (walking) such as the continuous sidewalk and bike route system, fewer dead-ends, and smaller blocks (Handy, 1996; Cervero and Kockelman, 1997; Hess et al., 1999; Randall and Baetz, 2001; Moudon and Lee, 2003; Saelens et al., 2003). In addition Song and Knaap (2003) argue that single family housing values rise with smaller block size in the neighborhood. Moreover, a few researchers found that cul-de-sacs generated about a 30% price premium over houses compared to grid street patterns (Asabere, 1990; Song and Knaap, 2003).

Hence, it would be expected that *sidewalk connectivity*, *bike-lane connectivity* variables, and *median length of cul-de-sac* may have a positive relationship with housing value. On the other hand, *median length of block* may have a negative effect on housing value.

Among walkability characteristics, *sidewalk connectivity* and *median length of block* variables in HPM, and *median length of cul-de-sac* and *median length of block* variables in HLM were statistically significant. *Sidewalk connectivity* showed a positive relationship with housing appraisal value, and the *median length of cul-de-sac* variable showed a negative relationship with the housing appraisal value in HPM. The mean number of accessible entrances of the subdivisions was about four, and the mean value of *greenway connectivity* was about 0.6. Based on these mean values, on average, the *median length of cul-de-sac* showed positive relationship with housing value (i.e., 0.044-

0.01*4 = 0.004), and the *median length of block* variable showed a negative relationship with housing value (i.e., -0.136 +0.195*0.6 = -0.019) in HLM.

Table 6-7

Coefficients of Walkability Characteristics

Variable	HPM	HLM
LN (Sidewalk Connectivity)	**.0116*** **	Not Significant
LN (Bike-Lane Connectivity)	Not Significant	Not Significant
LN (Median Length of Cul-De-Sac)	Not Significant	**0.044 - 0.001*ACCENT *** **
LN (Median Length of Block)	**-.0474*** **	**-0.136 + 0.195*GRECON *** **

Note. * p<.05, ** p<.01, *** p<.001

However, the *median length of cul-de-sac* and *median length of block* variables in HLM should be interpreted carefully for each subdivision. If a subdivision had less than five accessible entrances, there would be a positive relationship between the *median length of cul-de-sac* and housing value in the subdivision; however, if the subdivision had equal or more than five accessible entrances, there would be a negative relationship between housing values and the *median length of cul-de-sac*. In view of the *median length of blocks*, if a subdivision was connected to any greenway trails, there would be a positive relationship between housing values and the *median length of block*, and vice versa.

For a 1% increase in the *sidewalk connectivity* ratio of a subdivision, the average appraisal value of a house nested in the subdivision increases by 0.01%. For example, a house valued at $177,800 was in a subdivision with 0.01miles of sidewalk per one mile street. If the subdivision had 0.02 mile of sidewalk per 1 mile street, the housing value would increase by $1,780 (= 177,800 * 0.01), other things being constant. According to some of the literature, sidewalk and bike route systems encourage more physical activities (Handy, 1996; Cervero and Kockelman, 1997; Hess, 1999; Randall and Baetz, 2001; Moudon and Lee, 2003; Saelens et al., 2003). In addition, the result of the final HLM shows that *sidewalk connectivity* increases housing value as well (See Table 6-7). However, *bike-lane connectivity* did not show any relationship with housing value, even though literature shows that there was a positive relationship between *bike-lane connectivity* and physical activity.

For a 1% increase of the *median length of cul-de-sac* of a subdivision, if the subdivision had four accessible entrances, the appraisal value of a house, which was nested in the subdivision and had the mean value of the subdivision, increased by 0.004% (= 0.044 - 0.01 * 4). For example, a house valued at $177,800 was in a subdivision with a *median length of cul-de-sac* of 0.01 miles and four accessible entrances. If the subdivision had 0.0101 miles of the *median length of cul-de-sac*, the housing value would increase by $7 (= 177,800 * 0.00004), other things being constant. Because a few researchers found that cul-de-sacs generated about a 30% price premium over houses compared to grid street patterns (Asabere, 1990; Song and Knaap, 2003), it was expected that there was positive relationship between housing values and the *median length of cul-de-sac*.

Finally, for a 1% increase of the *median length of block* of a subdivision, if the subdivision had an average connection rate of 0.6 to greenway trails, the appraisal value of a house, which was nested in the subdivision and had the mean housing value of the subdivision, decreased by 0.019% (= -0.136 + 0.195 * 0.6). For example, a house valued at $177,800 was in a subdivision with the *Median Length of Block* of 1 mile and had the average connection rate of 0.6 to any greenway trails. If the subdivision had 1.01 miles of the *median length of block*, the housing value would decrease by $34 (= 177,800 * 0.00019), other things being constant. The result would be similar to the result of a study by Song and Knaap (2003).

6.1.1.4 Circulation System

Several studies showed the relationships between circulation system characteristics and single family housing values. Circulation system characteristics are related to street design with nodes, street lengths, and cul-de-sac. Song and Knaap (2003) show that single family housing values rise with the length of streets, and the fewer number of street nodes in the neighborhood. Some research found that cul-de-sacs generated about a 30% price premium over houses compared to grid street patterns (Asabere, 1990; Song and Knaap, 2003). Moreover, relatively new developed subdivisions had fewer accessible entrances than old subdivisions, and a few recently developed subdivisions had only one accessible entrance as a gated community (Region "C" in Figure 2-3) in College Station. Hence, it would be expected that street density and cul-de-sac density variables might have a positive relationship with housing value. On the other hand, intersection density, 4-way intersections, node connectivity, and accessible entrance variables might have negative effects on housing value.

In the circulation system characteristics, the street density variable and the accessible entrance variable were statistically significant in HPM, and the accessible entrance variable was statistically significant in HLM (See Table 6-8). The accessible entrance variable had negative relationship with appraisal value, as was expected. On the other hand, in contrast to the result of the study by Song and Knaap (2003), single family housing values rise with lower street density in the subdivision. The street density variable might be related to street patterns in the city of College Station. In general, older subdivisions have grid street patterns and small blocks (Region "A" in Figure 2-3) and recently developed subdivisions have curved street patterns and large blocks (Region "C" or "D" in Figure 2-3) in the city of College Station. The average appraisal value of recently developed subdivisions is higher than the value of older subdivisions.

It was expected that *intersection density*, *4-way intersection*, and *node connectivity* variables would have negative effects on housing value, and the *cul-de-sac density* variable would have a positive effect on housing value. However, these four variables were not significant in two models.

For a one percentage increase in street density, the average appraisal value dropped by 41.9%. For example, a house valued at $177,800 was in a subdivision with

0.07 miles of streets per hectare. If the subdivision had 0.08 miles of streets per hectare, the housing value would decrease by $745 (= 177,800 * 0.0042), other things being constant.

Table 6-8

Coefficients of Circulation System Characteristics

Variable	HPM	HLM
Street Density	**-.4189*** **	Not Significant
Intersection Density	Not Significant	Not Significant
LN (Cul-De-Sac Density)	Not Significant	Not Significant
4-way intersection	Not Significant	Not Significant
Node Connectivity	Not Significant	Not Significant
The Number of Accessible Entrances	**-.0024*** *	**-0.0536 - 0.010*lnMEDCUL *** **

Note. * p<.05, ** p<.01, *** p<.001

For one more accessible entrance to a subdivision, if the subdivision had the mean value of the *median length of cul-de-sac* of 0.014, the appraisal value of a house, which was nested in the subdivision and had the mean housing value of the subdivision, decreased by 1.09% (= -0.0536 -0.01 * ln(0.014) = -0.0536 + 0.043). For example, a house valued at $177,800 was in a subdivision which had four accessible entrances and the *median length of cul-de-sac* was 0.014 miles. If the subdivision had five accessible entrances, the housing value would decrease by $1,940 (= 177,800 * 0.0109), other things being constant.

6.1.1.5 Amenity

In this study, amenity characteristics were mainly related to park and greenway connections. Quite a few papers show that parks and open spaces have positive effects on single family housing values (Lyon, 1972; Hammer et al., 1974; Palmquist, 1980; More et al., 1982; Frech and Lafferty, 1984; Bolitzer and Netusil, 2000; Buffington, 2000; Crompton, 2000; Lutzenhiser and Netusil, 2001; Geoghegan, 2002; Irwin, 2002; Crompton, 2005).

Table 6-9

Coefficients of Amenity Characteristics

Variable	HPM	HLM
Park Connectivity	Not Significant	Not Significant
Greenway Connectivity	Not Significant	**1.7052 - 0.1999*lnTMA_GM + 0.1952*lnMEDBLO** *

Note. * p<.05, ** p<.01, *** p<.001

The greenway connectivity variable in amenity characteristics was statistically significant in HLM; however, park connectivity was not statistically significant in both models (See Table 6-9). The mean total main area of subdivisions was about 2,000 square feet, and the mean of median length of blocks was 0.5 miles. Based on these mean values, it could be said that greenway connectivity had a positive effect on housing value on average (i.e., 1.7052-0.1999 * ln(2000) + 0.1952 * ln(0.5) = 0.051).

If a subdivision, which has a mean total main area of 2,000 square feet and the mean of the median length of block of 0.5 miles, was connected to greenway trails, the appraisal value of a house which was nested in the subdivision would increased by 5.177% (= 100 * (exp (1.7052 - 0.1999 * ln(2000) + 0.1952 * ln(0.5))-1) = 5.177). For example, a house valued at $177,800 was in a subdivision with the mean total main area of 2,000 square feet and with the mean of the median length of block of 0.5 miles. If the subdivision was connected to greenway trails, the housing value would increase by $9,000 (= 177,800 * 0.05048), other things being constant.

6.1.2 Housing Level Characteristics

To study the effects of housing level variables on single family housing values would show useful information, even though it is not the primary purpose of this study. Each variable is evaluated with both HPM and HLM methodologies.

6.1.2.1 Structural Characteristics

Structural characteristics relate to the characteristics of a house itself, such as the number of bedrooms, the number of bathrooms, garage size, main area, lot size, age of the building in years, swimming pool, stories, and so on. In general, these variables are positively related to the single family housing price except the age of the building in years (Weicher and Zerbst, 1973; Palmquist, 1980; Gillard, 1981; Rodriguez and

Sirmans, 1994; Do and Grudnitski, 1995; Lutzenhiser and Netusil, 2001; Simon et al., 2001; Geoghegan, 2002; Irwin, 2002; Pompe and Rinehart, 2002; Grudnitski, 2003; Song and Knaap, 2003).

Table 6-10

Coefficients of Structural Characteristics

Variable	HPM	HLM
The number of Bedrooms	Not Significant	Not Significant
LN (The Number of Bathrooms)	Not Significant	**0.054*** **
LN (Total Main Area)	**.9105*** **	**0.353 + 0.100*SENOFARR + 0.021*ACCENT *** **
Attached Garage	**.0001*** **	**0.0013 + 0.00004*SENOFARR + 0.0002*TMA_GM *** **
LN (All Porches)	**.0146*** **	**.009*** **
Sold Year	Not Significant	Not Significant
Building Age	**-.0059*** **	**-.0066*** **
2^{nd} Floor	Not Significant	Not Significant
Swimming Pool	**.0710*** **	**.0616*** **

Note. * p<.05, ** p<.01, *** p<.001

Some variables in structural characteristics were significant in one model and not the other. It could be explained by the assumptions and equations of the two models. The HPM was calculated assuming that there was no hierarchical difference among variables. Hence, the HPM consisted of only one equation (See Equation 5-2). On the other hand, the Hierarchical Linear Model (HLM) was calculated assuming that there was a hierarchical difference among variables. The HLM consisted of more than two equations, and a combined model was made with the equations (See Equations 5-12, 5-13, and 5-14). The HLM included several interaction terms between housing level variables and subdivision level variables, or among subdivision level variables themselves.

Total main area, attached garage, all porches, building age, and *swimming pool* variables were statistically significant in both HPM and HLM (See Table 6-10). The *Bathrooms* variable was statistically significant in only HLM. All significant variables had a positive relationship with appraisal value except the built age variable.

Contrary to expectation, the number of bedrooms variable was not statistically significant; however, it was not an extraordinary result, for several models in the literature only included the main area (living area) variable without the number of bedrooms or bathrooms (Benson et al., 2000; Mooney, 2001; Colby and Wishart, 2002; Rosiers et al., 2002). Next, it was reasonable that the sold year variable was not statistically significant, for the dependent variable was not sale value but appraisal value. Finally, the second floor dummy variable was not significant in any models. This might be explained by a multicollinearity problem. Even though the correlation between the second floor variable and total main area variable did not have any meaning because the second floor variable was a dummy variable, it was clear that houses with a 2nd floor had a large total main area (See Table 6-11).

For a 1% increase of the total main area of a single family house which was nested in a subdivision and had the mean value of the subdivision, if the subdivision had the sense of arrival value of 3 and had four accessible entrances, the appraisal value of the house increased by 0.74% (= 0.353 + 0.100 * 3 + 0.021 * 4). For example, a house valued at $177,800 was nested in a subdivision which had the sense of arrival value of 3 and had four accessible entrances. The total main area of the house was 2,000 square feet. If the house had total main area of 2,020 square feet, the housing value would increase by $1,300 (= 177,800 * 0.0074), other things being constant.

Table 6-11

Mean Total Main Area versus 2nd Floor

2nd Floor	# of House	Mean Total Main Area
0	6,017	171,308.0256
1	575	248,757.1009

For a 1% increase of the porch size of a single family house which was nested in a subdivision and had the mean value of the subdivision, the appraisal value of the house increased by 0.01%. For example, the porch area of a house valued at $177,800 was 150 square feet. If the house had a porch area of 151.5 square feet, the housing value would increase by $16 (= 177,800 * 0.00009), other things being constant.

For a 100% increase of the number of bathrooms of a single family house which was nested in a subdivision with the median length of block of 0.5 miles, the appraisal value of the house increased by 5.4%. For example, a house valued at $177,800 with one bathroom was nested in a subdivision with the median length of block of 0.5 miles. If the house had two bathrooms, the value of the house would increase by $9,600 (= 177,800 * 0.054), other things being constant.

For a square foot rise in the attached garage of a single family house which was nested in a subdivision and had the mean value of the subdivision, if the subdivision had the sense of arrival value of 3 and the mean total main area of 2,000 square feet, the appraisal value rose by 0.01% (= 0.00133 + 0.00004 * 3 - 0.00018 * ln(2,000) = 0.0001). For example, if the attached garage area of the house was 410 square feet, the housing value would increase by $180 (= 177,800 * 0.001), other things being constant.

The expected appraisal value for a house with a swimming pool was 6.35% (= 100 * (exp(0.0616) -1) = 6.35) higher than the appraisal value for a house without a swimming pool. For example, a house valued at $177,800 had a swimming pool. If the house did not have a swimming pool, the housing value would decrease by $11,600 (= 177,800 * 0.0635), other things being constant.

On the other hand, for a year rise in building age, the appraisal value dropped by 0.66%. For example, the age of a house valued at $177,800 was nineteen years. If the age of the house was twenty years, the housing value would decrease by $1,170 (= 177,800 * 0.0066), other things being constant.

6.1.2.2 Locational Characteristics

Several papers show the negative relationships between the single family housing values and the geographic distance from amenities such as parks, open spaces, golf courses or greenways, shopping centers, churches, highways, elementary public schools, and CBD (Central Business Districts) (Lyon, 1972; Hammer et al., 1974; Palmquist, 1980; More et al., 1982; Jud, 1985; Hirsh, 1994; Do and Grudnitski, 1995; Buffington, 2000; Crompton, 2000; Rosiers et al., 2001; Simons et al., 2001; Geoghegan, 2002; Irwin, 2002; Grudnitski, 2003; Crompton, 2005).

Attached to a golf course, sport facilities, and network distance from nearest elementary school variables in locational characteristics were statistically significant in HPM; however, only attach to a golf course variable in locational characteristics was statistically significant in HLM (See Table 6-12). It could be explained by the assumptions and equations of HLM as well; that is, locational variables except the attach to a golf course variable was not statistically significant after considering variables in the subdivision level.

Table 6-12

Coefficients of Locational Characteristics

Variable	HPM	HLM
Attach to Golf Course	**.1763*** **	**.1506*** **
Attach to the nearest Park	Not Significant	Not Significant
Across to a Park	Not Significant	Not Significant
On Cul-De-Sac	Not Significant	Not Significant
On Corner	Not Significant	Not Significant
Park Size	Not Significant	Not Significant
Parking Lots in the nearest park	Not Significant	Not Significant
Total Facilities	Not Significant	Not Significant
Total Lighted Facilities	Not Significant	Not Significant
Sports Facilities	**.0012*** **	Not Significant
Lighted Sports Facilities	Not Significant	Not Significant
Network Distance from School	**-.0264*** **	Not Significant
Network Distance from TAMU	Not Significant	Not Significant
Network Distance from Park	Not Significant	Not Significant

Note. * p<.05, ** p<.01, *** p<.001

As was expected, *attach to a golf course* and *sport facilities* variables showed positive relationships with housing appraisal value, and *network distance from the nearest elementary school* variable had a negative relationship with appraisal value.

Even though the results of a few papers showed the negative effects of facing heavily-used park facilities on single family housing values (Weicher and Zerbst, 1973; Li and Brown, 1980; More et al, 1982, Crompton, 2000), attach-to-a-park and across-to-a-park were not significant. The reason why the two dummy variables were not significant in two models could be found from the small number of houses which are located in attach to a park or across a road to a park. Only 130 houses were attached to a park and 118 houses were across a road to a park among 6,562 houses.

Next, cul-de-sac and corner lot dummy variable were not significant as well, although a few papers showed their positive effects on housing value (Asabere, 1990; Song and Knaap, 2003). This might be explained from street patterns of old subdivisions. First, the cul-de-sac variable showed negative relationships with two variables – sports facilities, and network distance from school. A lot of houses on cul-de-sac in Region "A" attached to a park (See Figures 2-3 and 2-4), and the older subdivisions had relatively small parks, the number of park facilities of the parks were fewer. Hence, the number of sports facilities in the nearest park from houses on cul-de-sac was small (See Table 6-13). Moreover, the network distance from houses on a cul-de-sac to the nearest elementary school would be long (See Table 6-13). Second, grid patterns cause a lot of corner lots. Old subdivisions had grid street patterns and small blocks (Region "A" in Figure 2-3).

Because of these reasons, cul-de-sac and corner lot dummy variable might not be statistically significant.

Six park-related variables (*park size, the number of parking lots, total number of park facilities, lighted park facilities, total number of sport facilities,* and *lighted sport facilities*) were very highly correlated (See Table 5-3). Among them, only the sport-facility variable was statistically significant. It would be reasonable that only one variable among the six park-related variables was significant in the final models, considering the multicollinearity problem among the six variables.

Generally, a center-facility in the study area was selected to measure locational characteristics of houses (e.g. the distance from City Hall in Houston). For this research, the nearest entrances to Texas A&M University were used, because the city of College Station is a campus town. However, the network distance from TAMU variable was not statistically significant. It might be explained by the fact that the city of College Station is too small to consider any centered facility for controlling the locational relationship with all houses in the city. Next, the reason why the distance from the nearest park was not significant in two models could be explained with the distribution of parks and the geographical relationship between parks and subdivisions in older areas. In older districts around Texas A&M University, several subdivisions are attached to or across a road from a park, and the mean value of houses in the older subdivisions was relatively low. Moreover, about two thirds of the parks are in the older districts. The effects of the network distance from the nearest park might conflict over both old and new subdivisions (See Figures 2-3 and 2-4).

Table 6-13

Cul-de-Sac vs Sports Facilities vs Network Distance from the Nearest Elementary School

Cul-De-Sac	# of Sport Facilities	Network Distance from School (mile)
0	5.0	1.20
1	3.5	1.38

For a unit rise in sport facilities in the nearest park, the appraisal value rose by 0.1%. For example, the number of sport facilities in the nearest park from a house valued at $177,800 was 5. If the number of sport facilities of the park was 6, the housing value would increase by $180 (= 177,800 * 0.001), other things being constant.

For a mile rise in network distance from the nearest elementary school, the appraisal value dropped by 0.12%. For example, the network distance from the nearest elementary school from a house valued at $177,800 was one mile. If the network distance from the school was two miles, the housing value would decrease by $220 (= 177,800 * 0.0012), other things being constant.

The expected appraisal value for a house abutting a golf course was 16.25% (= 100 * (exp(0.1506) - 1)) higher than the appraisal value for a house which was separated from any golf courses. For example, a house valued at $177,800 was abutting a golf course. If the house was not abutting the golf courses, the housing value would decrease by $28,900 (= 177,800 * 0.1625), other things being constant.

6.1.2.3 Neighborhood Characteristics

Neighborhood characteristics are related to socio-economic characteristics of neighboring residents, such as quality of neighboring structures, median income of a block group, population density in a block group, crime and vandalism, and percent of individuals in a block group with a bachelor's degree. African-American, poverty, population density, and crime variables have a negative relationship with single family housing values; on the other hand, median income and education variable show a positive relationship with residential sales price (Li and Brown, 1980; Palmquist, 1980; Gillard, 1981; Simons et al., 1998; Ding et al., 2000; Geoghegan, 2002; Irwin, 2002).

Population density, income, tenure (ratio of rental houses), workable age (over 20 years old), and employment variables in neighborhood characteristics are statistically significant in HPM; however, no variables in neighborhood characteristics were statistically significant in HLM (See Table 6-14). This might be explained by different geographic boundaries of subdivisions and neighborhoods as well as the assumptions and equations of HLM. The neighborhood variables were not statistically significant after considering variables in the subdivision level in Equation 5-13. Moreover, the neighborhood attributes were measured on the basis of census tracks/ block group/ block which were not exactly equal to the subdivision boundaries (See Figure 1-1). In HLM, each house was nested in a subdivision; that is, houses were considered as units in any corresponding subdivisions. However, houses within the same census unit should have the same scores for neighborhood variables, and each census unit existed over several subdivisions. This geographical confusion might cause the neighborhood variables to not be statistically significant in HLM.

Income, workable age, and employment variables showed a positive relationship with housing appraisal value. On the other hand, population density and tenure variables had a negative relationship with appraisal value, as was expected.

The city of College Station is a campus town. Large numbers of residents are students or faculty. Hence, the reason the education variable was not significant in two models could be explained by the population characteristics of the city of College Station.

For a million dollar rise in income, the appraisal value rose by 24.6%. For example, the mean income of a census block which included a house valued at $177,800 was $0.18M. If the mean income became $0.19M, the housing value would increase by $440 (= 177,800 * 0.00246), other things being constant. For a percentage rise in employment, the appraisal value rose by 24.7%. For example, the mean employer ratio of a census block which included a house valued at $177,800 was 50%. If the mean employer ratio became 51%, the housing value would increase by $ 44,000 (= 177,800 * 0.247), other things being constant. For a percentage rise in workable age (ratio of over 20 years old to population), the appraisal value rose by 6.3%. For example, the mean workable person ratio of a census block which included a house valued at $177,800 was 50%. If the mean workable person ratio became 51%, the housing value would increase by $11,200 (= 177,800 * 0.063), other things being constant.

Table 6-14

Coefficients of Neighborhood Characteristics

Variable	HPM	HLM
LN (Population Density)	**-.0025****	Not Significant
Income	**.2461*****	Not Significant
Tenure	**-.0371*****	Not Significant
Work Age	**.0631*****	Not Significant
Employment	**.2454*****	Not Significant
Education	Not Significant	Not Significant

Note. * p<.05, ** p<.01, *** p<.001

Whereas, for a 1% increase of population density of a census block including the single family house, the average appraisal value of houses decreased by 0.003%. For example, the mean population per hectare of a census block which included a house valued at $177,800 was twenty. If the mean population per hectare became twenty-two, the housing value would decrease by $40 (= 177,800 * 0.0003), other things being constant. For a percentage rise in tenure (ratio of rental houses to occupied houses), the average appraisal value of houses decreased by 3.7%. For example, the mean rental housing ratio of a census block which included a house valued at $177,800 was 20%. If the mean rental housing ratio became 21%, the housing value would decrease by $6,600 (= 177,800 * 0.037), other things being constant.

6.1.3 Summaries

From the results of HPM and HLM, it is clear that nine hypotheses of sixteen were statistically significant (See Figure 6-2). Among the nine hypotheses, sense of arrival, sidewalk connectivity, median length of cul-de-sac, and greenway connectivity variables had positive effects on housing value.

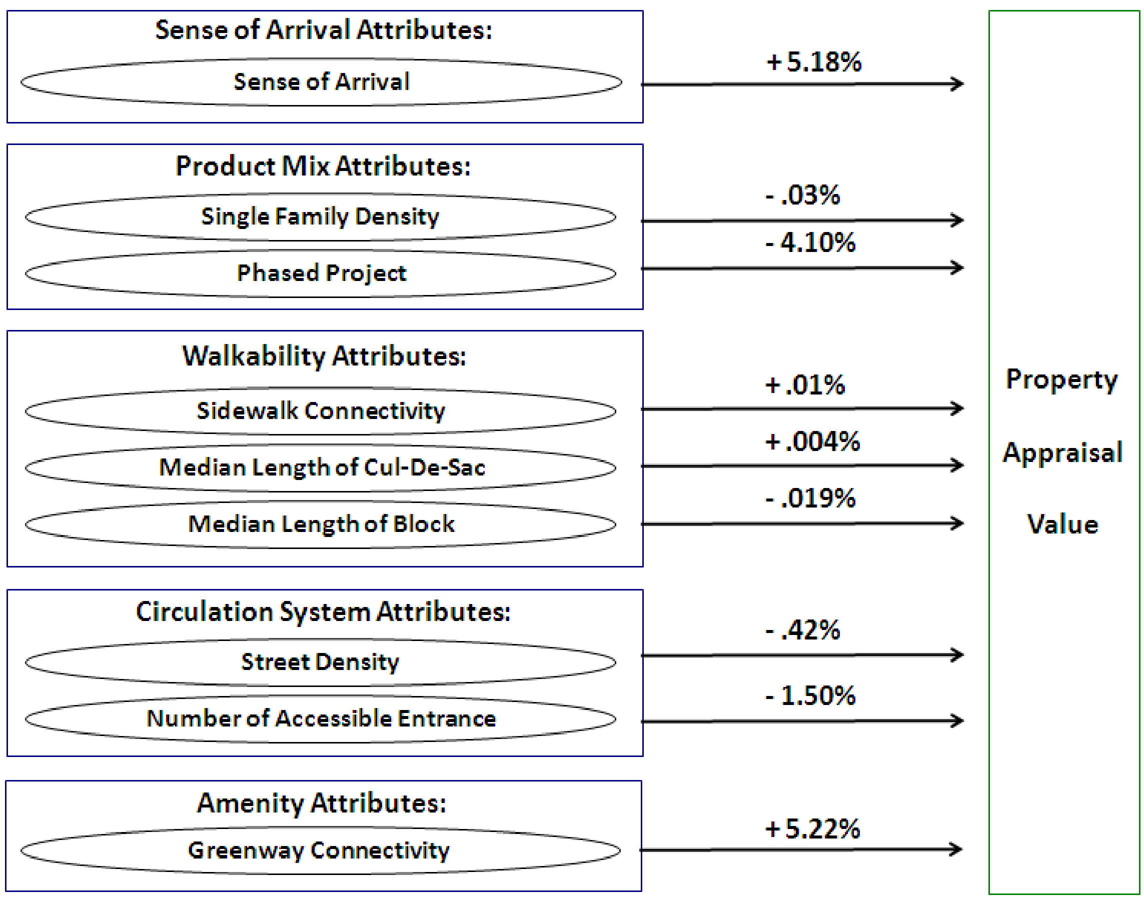


Figure 6-2. Statistically Significant Hypotheses in Either HPM or HLM.

Table 6-15

Summaries of Significant Factors and Variables

Level	Factor	Variable	Direc-tion of Effect	% Change	$ Change for $177,800 house	Note	Prio-rity
Sub-division	Sense of Arrival	**Sense of Arrival**	+	**5.18 % (4.10%)**	**$9,000 ($7,300)**	U	2
	Product Mix	Single Family Density	-	0.03%	$54	P	6
		Phased Project	-	4.10%	$7,300	D	3
	Walkability	Sidewalk Connectivity	+	0.01%	$19	P	8
		Median Length of Cul-De-Sac	+	0.004%	$7	P	9
		Median Length of Block	**-**	**0.019%**	**$33**	P	7
	Circulation System	Street Density (0.01mile / hectare)	-	0.42%	$745	U	5
		Num. of Accessible Entrance	**-**	**1.50%**	**2,700**	U	4
	Amenity	Greenway Connectivity	+	5.22%	$9,300	D	1
Housing	Structural	Number of Bathrooms	+	0.054%	$96	P	
		Total Main Area	+	0.74%	$1,300	P	
		Attached Garage	+	0.01%	$18	U	
		All Porches	+	0.009%	$16	P	
		Building Age	-	0.66%	$1,170	U	
		Swimming Pool	+	6.35%	$11,600	D	
	Locational	Attach to Golf Course	+	16.25%	$28,900	D	
		Sports Facilities	+	0.10%	$180	U	
		Network Dist. from School	-	0.12%	$220	U	
	Neighbor-hood	Population Density	-	0.003%	$4	P	
		Income ($1,000)	+	0.025%	$44	U	
		Tenure	-	3.70%	$6,600	U	
		Workable Age	+	6.30%	$11,200	U	
		Employment	+	24.70%	$44,000	U	

Assume: 1) The value of a house in a subdivision is $177,800
2) The subdivision has an average connection rate of 0.6 to greenway trails
3) The subdivision has four accessible entrances
4) The subdivision has the mean value of median length of cul-de-sac of 0.014 miles
5) The subdivision has the mean value of median length of block of 0.5 miles
6) The subdivision has a mean value of total main area group mean of 2,000 square feet
7) The subdivision has a mean value of a sense of arrival score of 3
8) Figures in parenthesis in sense of arrival refer to changes for whites (twenty-seven students)
9) The percentage or dollar changes of variables, which were statistically significant in both the HPM and the HLM, were gathered from the result of the HLM (**Bold** Characters)

Note: P: % change of housing value for a 1% change of the variable
U: % change of housing value for one unit change of the variable
D: % change of housing value when the variable exists (dummy variable)

Priority: Priority order of value creation concepts for developers based on % and $ changes

In Table 6-15, priority of the nine value creation concepts were identified based on the dollar change for $177,800 as well as the percentage change of the nine value creation concepts. In Figure 6-2 and Table 6-15, the percentage or dollar changes of variables, which were statistically significant in both the HPM and the HLM, were gathered from the result of the HLM. *Greenway connectivity* and *sense of arrival* variables had higher than 5% change or higher than $9,000 per one percent or one unit change. Next, *phased project* and the *number of accessible entrances* variables had higher than 1% change or higher than $2,000 per 1% or one unit change.

Finally*, street density*, *single family density*, *median length of block*, *sidewalk connectivity*, and *median length of cul-de-sac* variables had lower than 1% change or lower than $2,000 per 1% or one unit change.

6.2 Study Limitations

First, the results from this research are limited to College Station, Texas, or to similar sized and characterized campus towns in Texas. Second, GIS data and U.S. Census data can be inaccurate sources for this research. In general, the GIS data are not frequently updated so that the GIS data used in this study may reflect past situations. In addition, the only U.S. Census data that could be used are for the year 2000.

Finally, appraisal value is used as a proxy of real sale data. The sale value of the Brazos County Multiple Listing Services (BCMLS) for each house is much better than the appraisal value of the house. The use of appraisal value has been a drawback to the research for three reasons: 1) time lag, 2) lack of housing market information, and 3) systematic assessment error. Because of recent government legislation, the sales data that BCAD maintains is no longer available for public use (See Appendix 4). However, appraisal value is about 95% of the sale price, and is almost perfectly correlated with sales data. Moreover, a large portion of the three problems caused by using appraisal value can be reduced by using a larger sample size.

6.3 Practical Implications

The main practical application of this study is to give the opportunity for researchers and real estate developers to examine the role of value creation concepts in terms of the amount of potential change in single family housing values.

First, developers are guided to protect or enhance the property values by actively adapting positive value concepts in subdivision development. From the priority list in Table 6-15, it could be concluded that dwellers may pay more money for a house within a subdivision with greenway connectivity or a favorite shape of the subdivisions' entrance. Next, a subdivision with a fewer number of development phases, fewer number of subdivision entrances, shorter streets, or fewer houses was preferred as well. Finally, a subdivision with small blocks, more sidewalk lanes, or longer cul-de-sacs was preferred, even though the sizes of the effects of the three concepts were small (See Table 6-15).

Second, the information helps urban planners or designers to consider the appropriate type and number of value creation concepts minimizing negative effects on housing values in the design of new subdivisions. In the new subdivision design, the planners or designers have to apply a good transportation network system with adequate block size, sidewalk or greenway connectivity, shorter street length, and a small number of entrances and so on in the subdivision. The shape of the new subdivision can be decided with an adequate number of single family houses as well (See Table 6-15).

Finally, it is expected that appraisals predict more accurately the property values and the sale prices by applying weights depending on the number and type of value concepts. To evaluate the more reasonable value of each house, the appraisals have to consider not only structural and locational variables of houses, but also sense of arrival, product mix, walkability, circulation system, and amenities characteristics in a subdivision which nest the houses.

Another important application of the research findings is to use the Hierarchical Linear Model (HLM) as well as the Hedonic Price Model (HPM) to measure the relationship between the housing values and variables in both the housing level and the subdivision level. The HPM is extensively used in most research related to the relationship between housing values and the housing-related variables due to easy application and interpretation. Even though the HPM is a good model, the results can be slightly biased when the data in the model has a hierarchical structure. The HLM includes interaction terms between housing level variables and subdivision level variables, and among subdivision level variables themselves; that is, a subdivision level variable can be considered to evaluate another subdivision level variable. Hence, the HLM can be used to complement the HPM.

6.4. Further Research

First of all, the models should be applied to other places which have different climates or crime rates, etc., to generalize the external validity. Until now, there is no research about the effects of value creation concepts on housing values. Moreover, the study area of this paper is one place, College Station, Texas, which has specific characteristics such as a hot climate and is a university town.

Second, subjective evaluation of value creation concepts could be reexamined. This paper tries to find objective evaluation of value creation concepts. If opinions of developers who made each subdivision can be gathered through interviews or surveys, it will be possible to do a subjective evaluation of value creation concepts. Each developer may have preferred value creation concepts which he or she already applied to previous subdivisions.

Third, coefficients of some value creation concepts in HLM with linear relations instead of constants could be examined in detail. For example, the coefficient of the *median length of cul-de-sac* variable in HLM shows with an equation of "0.044 - 0.001 * the *number of accessible entrance*;" that is, the *median length of cul-de-sac* variable of a subdivision would be decided by the number of entrances of the subdivision. In this study, to compare the results in both models with ease, the coefficient was calculated by applying the mean value of the number of entrances in College Station, Texas.

Fourth, the effects of components of the sense of arrival variable on housing value could be examined. The sense of arrival variable was evaluated with pictures of subdivision entrances in this study. Each scene has different components such as trees, signage, a gate, sidewalk, and so on, and each component may have different effects on housing value.

Finally, this study could be developed with real sales data instead of appraisal values. Comparison of the results from a model with real sale data with the results of this study will be helpful to enhance validity and reliability of this study.

6.5. Conclusion

As developers apply designs on the land in the development of subdivisions, great effort is taken to find variables in the subdivision level, value creation concepts, as well as variables in the housing level. In the face of several limitations, this study identified useful variables in the subdivision level to evaluate single family housing appraisal value.

The Hierarchical Linear Model (HLM) and Hedonic Price Model (HPM) are used to measure the relationship between housing values and variables in both the housing level and subdivision level. The results of the HLM show that the HLM can be used to complement the HPM.

Findings propose that sense of arrival, product mix, walkability, circulation system, and amenity characteristics have effects on housing appraisal values. Consequently, the study recommends that nine value creation concepts should be considered in evaluating exact housing values. Sense of arrival, median length of cul-de-sac, and greenway connectivity variables have positive effects on single family housing values; on the other hand, single family density, land use mix, phased project, street density, median length of block, and the number of accessible entrances have negative effects on single family housing values. In view of percentage change of a housing value per one percent or one unit change of a subdivision variable from the results of the HLM and HPM, developers may consider mainly greenway connectivity (5.2%) and sense of arrival (5.2%) variables in their residential development. Next, phased project (4.1%) and the number of accessible entrance (1.5%) variables will be applied. Finally, street density (0.42%), single family density (0.03%), median length of block (0.02%), sidewalk connectivity (0.01%), and median length of cul-de-sac (0.004%) variables also will be considered.

To investigate the value creation concepts on single family housing is expected to allow researchers, real estate developers, and appraisers to examine the role of value concepts not only for minimizing negative effects and maximizing positive effects on housing values in the design of new subdivisions, but also to predict more accurately the property values.

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APPENDIX 1

REVISED MULTIDISCIPLINARY DEVELOPMENT PLANNING MODEL (RMDPM)

The Revised Multidisciplinary Development Planning Model (RMDPM) has two sides: a financial side and a physical side. The financial side of the model consists of three deductive inference-based steps: market analysis, marketability analysis, and financial modeling; while the physical part of the model involves five inductive reasoning-based steps: site analysis, environmental analysis, developer's facilities program, value creation concepts for design, and design plans (See Figure A-1).

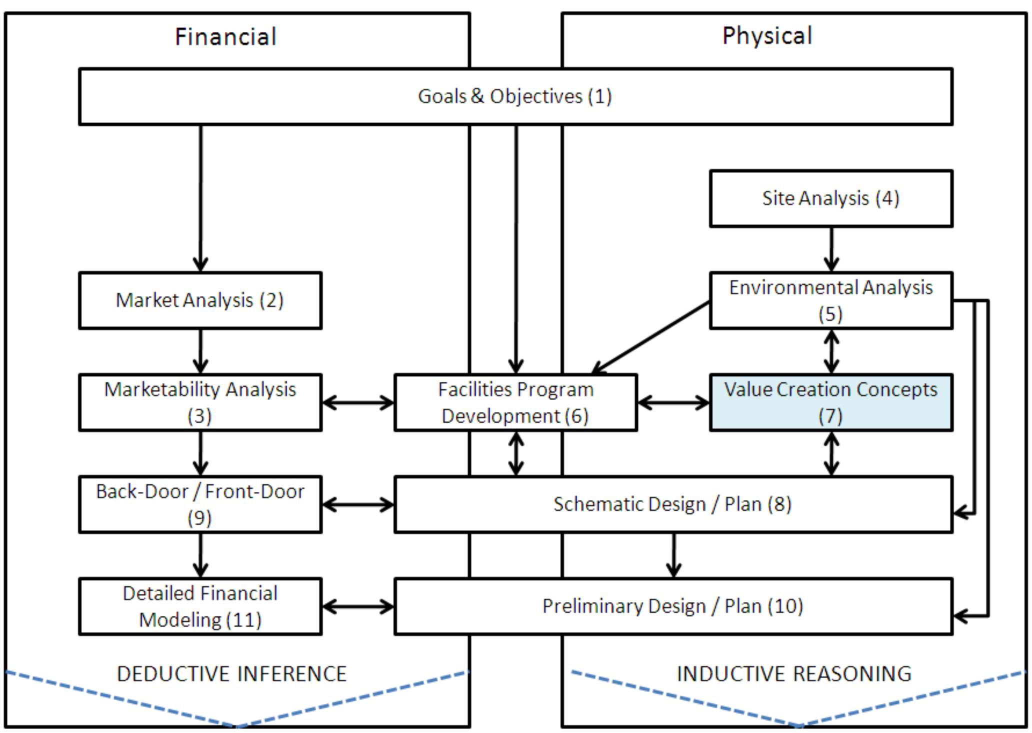

Figure A-1. Inductive Reasoning & Deductive Inference in the RMDPM.
(Source: Sharkawy, 1994)

APPENDIX 2

A PHYSICAL-FINANCIAL MODEL FOR DESIGN ECONOMY TRADE-OFFS (PHYS-FI) MODEL AND KEY VALUE CREATION CONCEPTS

Table A-1

PHYS-FI: Classes, Categories, and Concepts of Design Economy Trade-Offs & Key Value Creation Concepts

(Source: Sharkawy, 1994)

Class	*Category*	*Node (Concept)*
Optimizing Capital Cost	Hard Cost	Cost Intensity, Cost Transfer Functional Efficiency Cost Efficiencies
	Soft Cost	Phasing Profit Centers
	Land Cost	Opportunity Sites Decreased Unit Cost Residual Values
Creating Real Estate Value	**Environment**	**Topographic Fit** **Water Context**
	Product Synergy	**Amenity Dollars** **Contextual Fit** **Product Mix**
	Design Differentials	**Thematic Frameworks** **Cultural Schemata** **Relational Schemata** **Form Schemata**
Increasing Cash Flow from Operations	Increasing Product Efficiency	Auxiliary Income Operational Efficiency
	Increasing Rates / Decreasing Vacancy	Creating User Values Pricing Strategies Product Cycles
	Decreasing Operating Expenses	Life-Cycle Efficiencies Energy Saving

The Physical-Financial Model for Design Economy Trade-Offs (PHYS-FI) model consists of three classes: Optimizing Capital Cost, Creating Real Estate Value, and Increasing Cash Flow from Operations. Sharkawy (1994) identified classes and categories, which are within the classes, based on a review of financial and design models. Next, he identified nodes within each category based on case studies generated from the ULI (Urban Land Institute)'s projects.

There are nine key value creation concepts: environment category (topographic fit and water context), product synergy category (amenity dollars, contextual fit, and product mix), and design differentials category (thematic frameworks, cultural schemata, relations schemata, and form schemata) (See Table A-1).

APPENDIX 3

SENSE OF ARRIVAL RATING RESPONSE SHEET

You will be shown, one at a time, 110 color slides of entrance scenes from each subdivision in College Station, Texas. Please evaluate these entrances rather than the visual quality or composition of the slides themselves.

Please evaluate the entrance scenic quality of each subdivision by giving it a rating number between 1 and 5. Assign a rating of 1 to an entrance judged very low in entrance scenic quality, and a rating of 5 to an entrance judged very high in entrance picturesque quality.

Before evaluating entrance qualities, I would like to ask you for some standard background information. Please check the box that BEST applies to you or write an answer.

1. Your Age: ___________________

2. Your Gender
- ☐ **Male**
- ☐ **Female**

3. Your race
- ☐ **White**
- ☐ **African American**
- ☐ **Hispanic**
- ☐ **Asian**
- ☐ **Other**

Please use the **full range of numbers (1-5)** if you possibly can, and please respond to each slide.

Sense of Arrival Rating Scale

1	2	3	4	5
(Very Low)	**(Low)**	**(Medium)**	**(High)**	**(Very High)**

1 ___________	**23** ___________	**45** ___________	**67** ___________	**89** ___________
2 ___________	**24** ___________	**46** ___________	**68** ___________	**90** ___________
3 ___________	**25** ___________	**47** ___________	**69** ___________	**91** ___________
4 ___________	**26** ___________	**48** ___________	**70** ___________	**92** ___________
5 ___________	**27** ___________	**49** ___________	**71** ___________	**93** ___________
6 ___________	**28** ___________	**50** ___________	**72** ___________	**94** ___________
7 ___________	**29** ___________	**51** ___________	**73** ___________	**95** ___________
8 ___________	**30** ___________	**52** ___________	**74** ___________	**96** ___________
9 ___________	**31** ___________	**53** ___________	**75** ___________	**97** ___________
10 ___________	**32** ___________	**54** ___________	**76** ___________	**98** ___________
11 ___________	**33** ___________	**55** ___________	**77** ___________	**99** ___________
12 ___________	**34** ___________	**56** ___________	**78** ___________	**100** ___________
13 ___________	**35** ___________	**57** ___________	**79** ___________	**101** ___________
14 ___________	**36** ___________	**58** ___________	**80** ___________	**102** ___________
15 ___________	**37** ___________	**59** ___________	**81** ___________	**103** ___________
16 ___________	**38** ___________	**60** ___________	**82** ___________	**104** ___________
17 ___________	**39** ___________	**61** ___________	**83** ___________	**105** ___________
18 ___________	**40** ___________	**62** ___________	**84** ___________	**106** ___________
19 ___________	**41** ___________	**63** ___________	**85** ___________	**107** ___________
20 ___________	**42** ___________	**64** ___________	**86** ___________	**108** ___________
21 ___________	**43** ___________	**65** ___________	**87** ___________	**109** ___________
22 ___________	**44** ___________	**66** ___________	**88** ___________	**110** ___________

APPENDIX 4

GOVERNMENT CODE CHAPTER 552.PUBLIC INFORMATION

Subchapter C. Information Excepted from Required Disclosure

Sec. 552.148. EXCEPTION: RECORDS OF COMPTROLLER OR APPRAISAL DISTRICT RECEIVED FROM PRIVATE ENTITY.

(a) Information relating to real property sales prices, descriptions, characteristics, and other related information received from a private entity by the comptroller or the chief appraiser of an appraisal district under Chapter 6, Tax Code, is excerpted from the requirements of Section 552.021.

(b) Notwithstanding Subsection (a), the property owner or the owner's agent may, on request, obtain from the chief appraiser of the applicable appraisal district a copy of each item of information described by Section 41.461(a) (2), Tax Code, and a copy of each item of information that the chief appraiser took into consideration but does not plan to introduce at the hearing on the protest. In addition, the property owner or agent may, on request, obtain from the chief appraiser comparable sales data from a reasonable number of sales that is relevant to any matter to be determined by the appraisal review board at the hearing on the property owner's protest. Information obtained under this subsection:

(1) remains confidential in the possession of the property owner or agent; and (2) may not be disclosed or used for any purpose except as evidence or argument at the hearing on the protest.

(c) Notwithstanding Subsection (a) or Section 403.304, Government Code, so as to assist a property owner, a school district, or an appraisal district in a protest filed under Section 403.303, Government Code, the property owner, the district, or an agent of the property owner or district may, on request, obtain from the comptroller any information, including confidential information, obtained by the comptroller in connection with the comptroller's finding that is being protested. Confidential information obtained by a property owner, a school district, an appraisal district, or an agent of the owner or district under this subsection:

(1) remains confidential in the possession of the owner, district, or agent; and (2) may not be disclosed to a person who is not authorized to receive or inspect the information.

Added by Acts 2007, 80th Leg., R.S., Ch. 471, Sec. 1, eff. June 16, 2007.

APPENDIX 5

SPSS SYNTAX FOR HIERARCHICAL LINEAR MODEL

6-1. Syntax for Random-Effect ANOVA Model

```
MIXED MARKETVAL1
/METHOD = REML
/FIXED = INTERCEPT
/RANDOM = INTERCEPT | SUBJECT(SUBDIV_ID)
/PRINT = SOLUTION TESTCOV.
EXECUTE.
```

6-2. Syntax for Random-Coefficient Regression Model

```
MIXED MARKETVAL1 WITH lnTMA_C lnBATH_C lnAP_C AG_C BA_C POOL GOLF TENURE
/CRITERIA = MXITER(3000000)
/METHOD = REML
/FIXED = INTERCEPT lnTMA_C lnBATH_C lnAP_C AG_C BA_C POOL GOLF TENURE
/RANDOM = INTERCEPT lnTMA_C lnBATH_C lnAP_C BA_C  | SUBJECT(SUBDIV_ID)
COVTYPE(UN)
/PRINT = G COVB SOLUTION TESTCOV.
EXECUTE.
```

6-3. Syntax for an Intercepts- and Slopes-as-Outcomes Model

```
MIXED MARKETVAL1 WITH lnTMA_C lnBATH_C lnAP_C AG_C BA_C POOL GOLF
lnTMA_GM lnBATH_GM AG_GM
SENOFARR lnMEDCUL lnMEDBLO ACCENT GRECON
/CRITERIA = MXITER(3000000)
/METHOD = REML
/FIXED = INTERCEPT lnTMA_C lnBATH_C lnAP_C AG_C BA_C POOL GOLF lnTMA_GM
lnBATH_GM AG_GM SENOFARR lnMEDCUL lnMEDBLO ACCENT GRECON
lnTMA_GM*GRECON lnMEDCUL*ACCENT lnMEDBLO*GRECON lnTMA_C*SENOFARR
lnTMA_C*ACCENT AG_C*lnTMA_GM AG_C*SENOFARR
/RANDOM = INTERCEPT lnTMA_C lnBATH_C lnAP_C BA_C  | SUBJECT(SUBDIV_ID)
COVTYPE(UN)
/PRINT = G COVB SOLUTION TESTCOV.
EXECUTE.
```

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