GOING GREEN – IMPACT ON RESIDENTIAL PROPERTY VALUES

by

RAMYA RAJAJAGADEESAN AROUL

Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN REAL ESTATE

THE UNIVERSITY OF TEXAS AT ARLINGTON

August 2009

To my husband Praveen and my little one Guru Sashank

ACKNOWLEDGEMENTS

I would first like to thank my committee chair, Dr. Andrew J Hansz for all of his valuable time, guidance and interest in my thesis area. I would like to thank Dr Salil K Sarkar for taking an interest in me and accepting to be on my committee and also for his precious time and advice. I would also like to thank Dr. Darren Hayunga for the many hours of assistance he gave me as a student.

Also, I would like to thank Mr. Ryan J Middleton, Planner, Comprehensive & Environmental Division Development Services City of Frisco for his valuable time and inputs.

I would also like to recognize my parents. For my mother who gave so selflessly of herself, by taking care of my little one when I was busy with my research whose love and friendship was always there. I hope that one day I can be even half the mother you have been to me. And for my father, who has been my source of confidence and whose encouragement helped me achieve so much. For my sister who has been my little tormentor and an angel.

Also I want to thank my husband, Praveen without whose support and encouragement I could not have accomplished this goal. I thank God for all the love and support you have given me and look forward to spending the rest of my life with you. I am so proud to be your wife.

Above all, I wish to acknowledge the patience of my little one Guru Sashank who has been a sweet heart and did not trouble me much while I accomplished this thesis, really a huge task for a newborn.

July 16, 2009

ABSTRACT

GOING GREEN – IMPACT ON RESIDENTIAL PROPERTY VALUES

Ramya Rajajagadeesan Aroul, M.S.

The University of Texas at Arlington, 2009

Supervising Professor: Andrew J. Hansz

Hedonic pricing model is generally used to empirically understand the relationship between various housing characteristics and the housing values. In the past hedonic studies have looked at the relationship between the housing prices and structural features, environmental amenities, neighborhood characteristics, time variables and even financing. But real estate researchers have greatly overlooked to study the impact of greenness on residential properties though there has been a huge interest among the researchers and practitioners on green buildings. This study poses the primary question of if any potential relationship exists between greenness and property values. This study further extends the research question to find out if there is any impact on property values as a result of the mandatory green building programs. The study finds significant positive relationship between the greenness and the residential property prices. The study also finds significant positive relationship between greenness in Frisco adding premium to the property values.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Interest in green buildings is growing at a spectacular rate. Indeed, the intensity of attention expressed by the real estate and land development industry is a sign of mounting acknowledgment of the need for green and sustainable practices. With the stimulus funds from the American Recovery and Reinvestment Act (ARRA), more funds are channeled into the green development projects. This has further fueled the already fast growing green revolution in the country. Green buildings are usually identified as more expensive than traditional buildings and more often these costs are perceived to not justify the economic value created. But there have been studies that found that the additional costs for a green building are lower than is often thought and the future benefits are humungous (Kats, 2003). The economics behind the green development can be looked at positively only when the focus of financial evaluation of the green buildings shift beyond the initial cost and start to look at the net present value that takes into account the future benefits that are both tangible and intangible. But robust scientific methods are at call for efficient evaluation of both tangible and intangible future benefits. Even though the economics of green buildings are still questionable, the interest in the green movement has not gone down.

As a result of the growing environmental scares of shortages and increasing need to curb pollution, residential green residential programs have begun flourishing throughout the country. The scholars in urban planning and architecture have attempted to answer the question of whether these residential green building programs really make a difference in regards to resource conservation and increase in quality of life (Tinker, 2003). The fundamental question that is of interest to scholars in real estate is if these residential green building programs add value to the property. But there has not been a significant amount of research done in this area.

Frisco is the first city in the United States to adopt a mandatory Residential Green Building Program (www.ci.frisco.tx.us). The Residential Green Building Program of the City of Frisco has set minimum standards for energy efficiency, conservation of water, indoor air quality and waste recycling for residential buildings. This study focuses on the impact of the Frisco Residential Green Building Program on the property values of single-family homes.

This research offers the following contributions to existing scholarship. First, while the previous studies in property valuation have looked at variables like square footage, bedrooms, garage, pool etc that are characteristics of the building (Sirmans et al, 2005), the variable of interest of this study, the “greenness” of the building has been overlooked by scholars. This study by attempting to examine the relationship of greenness to the property values tries to fill in this gap in the literature. In fact this study could be one of the first studies that make an effort to open up a new series of studies in this area of research focusing on green residential buildings.

Little research has been done on the property values of houses involved with mandatory green building programs. Even the few studies that had been done on these green programs focus on the energy efficiency and water consumption benefits. The second scholarly contribution of this study is that it looks at the green mandatory program of the City of Frisco and attempts to evaluate the impact of this program on property values. One could argue greenness to be a characteristic of the building even though it is strictly a result of following few green building practices. Hence greenness is treated as a hedonic variable the first time in this study. The third contribution of this study is in the usage of the green variable as a hedonic variable in the hedonic pricing model.

It would not be an overstatement to articulate that this research is one of the first studies that attempts to unravel the marginal economic contribution greenness adds to a residential property. The results of this study show a positive relationship between greenness and property values. Also, there exists a positive relationship between the presence of a mandatory green building program and property values. This could have a lot of policy implications. Extending this study to look at the macro policy implications could be a reasonable extension to this research. Also, this research could be of interest to practitioners like developers for whom some evidence that there is an addition of a premium to property values due to green practices could have an impact in their decision of green development. This study to some extent provides evidence of “dollar” implications to green buildings one that the green building supporters have been trying to convince the general public.

1.1 Research Motivation

Hedonic pricing models have been applied to study relationships between housing attributes like structural characteristics, environmental amenities and disamenities, neighborhood characteristics, time variables, financing options and many other locational attributes on the property values. But there exists another important housing attribute that is gaining a lot of social, environmental and ethical concern and popularity over the past decade that has been largely overlooked by studies of this nature.

There have been an increasing interest in real estate academia on this green revolution for the past few years but most of the work has been focused on the commercial green buildings with the increased spur of voluntary green building programs. But this study differs from other studies looking at green buildings in two ways. Firstly, this study focuses on the residential green buildings and secondly this study does not look at voluntary green building programs but at the mandatory residential green building program. This thesis attempts to answer two main questions.

1. Do properties yield a premium in their selling prices if they are green properties?
2. Does a mandatory green building program have an impact on the selling prices of the properties?

In an attempt to answer the above stated questions, this study looks at two demographically similar cities, one with a mandatory residential green building program and another without the mandatory residential green building program and evaluates the relationship between greenness and the property values. In order to evaluate the impact of the mandatory green building program on the residential property values, an interaction effect between the greenness and the city is taken as a proxy. This study is one of the first of this kind to look at both main effects and interaction effects of greenness on the property values.

1.2 Organization of Thesis

The remainder of the thesis is organized as follows. Chapter 2 introduces the concepts related to green development like the definitions and differences between green development and sustainability, the economic viability of green buildings, green building rating systems in practice, green building programs organized by local governments and the residential green building program by the City of Frisco in particular. Chapter 3 provides a review of hedonic pricing model literature and identifies gaps in literature. Chapter 4 develops the hypotheses for the study. Chapter 5 discusses the study outline, data selection and creation of the green variable. Chapter 6 discusses the data analysis, variables of interest, multiple linear regression analysis using ordinary least squares method, violations of regression assumptions and the relevant corrections. Chapter 7 discusses the two models one for evaluating main effects and the other for evaluating the interaction effects and then goes on to explore the empirical results of these models. Chapter 8 gives the conclusions, contributions of this research to the scholarly community, limitations of this study and future scope and extensions for research.

CHAPTER 2

GOING GREEN

2.1 Defining Green and Sustainability

Interest in green building is growing at a spectacular rate. Indeed, the depth of interest expressed by the many sectors of the real estate and land development industry is a sign of growing recognition of the need for green and sustainable practices. It is very important for us to look at the issues of sustainable development as it is gaining enormous attention these days and has a tremendous impact on the real estate development process. Before looking at the impact, it is important to understand and examine the concepts of sustainable development and green development and to distinguish between both. The term of “sustainable development” is often criticized because of its vagueness. The most frequently used definition of sustainability is from *Our Common Future: The Report of the World Commission on Environment and Development*, commonly known as the Brundtland Commission report. The Brundtland Commission report’s forward-looking definition of sustainability is “design, construction, operations, and maintenance practices that meet the needs of the present without compromising the ability of future generations to meet their own needs.”

Green development and sustainable development are used interchangeably by many in most circumstances. But there is a notable difference between the two and the planner’s triangle shown in Figure 2.1 gives a conceptual understanding about the two.

Using the simple triangular model to understand the conflicting priorities of planning Campbell (1996) argues that while planning and developing a real estate project there is always a clash of interest between three major schools of thought, economic, environment and equity (society). Sustainability is attained in the center of the triangle where a good balance of all the

three legs is achieved. Of the three legs, one leg the environment is what is considered as the green development.

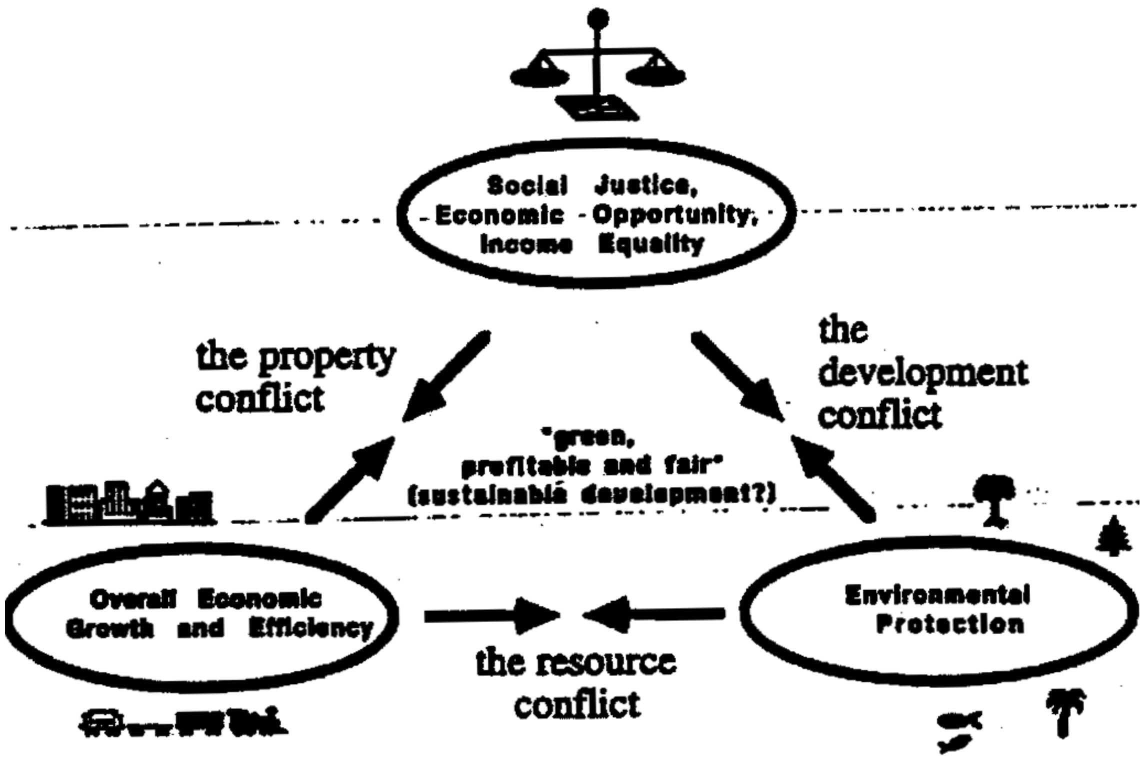

Figure 2.1 Planner's Triangle (Campbell, 1996)

Using the simple triangular model to understand the conflicting priorities of planning Campbell (1996) argues that while planning and developing a real estate project there is always a clash of interest between three major schools of thought, economic, environment and equity (society). Sustainability is attained in the center of the triangle where a good balance of all the three legs is achieved. Of the three legs, one leg the environment is what is considered as the green development.

Green development is different from sustainable development in that green development has the objective of environmental sustainability over economic and social concerns. Supporters of sustainable development argue that green development is unattainable when we try to improve overall sustainability as a balance between the three legs would have a compromise on green development. For example, an industrial plant that is ideal as per environmental consideration but too expensive to install and maintain will be a non sustainable plant even though it will be a green plant. In order to make the plant sustainable we have to build the plant in an economically viable way. This would compromise the greenness in the plant but will be a sustainable option. A considerable amount of research on this concept is evolving promoting the complimentary social, environmental, and economic impacts of this approach to real estate development (Loban and Jones, 2008).

The definition of green building is still a vague concept and it varies between scholars and practitioners and also among various sources. Green is considered as a term that is treated as identical with the term sustainability that has a meaning of minimum ecological impact (Talarico, 1998). Bynum & Rubino (1999) argued that green building construction is not a component by component substitution but a systems approach to building. Green building can be identified as any development that endorses less energy consumption, promotes water conservation, propagates the best use of building materials, uses renewable resources, encourages competent waste management techniques, preserves natural environment and looks at health and environmental standards (Heekin and Meyers 2001). In particular, green buildings refer to the attributes and quality of properties resulting from the execution of the principles and methods of sustainable construction.

The founder of Leadership in Energy and Environmental Design (LEED), the United States Green Building Council, described green building as the “design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas:

1. sustainable site planning,
2. safeguarding water and water efficiency,
3. energy efficiency and renewable energy,
4. conservation of materials and resources, and

5. indoor environmental quality" (USGBC, 2001)

The definition of sustainability and green buildings is still evolving. It would take an entire thesis to go about attaining a definition for the same. The focus of this thesis is not about defining green development. Hence, a simple and general definition of green development that could encompass a broader perspective of sustainability would suffice for the purpose of this research. Out of the above stated definitions of green buildings provided by various scholars and green building organizations, the definition given by Talarico (1998) is taken as a premise for this research as Talarico (1998)'s definition of green building is the simplest of all the definitions and covers a broad spectrum. This thesis brings into light the vagueness caused in both the definitions of green development and sustainability as these words are used quite interchangeably in the real estate development practice. In order to get away from the debate encircling the definitions of these two concepts, this thesis takes Talarico (1998)'s definition as the base. To reinstate once more, this research considers green development and sustainability as interchangeable concepts for simplicity and to avoid any vagueness caused by treating both the concepts differently.

2.2 Green Buildings – Are they economically viable?

Does "green" pay off? This is one of the most commonly occurring questions in the minds of home owners, developers and policy makers all alike. Green building practices are very new to the construction industry and it is quite natural to see some resistance to change. It is human nature to resist when a new technology or an idea is introduced and this is exactly what the green development building practice is receiving from majority of the sections in the society. The scholars in urban planning and architecture have attempted to investigate the environmental viability of green buildings and their impact on ecology in regards to resource conservation and increase in quality of life. The fundamental question that is of interest to scholars in real estate will be to see if the green building projects are economically viable, i.e., if these buildings will provide a positive net present value to the property investors.

Green buildings are usually identified as more expensive than traditional buildings and more often these costs are perceived to not justify the economic value created. Usually the increase in cost is an outcome of the usage of sustainable materials that are more expensive, mechanical systems that are more efficient and thereby pricey, and better design, modeling and integration that proves financially more costly. The cost premium associated with green buildings is highly dependent upon the choices made by the developer. If the financial benefits of the green buildings in the form of operational efficiency are higher than the initial outlay, then the green buildings will be economically viable.

Advocates of green building argue that the cost debate surrounding the issue is the actual barrier to green movement rather than the actual costs and also state that the common belief that the green building costs more is a preconceived notion. Kats (2003) conducted a study for the Massachusetts Technology Collaborative, the state's development agency for renewable energy and the innovation economy to determine the costs and benefits of green buildings. Kats (2003) found that the average cost premium for green buildings is slightly less than 2% which is much lower than the commonly perceived costs. As per the study the major chunk of the costs is due to the design time and the time and costs associated with the integration of sustainable building practices into the projects. This is in fact a problem every technology faces in the adoption stage. The green building practices are so new and different from the traditional building practices. The knowledge of these green development practices is still in its nascent stage and the diffusion of this knowledge is a rather a slow continuous process. The most important cost associated with any new technology is the cost of learning the technology itself. In the case of the green building practice, every developer has to dedicate time to attain the required sustainable building practice as advocated by either by the voluntary green building rating system or by the mandatory green building program. This would contribute to the majority of the cost premium associated with the green buildings. So it is estimated that the cost of green buildings may go down once the developers reach their maturity in their learning curve.

Green buildings provide financial benefits that the traditional buildings do not. The benefits occur in lowering the operational costs over the lifetime of the buildings through lower energy consumption, water conservation, waste reduction and better indoor air quality. Also there have been studies that have found significant relationship between green buildings and greater employee productivity and lesser employee health costs. Kats (2003) also found that the financial benefits of green buildings are ten times their initial cost premium. Other studies also find that the additional costs for a green building are lower than is often thought. Turner Construction (2005) found average cost premiums of 0.8% for LEED certified, 3.1% for silver, 4.5% for gold, and 11.5% for platinum buildings. Davis Langdon (2004) in his study found no statistically significant cost difference between comparable quality LEED and non LEED buildings. This is in consensus with the green movement supporters' claim that green buildings might lose the initial cost war but will win hands down the battle of benefits.

Kats (2006) does a national review of 30 green schools and provides the financial costs and benefits associated with green schools compared to conventional schools. The findings of the study reiterate the findings of Kats (2003). Green schools cost almost 2% more than the conventional schools but the financial benefits are 20 times more.

The economics behind the green development can be looked at positively only when the focus of financial evaluation of the green buildings shift beyond the initial cost and start to look at the net present value that takes into account the future benefits that are both tangible and intangible. Part of the reason for the question of economic viability of the green buildings arise due to the fact that the market has struggled to calculate the value of green buildings as the benefits has a longer lifespan. There is significant amount of research done to understand and to help estimate the future economic and financial benefits of green buildings.

A study conducted in 2000 by Xenergy for the City of Portland found that there was a 15% lifecycle savings by getting three buildings up to United States Green Building Council's LEED certification levels. Sustainability Matrix and Sustainability Report (2002) found that with each increasing level of sustainability measured based on the different levels of LEED, short-term costs increased, but long-term costs decreased dramatically. Moreover, there are a significant number of studies that has found evidence of quantifiable benefits for improved day lighting, natural ventilation, and improved indoor air quality in buildings.

Also there have been studies that looks at intangible benefits associated with these green buildings and found significant relationship between the buildings and enhanced worker and student productivity, as well as reduced absenteeism and illness. A study conducted by the Heschong-Mahone group in 1999 examined students in three cities and found evidence that students in classrooms with the highest level of day lighting performed almost 20% better than those in classrooms that had lower levels of daylight. Another study at Herman-Miller in 2000 showed up to a 7% increase in worker productivity after moving to a green office facility (Heerwagon, 2000).

This thesis looks at Kats (2003)'s summary of findings about the financial benefits of the green buildings that accounts for both tangible and intangible benefits in the Net Present Value calculations. The summary of findings is presented below in Table 2.1. If we take a close look at the findings shown in Table 2.1, we see that almost 75% to 80% of the projected future benefits are productivity and health value benefits that are indeed intangible benefits. It again does not provide considerable quantitative evidence to show evidence of substantial future tangible benefits. But the study indeed shows that the tangible benefits from green buildings constitute about 20% to 25% of the total future benefits which in itself would provide a positive net present value for the green buildings. Unless there is a valid universally accepted scientific method that could be able to evaluate the intangible benefits quantitatively in dollars, the question of economic viability will still linger among scholars, practitioners and all stakeholders. More research is needed in the areas of building new measures to capture the life cycle benefits or reconfiguration savings from sustainable buildings.

Table 2.1 Net Present Value of Green Buildings (Kats, 2003)

Category	**20-year NPV**
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Waste Value (construction only) – 1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Health Value (Certified and Silver)	$36.89
Productivity and Health Value (Gold and Platinum)	$55.33
Less Green Cost Premium	($4.00)
Total 20-year NPV (Certified and Silver)	**$48.87**
Total 20-year NPV (Certified and Silver)	**$67.31**

2.3 Green Building Rating Systems

Traditionally buildings are expected to meet the building code requirements but the green buildings are expected to perform more by reducing their impact on the environment. In order to maintain a systematic assessment of the environmental performance of buildings, an applicable and meaningful yardstick for measuring environmental performance is needed. Therefore it is essential to have a third party green building rating system that could evaluate and rate the greenness of buildings. Many green building rating systems have been developed in the past decade in different countries to evaluate the environmental performance of the buildings without prejudice.

The first environmental rating system was developed in the United Kingdom in 1990 called as BREEAM (Building Research Environmental Assessment Method). The Building

Research Environmental Assessment Method was brought to Canada in 1996. In the United States, the United States Green Building Council introduced the Leadership in Energy and Environment Design (LEED) Green Building Rating System in 1998. The Green Building Initiative (GBI) created the Green Globes by modifying the Canadian version of BREEAM and released it in the United States in 2005 (Smith et al., 2006).

Out of the green building rating systems LEED is the market leader. It is evident by the fact that nowadays a commercial green building is being described as one that is certified by the LEED green building rating system of the United States Green Building Council. The United States Green Building Council is a consensus based group that has firms, schools, government agencies, universities, non profit organizations and trade organizations. The United States Green Building Council released the LEED green building rating system to the public in 2000 for commercial buildings. LEED was the first green building rating system in the United States that evaluated commercial buildings based on their impact on the environment like their energy consumption, water usage, land use, resource conservation and indoor air quality. The LEED rating system started off for commercial buildings and now has extended to residential buildings as well. Since 2000, the United States Green Building Council has released six green building rating systems. They pertain to new construction, tenant improvements, existing buildings, core and shell buildings, single family homes and low rise residential buildings, and neighborhood development. The LEED green building rating system for the single family homes is a relatively new rating system and it will take time to penetrate into the residential market (USGBC,2001).

The Environmental Protection Agency’s Energy Star program was present even prior to LEED. Energy Star is a joint certification program of the United States Environmental Protection Agency and United States Department of Energy for buildings that meet strict energy efficiency guidelines. Energy Star is the most popularly known energy certification program and energy product brand in the country and is also a good indicator of the demand of green homes. The Energy Star program centers exclusively on energy efficiency but LEED is a much more holistic environment rating system. But the Energy Star's HERS (Home Energy Rating System) rating is the most popular rating system in the residential market. The HERS Index is a rating system set up by the Residential Energy Services Network (RESNET) in which a house built to the terms of the HERS Reference Home (based on the 2006 International Energy Conservation Code) attains a HERS Index of 100. A house that is a net zero energy home attains a HERS Index of 0. Thus the lesser score the house receives on its HERS Index, the more energy efficient it is in comparison to the HERS Reference Home (RESNET, 2006).

2.4 Green Building Programs

Local governments have become more and more concerned in improving the quality of new houses from both environmental and long term economic sustainability perspectives. There are several stakeholders' interests to be balanced. Policy makers, house owners and developers want to see the houses constructed to hold their value over a long time, the house owners want lower utility bills, and we all want minimal impact of the development on our natural resources.

Laws regarding the building practices are generally regulated by building codes. There are a lot of approved building codes that the residential construction industry and developers should abide by. Mostly, the building codes do not address the issue of sustainability instead there are programs and incentives that are offered by various governmental agencies that promote sustainable building practices. With a lack of significant federal and state green building legislation, the local governments play a vital role in developing and updating ordinances and policies that revolve around the theme of sustainable development and conservation.

There are numerous cities and counties in the United States that have passed ordinances that provide incentives or regulations to promote sustainable buildings. Some of these governments also have taken a lead by planning, designing and developing public buildings according to sustainable design standards. The local governments through their lead in crafting these policies are thus initiating small changes towards a sustainable community. In order to increase the quality and sustainability of houses and to decrease the impact of buildings on the environment, local governments are generally adopting residential green building programs. Several communities across the nation have successfully implemented and reaped tremendous results as a consequence of these green building best management practices.

The residential green building programs across the country could be classified as mandatory and voluntary programs. The voluntary green building programs are easy to get a go ahead signal from the developers as they are not mandated to follow the green building practices but those developers that want to follow the green management practices will be recognized and rewarded with green ratings for the buildings. The City of Austin's Residential Green Building program is a voluntary program that provides certification of green homes on a scale of one to four stars. Homes receive more stars if more green features are present. The City of Austin is the leader in sustainable programs in Texas and around the country. The city has developed numerous sustainable programs such as the Green Building Program, Water Conservation Program and Air Quality Program. The city's most well-known program called the Austin Green Builder Program was the first residential green building program developed in the United States (City of Austin). Austin could be a great example to visualize the impact of even a voluntary program advocated by the city could have in achieving the objective of sustainability in communities.

On the other hand, the mandatory programs will not be accepted with open arms by the developers and hence passing the ordinance itself will be a tough ask for the city but the mandatory green building program has its own benefits. Since all the builders are mandated to follow green building practices there will be a dramatic shift in the best practices in the building industry helping to achieve the dream of sustainability in the community. Owing to the skepticism and unwillingness from the developers most of the green building programs in the country are voluntary in nature. There are a very handful of green building programs in the country that sets mandatory green building requirements. One such program is the City of Frisco's Residential Green Building Program. The research question that this study attempts to answer is the effect of a mandatory residential green building program on residential property values. This thesis looks at City of Frisco's Residential Green Building Program in particular and its impact on the property values in the area. Hence it is imperative to know the details of the city's residential green building program.

Frisco is one of the fastest developing cities in the Dallas Fortworth Metroplex region. Land that once was dedicated for the production of wheat and livestock feed now has a huge demand for new homes, schools, offices, and parks. The city's population is growing at a steady pace for the last two decades and hence there is an ever growing demand for housing. In the light of this exploding growth in housing, the city decided to have a residential green building program to develop a sustainable community. But the developers were apprehensive that they had to deviate so much from their known methods and materials and were anxious to try and test new methods and materials. This green development process is a paradigm shift from the traditional building practices. They were also concerned that their ability to do business would be adversely affected if they adopt green management practices. So the City of Frisco came up with the performance based mandatory Residential Green Building Program. This gave the builders the necessary flexibility to meet the requirements and at the same time managed to achieve the city's objective of sustainability. With a performance based program, the city provides the minimum requirements and the developers are left with alternatives for how they meet the requirements (Witt et al., 2005).

2.5 City of Frisco's Residential Green Building Program

In May 2001, Frisco became the first city in the United States to adopt a mandatory Residential Green Building Program. According to the ordinance passed on May 2nd 2001, all residential plats accepted after May 23, 2001 are required to build to the mandatory green building program standards. After more than five years of practice, the city restructured and enhanced the Residential Green Building Program. The revised program is put into effect for all homes receiving a building permit on, or after, July 1, 2007.

The City of Frisco's Residential Green Building Program mandates minimum energy efficiency, water conservation, indoor air quality and waste recycling standards for all residential buildings. Energy efficiency, water conservation, indoor air quality and water recycling are the four categories for which the City of Frisco's Residential Green Building Program sets forth minimum standards. The minimum requirements in these four categories are provided below (City of Frisco):

1. Energy Efficiency

   In addition to the city's existing building codes and other relevant regulations, the following must be accomplished.

   a. The single family residences should have the Environmental Protection Agency's Energy Star designation or a score of 83 or less on the HERS (Home Energy Rating Systems) index

   b. Every home must be tested by a RESNET (Residential Energy Services Network) approved HERS rater annually.

   c. Every story in the house should have atleast one programmable thermostat.

   d. Any room that will be closed with a door should have a return air path. The pressure differential in that door with the door closed and the air handler working should not be more than plus or minus 3 Pascal.

   e. All the joints in the air distribution system should be sealed with duct mastic.

2. Indoor Air Quality

In addition to the city's existing building codes and other relevant regulations, the following must be accomplished.

a. Every single family residence should have a minimum standard of ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 62.2 or its amendment.

b. Every HVAC unit that supplies air to a bedroom must get all or a portion of outdoor air distribution. Total ventilation rate must be split between each HVAC unit supplying air to a bedroom. Ducts carrying outdoor air must have manual dampers and a filter inside the return.

c. Outdoor air intakes must be located at a minimum of atleast 60 inches from all the roofing materials.

d. HVAC plenums on the supply & return side must be constructed using sheet metal or equivalent that is approved by the building officials.

e. Heating and cooling equipment can be used during construction only after manufacturer specified filter is installed.

f. Central vacuums must be expelled outdoors

g. Carpets, cushions, and carpet adhesives must have the carry the Carpet & Rug Institute (CRI) Green Label.

h. Vinyl wallpaper is not permitted to be used on the inside of the exterior walls and on wet walls.

i. Metal drip edge is to be provided at all exposed roof decking.

3. Water Conservation

In addition to the city's landscape ordinance and other relevant regulations, the following must be accomplished.

a. Bedding must be mulched to a depth of 2 to 4 inches using recycled materials that includes wood construction waste.

b. Each installed tree must be provided with a portable drip irrigation bag or zoned bubbler system.

4. Water Recycling

   In addition to the city's waste reduction and recycling regulations, the following must be accomplished.

   a. Brick and wood construction waste from the building site must be taken to a facility legally empowered to accept it for recycling as approved by the County and State in which the facility is located.

CHAPTER 3

LITERATURE REVIEW

3.1 Hedonic Pricing Models in Real Estate Literature

Hedonic analyses can be traced back to Waugh's (1928) study of agricultural markets. Rosen's (1974) influential paper on the role of housing attributes in consumer decision making inspired the theoretical and empirical literature on housing attributes. The value of the house is affected by the various characteristics of the house itself. Housing choices not only depends on the structural housing characteristics, but also on the location characteristics of the property such as proximity to external amenities and disamenities. Observation of housing choices could reveal information about the underlying preferences for the housing characteristics and other environmental amenities. Hedonic price functions are used to analyze the consumer demand for attributes of heterogeneous goods (Sheppard, 1999). One of the most important reasons for using hedonic analyses for housing markets is to study the relationship between housing attributes, environmental amenities and housing prices. Hedonic regression analysis is in general used to estimate the marginal contribution of individual characteristics to the total value of the property.

Hedonic pricing is considered to be a willingness to pay technique. It tries to capture the fraction of property prices that are derived from the specific housing characteristics. Lot of authors like Linneman (1981), Parsons (1986), and Quigley (1982), have used the hedonic price model for estimating the willingness to pay for housing characteristics.

This section of thesis looks at the recent studies that have used hedonic modeling to estimate housing prices. By reviewing the recent literature, the most frequently included housing attributes in the hedonic pricing models are identified. These include, along with many other characteristics, lot size, square feet, age, the number of stories, the number of bathrooms, the number of rooms, the number of bedrooms etc. In the past hedonic studies have looked at the relationship between the housing prices and characteristics that could be classified as "structural features (lot size, square feet, age, number of bathrooms, and number of bedrooms), internal features (full baths, half baths, fireplace, air conditioning, hardwood floors, and basement), external features (garage spaces, deck, pool, porch, carport, and garage), natural environmental features (lake view, lake front, ocean view, and good view), neighborhood and location (location, crime, distance, golf course, and trees), public services (school district, percent of school district minority, public sewer), marketing, occupancy, and selling factors (assessor's quality, assessed condition, vacant, owner-occupied, time on the market, and a time trend) and financing (FHA financing, VA financing, foreclosure, favorable financing, and property taxes)"(Sirmans and Macpherson, 2003).

Most of the structural characteristics like square footage, lot size, age, and bedrooms have a positive effect on selling price although the magnitudes may vary across different regions in the country. Internal features like the number of bathrooms, fireplace and air conditioning also adds premium to the housing prices. External features like garage and swimming pool have a positive effect on the property values (Sirmans et.al, 2006). Natural environmental features like the view of the property also have an impact on the property values. A picturesque view is considered as a residential amenity associated with the location of a property. There have been a number of studies that have found that home buyers are ready to pay the extra premium for houses with a view (Benson et.al, 1998; Do and Sirmans, 1994; Rodriguez and Sirmans, 1994; Cassel and Mendelsohn, 1985; Gillard, 1981; Plattner and Campbell, 1978).

Externalities happen when a particular land use affects adjacent properties and results in change in their values. The neighborhood amenities and the location of the residential property are also characteristics that have either a positive or negative effect on the price of the property. Several studies have accounted considerable effects on housing prices due to a variety of location specific externalities. While some of these studies look at the diseconomy associated with negative location specific externalities, other studies have revealed that a property's adjacency to positive location specific externalities will add value. Hite et.al. (2001) have demonstrated that there is a decrease in property values of significant magnitude for residential property values near landfills. There have been studies that have looked at floodplains and found some discount associated with a property's location in a floodplain (Troy and Romm, 2004) Few studies have examined the adverse effects of detecting environmental contamination on the value of real estate (Dotzour, 1997). Do et.al (1994) find a negative externality effect to the proximity to churches. Other examples of negative externalities include "proximity to contaminated properties (Kinnard and Geckler, 1991); noise pollution and proximity to industries (Li and Brown, 1980); air pollution (Nourse, 1970; Nelson, 1978; Harrison and Rubenfeld,1978); airport noise (Mieszkowski and Saper, 1978; and Nelson, 1980); nuclear power plant (Gamble and Downing, 1982; and Nelson, 1981)" (Do et.al, 1994).

There are studies that have shown the threat that the foreclosures pose to the stability and well being of the neighborhood. Immergluck and Smith (2006) find evidence of higher crime associated with higher foreclosures in the neighborhood. Shlay and Whitman (2004) found an inverse relationship between vacant residential buildings and property values of nearby homes. Foreclosure often results in vandalism, disinvestment and other negative spillover effects in the neighborhood (Lin et al., 2007). Hence there is ample premise to consider foreclosures as negative external amenities while estimating property prices.

Studies have also shown that positive externalities like greenbelts (Correll et al., 1978), neighborhood parks (Weicher and Zerbst, 1973), and travel times (Nelson, 1977) add premium to the housing prices. Asabere and Huffman (2009) show that trails, greenbelts, and trails are associated with higher price premiums. Also, the study finds that the proximity to golf course, neighborhood playground, tennis court, neighborhood pool, view, and cul-de-sac are other amenities that add value to housing prices. Studies have also shown a positive impact of sports arenas on property values within a specified radius (Ahlfeldt and Maennig, 2008; Tu, 2005). Public services such as schools (Clotfelter, 1975, and Jud, 1985) have a positive impact on housing prices. Many studies have established the degree of public school quality's contribution to housing prices. Walden (1990) found that the houses assigned to better quality schools have that quality capitalized in their price and hence earned a premium over other houses.

There are studies that look at how time on the market affects selling price. Time on the market generally has a negative relationship, which means that a longer time to sell results in a lower selling price. In the case of this variable there also exists a reverse relationship. The time on the market has an effect on the property values and the selling price also affects the time the property is on the market. While looking at the latter relationship, there has been contradictory evidence. Some studies illustrate that houses with higher selling prices sell faster than those houses with lower selling price while other studies show that houses with higher selling prices have longer selling times. There have also been studies that show that a higher listing price results in a longer time on the market. Trippi (1977) and Miller (1978) find a considerable, positive relationship between time on the market and selling price. Miller (1978) argues that the positive relationship could be most probably due to disparity in the selling (search) costs. However, Cubbins (1974) finds a negative relationship between the selling price and time on the market and concludes that a house can be sold faster if a higher price is associated to it. Allen et al. (1987) find no significant relationship between time on the market and selling price. There are other studies that have found that the ratio of selling price to list price is negatively associated to time on the market (Belkin, Hempel, and McLeavey, 1976; Miller 1977). In short the longer the property remains on the market, other things being equal, the greater is the price concession (Larsen and Park, 1989).

Hedonic pricing models have been applied to study relationships between housing attributes like structural characteristics, environmental amenities and disamenities, neighborhood characteristics, time variables, financing options and many other locational attributes on the property values. But there exists another important housing attribute that is gaining a lot of social, environmental and ethical concern and popularity over the past decade that has been largely overlooked by these models. Transforming an existing residential property green or building a new green residential property has become a growing trend these days and this study is one of the first in examining the effects of greenness on property values.

3.2 Gap in the Literature

There have been an increasing interest in real estate academia on this green revolution for the past few years but most of the work has been focused on the commercial green buildings with the increased spur of voluntary green building programs. Miller et al. (2008) is one of the first organized studies on green buildings that explore research questions on the benefits of investing in energy savings and environmental design. The study compares all U.S. based Energy Star office buildings and LEED-certified office buildings as measures of “green” with a large sample of non-Energy Star and non–LEED rated buildings. The study finds evidence that Energy Star buildings are 25% more efficient in terms of energy conservation. A similar attempt by Fuerst and McAllister (2008) finds parallel results to those by Miller et al. (2008) and both the studies used the same data source. Eichholtz, Kok, and Quigley (2009) also find a slight positive result for controlled rent differentials.

In Tinker (2003)’s study about the Austin green building program’s impact on water conservation benefits, interviews were conducted and in a part of the water conservation research few questions related to the profitability of green homes were also asked. For the survey question whether “green homes are more profitable than non-green homes”, 16% of developers hinted that they were much more profitable, 14% said somewhat more profitable, approximately 31% indicated that greenness made no difference, 18% said they were somewhat less profitable and over 21% stated they were much less profitable.

Most studies on the benefits of green investment are case studies (Kohlhepp, 2007; RICS, 2005; Scheer and Woods, 2007). While most of the studies on commercial green buildings are still preliminary and in working paper form, studies on residential green buildings are yet to show up either in refereed journals or in working paper form. This study identifies this gap in literature and attempts to contribute to the body of research focusing on residential green buildings.

CHAPTER 4

HYPOTHESIS DEVELOPMENT

During the past two decades, there has been a huge wave in the commercial and residential real estate market towards sustainability which we now call as the green revolution. There has been a growing interest among the developers' community to get a good rating from one of these green building rating systems. All these third party green building rating systems are voluntary in nature. So what is the motivation behind the huge rush towards "greening" the real estate development? In the context of green buildings, is the huge rush towards getting the certification from any green rating system because of the intrinsic value created as a result of adopting the green practices? Or is it because of the bandwagon effect created by the sudden recognition created by these green rating systems in the society?

If the builders go for the green building rating looking at the benefits reaped as a result of adopting the green and sustainable building practices, the intrinsic value will be reflected in the value of the buildings. Hence the buildings that are rated green by green building rating systems will have a premium over the buildings that are built using traditional building practices. Contrarily, the explosive growth of green building practices could be an indication of the punctuated equilibrium. Loch and Huberman (1999) used the term punctuated equilibrium in the context of technology adoption. They argue that a new technology could experience mass adoption even before the performance of the new technology has caught up with the old technology. If the developers go for the green building rating as a result of a bandwagon effect, it is evident that there is a positive signal in the market about the green building rating system. A positive signal in the market about the green building rating system also implies that the market would be willing to pay a premium for the houses built using green practices than those houses built using the traditional building practices.

Investors are increasingly looking at socially responsible investments as a priority. It is hence most likely that there exists a consumer preference for a sustainable community, hence for green development. These consumers positively value environmental benefits, and are willing to incur economic costs to achieve them, so they may be motivated primarily by the environmental rather than economic intrinsic benefits of the green buildings. So there will be a higher demand for green houses thereby escalating the prices of green houses in comparison to traditional houses.

It is indeed in the interest of real estate investors to have an investment option that provides the maximum net benefits. It is perceived that green buildings generally cost more but the associated future expected benefits compared to traditional buildings are more too. Also there have been studies that show evidence of almost ten times increase in the benefits reaped by green buildings. The perceived economic, environmental and societal benefits of green buildings adds an intrinsic premium to the value of green buildings thereby generating higher property values in comparison to traditional buildings. Hence,

Hypothesis: Greenness adds premium to the value of the property.

The motivation behind the first hypothesis assumes the voluntary nature of the green building rating systems. If there exits an ordinance in the city that mandates the residential buildings to be green, there would be an increase in the number of houses that are green in the community. This in fact brings in the concept of legitimacy, the fundamental principle of institutional theory. Organizations need to achieve and maintain environmental legitimacy in order to survive and to do that they conform to the rules and belief systems in the environment (DiMaggio and Powell, 1983). This can be extended to the residential real estate market. As it becomes a part of the system that the buildings should be green, those buildings that are not green are considered inferior which in turn makes the green properties superior and the market will be willing to pay the premium. Thus the impact of greenness on the property values will be enhanced by the presence of a mandatory green building program. Thus, *Hypothesis: Greenness and the presence of a mandatory green building program adds premium to the value of the property.*

CHAPTER 5

RESEARCH STUDY AND DATA

5.1 Study Outline

The Dallas Fortworth Metroplex is considered to be the financial hub of the Southwest, the growth of which is attributed to the high tech companies, manufacturing and service industries (Real Estate Center, TAMU). In order to understand the effect of greenness on the residential property values, this study looks at two cities, Frisco and McKinney in the Dallas Fortworth Metroplex region. The City of Frisco has the mandatory residential green building program and the City of McKinney does not currently have a residential green building program. McKinney is a city very identical to Frisco in demographics and the activity in the residential market and hence it is chosen along with Frisco for the study. Moreover both the cities are geographically adjacent to one another. Both of them are in the top 10 list of fastest growing cities in the United States. The City of Frisco falls under both Collin County and Denton County while the City of McKinney falls under the Collin County. Both the counties Collin and Denton witnessed tremendous population growth in the last decade. Collin County had a 73.9% increase in population from 1998 to 2008 while Denton County had a population growth of 61.6% in the same time period (U.S. Census Bureau, 2005 – 2007).

McKinney does not have the residential green building program as Frisco does. This provides a good platform for the study to compare the property values in these similar cities on the basis of the presence of green building program. The primary goal of this study is to find if there exists any statistically significant relationship between the property's greenness and the property values. Next, the study goes on to explore the relationship of the interaction of greenness and the presence of residential green building program to the property values.

5.2 Data Selection

This section of the thesis discusses about the methodology used to gather and code the data. Data on property sales prices was obtained from the North Texas Real Estate Information System (NTREIS)'s Multiple Listing Service (MLS) dating from January 2002 through July 1st, 2009. The City of Frisco adopted the mandatory Residential Green Building Program in May 2001. Hence the starting year for this study was chosen to be 2002 .The database contained 32562 data records. Using MLS home sales data was downloaded for both Frisco Area and McKinney Area. MLS can isolate data by Metropolitan Statistical Area (MSA). Here, when the data was downloaded for both Frisco and McKinney areas, there were data records that had other cities like Little Elm, Weston, Plano and Richardson. Since this study examines the housing prices in only Frisco and McKinney, the data records of cities other than these were eliminated from the database.

While downloading the data records, one of the search criteria was list date. When the dataset was downloaded, it was noticed that there were records that had null values in the list price field. On carefully examining the data records, it was determined that the possibility of the sales being recent ones was remote. MLS recently made certain fields to be mandatory while data entry and list price being one among them. Hence those data records with null values in their list price field can be safely assumed as sales that happened considerable time ago. Around 110 data records had null values in list date and were eliminated from the database.

The database was then searched for the presence of any duplicate data records. The MLS number was treated as the primary key while searching and duplicate records were identified. There were 252 duplicate records and they were eliminated from the database. Then the database was searched based on the property type and all the data records that were not single family residences were eliminated as the study looks at the impact of greenness on the sales price of single family residences. There were 134 properties that were not single family residences. They included townhomes, condominiums and ranch houses.

It was also noticed that there were irrelevant values entered in various fields in the database. One of the commonly occurred mistakes in the fields was the sales price field where the value per square foot was written in the sales price field. These mistakes were corrected by converting the sales price per square foot to absolute sales price values. These values were then compared with the listing price as a double check. There were 10 data records that had this problem. Another field that witnessed similar irrelevancy in the data entry was the year built field. The commonly entered mistaken values were “9999” and null. In this case, since there was no way of making a scientifically valid guess, these values were substituted with mean commonly known as the mean replacement technique. In this way, the data records were not eliminated from the database. There were 56 data records that had this problem. After the above stated data eliminations and data corrections, the final database contained 31,980 data records for the two cities Frisco and McKinney spanning over seven and a half years from 2002 to 2009 both years included.

5.3 Green Variable

The MLS database contains two fields that are devoted for identifying greenness in a residential building. The two green variables (green certification and the green features) in the MLS database were not populated as they were relatively new fields. There were only 356 residential properties that did not have empty values in these two green fields. Since the variable of interest in this study is greenness and the MLS database could not clearly capture the greenness through the designated green fields, the primary task was to create a green variable and populate the field based on other criteria. For this purpose of creating the “green” variable the dataset for both the cities were treated as separate datasets for as it would be a laborious task to create the variable with the combined dataset. The two cities though almost similar in many respects have a fundamental difference in terms of their policies towards green buildings. The City of Frisco has a mandatory green building program and hence the identification of green buildings follows a different methodology from that of the City of

McKinney as it does not have a mandatory residential green building program. In order to address these differences the datasets were treated separately for the creation of the green variable and after creating the variable the datasets were merged to form a single dataset.

5.3.1 Creation of Green Variable for Frisco

According to the ordinance passed on May 2nd 2001, all residential plats accepted after May 23, 2001 are required to build to the mandatory green building program standards of the City of Frisco's Residential Green Building Program. Hence the City of Frisco maintains a list of subdivisions that were platted after 2001. The list of subdivisions that were platted after 2001 was got from the City of Frisco. The list is attached in Appendix C. The MLS has a data field called subdivisions that records the name of the subdivision the residential property falls under. An extensive search was performed to identify and match the names of subdivisions provided in the green list by the City of Frisco to the MLS database of Frisco. The list contained 183 subdivisions that were platted as green subdivisions and hence the search was going to be an arduous one. In order to save on time and also to make the process more error free, a search based algorithm was programmed and executed using Microsoft Excel 2007. The execution of the program enabled all the data records in MLS with the names of subdivisions given in the list to be identified and marked as green. The green variable is a dummy variable that gets the value of 1 if the residential building is green and gets a value of 0 if the residential building is not green.

Since this is one of the most important tasks in the entire study, extra care was taken in determining and confirming if the residential property was green. The City of Frisco's website has a GIS interactive map provided with all the subdivisions with details about them. There is a field called green that is mentioned either as True or False depending on whether the subdivision is green or not. The entire GIS map was searched to check if the 183 subdivisions provided were green. Also the entire GIS map was searched to see if there were any additional subdivisions other than the 183 subdivisions in the provided list that were green to avoid missing any houses that were green.

The city updated and improved the Residential Green Building Program and the revised program is put into effect for all homes receiving a building permit on, or after, July 1, 2007. Therefore all buildings that were built after 2007 are green. Hence a search based on year built was made and all the data records with year greater than or equal to 2007 were marked as green. So the green variable gets the value 1 if the building is green and a value of 0 if the building is not green. These two ways of identifying green houses based upon the city's mandatory policies cover the major portion of the green houses present in Frisco. These houses are all houses either platted after 2001 or built after 2007. This sample does not cover those houses that were built or platted before 2007 and 2001 respectively but could be green due to the owner's preferences. So the following types of searches were done on the database to identify houses that were green from the remaining database. This constitutes only a small portion of the green houses.

A green building encompasses features that increase energy efficiency, water conservation, use of recycled products and renewable energy and also concerns for the environment. So a massive keyword search was performed with green words like solar, etc on the MLS database. The list of green words that were used in the search is attached in Appendix D. A search algorithm was written and executed in Microsoft Excel 2007 to conduct the keyword search across the huge database to improve the accuracy and the efficiency of the search. All data records that had one or more of the keywords were marked as green and the others were marked as non green. So the green variable gets the value 1 if the building is green and a value of 0 if the building is not green. The City of Frisco has around 6504 green homes in the list of 16720 homes in the database, almost 40 percent.

5.3.2 Creation of Green Variable for McKinney

Creating the green variable for the McKinney dataset was relatively an easier job. The data records that did not have empty values in the two green variables, green certification and green features in the MLS database were treated as green properties. In addition to this, a keyword search was performed with green words like solar, etc on the MLS database. The list of green words that were used in the search was the same as those used for the keyword search for Frisco and is attached in Appendix D. The same search algorithm that was written and executed in Microsoft Excel 2007 for Frisco's search was used to conduct the keyword search across the McKinney database. All data records that had one or more of the keywords were marked as green and the others were marked as non green. So the green variable gets the value 1 if the building is green and a value of 0 if the building is not green. The City of McKinney has around 598 green homes in the list of 15260 homes in the database, almost 4 percent. After the green variable was created for both the datasets, the two datasets were merged into one dataset.

CHAPTER 6

METHODOLOGY

Hedonic pricing model is generally used to empirically understand the relationship between various housing characteristics and the housing values. Smith (1971) established hedonic pricing model in real estate analysis and thus established legitimacy for the use of hedonic pricing as an efficient methodology in real estate literature. After undergoing a lot of refinement over almost four decades today's models are more robust and stable.

In the past hedonic studies have looked at the relationship between the housing prices and structural features that includes lot size, square feet, age, number of bathrooms, and number of bedrooms etc, internal features that includes full baths, half baths, fireplace, air conditioning, hardwood floors, and basement etc, external features that include garage spaces, deck, pool, porch, carport, and garage etc, natural environmental features that include lake view, lake front, ocean view, and good view etc, neighborhood and location characteristics that include location, crime, distance, golf course, and trees etc, public services that include school district, percent of school district minority, public sewer etc, marketing characteristics that include occupancy, and selling factors that include assessor's quality, assessed condition, vacant, owner-occupied, time on the market, and a time trend etc and financing characteristic that include FHA financing, VA financing, foreclosure, favorable financing, and property taxes etc.(Sirmans and Macpherson, 2003). This study uses hedonic pricing technique in an attempt to capture the fraction of property prices that are derived from greenness which is a specific housing characteristic.

6.1 Data Analysis

The database contained sales price ranging from sales as low as $9999 to sales a high as $3.5 million. The mean of the sales price was $220,000. It was very evident that the database contains sales data belonging to different submarkets. The first task was to break the sales data into submarkets. The database was divided into three broader submarkets the first submarket being the sales data between $100,000 to $300,000 and the second being the sales data between $300,000 to $600,000 and the third being sales data more than $600,000. There were 24782 data records in the $100,000 to $300,000 category, 6153 records in the $300,000 to $600,000 category and 1045 records in the above $600,000 category.

As the focus of this study is to examine the relationship between the variable of interest, the green variable to the dependent variable, the sales price it may be sufficient to look at one of the submarkets. The submarket chosen to understand the relationship is the first submarket with the sales data between $100,000 and $300,000. This submarket forms the majority of the database with around 78% of the data records from the main dataset. In order to statistically show evidence that the sample here the chosen sub market is a representative sample of the population here the entire dataset, statistical hypothesis testing was performed by comparing the means of the sample and that of the population. The null hypothesis for this statistical testing is that the means are equal. When the hypothesis was tested at 95% confidence level, the null hypothesis that the means were equal was not rejected and hence there is statistical evidence that the sub market chosen is a representative of the population and hence this study chooses to analyze and examine the relationship between the variable of interest and the dependent variable in the $100,000 to $300,000 submarket.

Histograms and box plot were drawn to examine the variables if they were symmetric or skewed. These univariate graphs suggested the presence of very strong outliers in the case of the age variable. On carefully examining the dataset, it was noticed that there were 183 sales with houses more than 100 years old. This really skewed the distribution of the variable and they were treated as strong outliers and were considered to be removed from the dataset. On examining their standard deviations it was found that they were more than 50 standard deviations away from the mean age and hence they were removed from the dataset. Another variable that had more than 12 standard deviations was the number of bedrooms. On carefully examining the data records with large standard deviations from the mean it was seen that there were inconsistent values in the number of bedrooms. So 8 data records were eliminated from the dataset and the final dataset contained 24591 data records.

6.2 Variables

The dependent variable in this multiple regression study is the sales price. Numerous other independent variables are introduced with the green variable being the variable of interest. Sales prices are regressed against a set of control variables like neighborhood variables (such as the quality of schools), and structural characteristics of the house (such as number of bedrooms). This can estimate how the residential property being green is related to a change in property value, holding other characteristics of the property constant.

This study uses structural characteristic variables like square foot, age, bedrooms, bathrooms, acres, fireplace and neighborhood characteristic variables like school district, locational characteristic variables like county as control variables for structural and neighborhood characteristics. The study also controls for foreclosure and the number of days the property is listed on the market. In order to control for the market condition and seasonality, the study uses year dummies as trend variables and month dummies as seasonality control variables.

In a review of hedonic pricing models (Sirmans et al, 2005), 125 studies were examined to find the most frequently used characteristics in the hedonic pricing models. These include, along with many other characteristics, square feet, age, fireplace, the number of bathrooms, the number of bedrooms etc. Square footage, fireplace, the number of bathrooms, the number of bedrooms, acreage all of which that are used in this study have an expected positive relationship with the sales price. Age is often the most frequent characteristic used in hedonic models and typically has the expected negative relationship with the sales price. One of the commonly used neighborhood characteristics is school district especially in an empirical analysis of property values in single family residences and there is an expected positive relationship between better school district and property values.

To control for characteristics at the community level, this study considers county dummies. The county dummy represents the locational differentials in median income level, demographic composition, crime rate and other factors that might affect the property prices in the neighborhood. This study does not choose to use city dummy to control for the locational differentials. This is due to the fact that there are factual demonstration of significant demographic differences among the two counties, Collin and Denton where the two cities belong to but there are lesser demographic differences among the two cities (U.S Census Bureau 2005 - 2007). In fact, the similarity in the demography of the two cities was one of the motivations behind the choice of cities for comparison. Year dummies are used to control for the overall market conditions over the period of 2002 to 2009 and month dummies are used to control for the seasonal effects. Generally effects of seasonality have been found significant in property sales (Goodman, 1992).

Table 6.1 shows the variables to be used along with the description of the same. Table 6.2 shows the descriptive statistics of the variables to be used in the model. The expected relationship between the exploratory variables and the dependent variable is shown in Table 6.3.

Table 6.1 Labels and Variables with their description

Label	Variable	Name	Description
SALES	sls	SALES PRICE	
LNSALES	lnsales	NATURAL LOG OF SALES	
SQFT	SqFt	SQUARE FOOTAGE	
ACRES	Acres	ACRES	
AGE	Age	AGE	
DOM	Days	DAYS ON MARKET	
BEDS	Beds	NUMBER OF BEDS	
BATH_FULL	FB	NUMBER OF FULL BATHS	
BATH_HALF	HB	NUMBER OF HALF BATHS	
D_POOL	Pooldummy	SWIMMING POOL	DUMMY VARIABLE VALUE EQUALS ONE IF POOL IS PRESENT
D_FP	Fpdummy	FIREPLACE	DUMMY VARIABLE VALUE EQUALS ONE IF FIREPLACE IS PRESENT
D_FENCE	Fencedummy	FENCE	DUMMY VARIABLE VALUE EQUALS ONE IF FENCE IS PRESENT
D_GREEN	green_city	GREEN	DUMMY VARIABLE VALUE EQUALS ONE IF PROPERTY IS GREEN
D_COUNTY	Countydummy	COUNTY	DUMMY VARIABLE VALUE EQUALS ONE IF PROPERTY IS IN COLLIN
D_SCHOOL	Schooldummy	SCHOOL DISTRICT	DUMMY VARIABLE VALUE EQUALS ONE IF PROPERTY IS IN FRISCO ISD
D_FORECLOSURE	foreclosuredummy	FORECLOSURE	DUMMY VARIABLE VALUE EQUALS ONE IF PROPERTY IS FORECLOSED
D_JAN	jan_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN JAN
D_FEB	feb_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN FEB
D_MAR	mar_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN MAR
D_APR	apr_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN APR
D_MAY	may_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN MAY
D_JUN	jun_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN JUN
D_JUL	jul_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN JUL
D_AUG	aug_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN AUG
D_SEP	sep_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN SEP
D_OCT	oct_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN OCT
D_NOV	nov_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN NOV
D_DEC	dec_dummy	SEASONALITY CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN DEC
D_2009	ys_09_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2009
D_2008	ys_08_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2008
D_2007	ys_07_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2007
D_2006	ys_06_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2006
D_2005	ys_05_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2005
D_2004	ys_04_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2004
D_2003	ys_03_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2003
D_2002	ys_02_dummy	TREND CONTROL	DUMMY VARIABLE VALUE EQUALS ONE IF SALE IS IN 2002

Table 6.2 Descriptive Statistics of dependent and independent variables

	N	Minimum	Maximum	Mean	Std. Deviation
SALES	24591	100500	300000	188480.47	47315.806
SQFT	24591	988	5095	2424.36	655.162
ACRES	24591	.0000	150.0000	.106658	1.8790594
AGE	24591	0	50	5.89	6.009
DOM	24591	0	884	99.13	68.199
BEDS	24591	2	7	3.66	.650
BATH_FULL	24591	1	5	2.31	.555
BATH_HALF	24591	0	5	.39	.495
D_POOL	24591	0	1	.07	.251
D_FP	24591	0	1	.84	.369
D_FENCE	24591	0	1	.90	.294
D_GREEN	24591	0	1	.17	.380
D_COUNTY	24591	0	1	.88	.330
D_SCHOOL	24591	0	1	.53	.499
D_FORECLOSURE	24591	0	1	.09	.290
D_JAN	24591	0	1	.05	.226
D_FEB	24591	0	1	.07	.251
D_MAR	24591	0	1	.09	.290
D_APR	24591	0	1	.09	.283
D_MAY	24591	0	1	.10	.298
D_JUN	24591	0	1	.11	.311
D_JUL	24591	0	1	.10	.293
D_AUG	24591	0	1	.09	.290
D_SEP	24591	0	1	.07	.263
D_OCT	24591	0	1	.08	.266
D_NOV	24591	0	1	.07	.256
D_DEC	24591	0	1	.08	.273
D_2009	24591	0	1	.06	.229
D_2008	24591	0	1	.13	.338
D_2007	24591	0	1	.15	.357
D_2006	24591	0	1	.17	.376
D_2005	24591	0	1	.18	.382
D_2004	24591	0	1	.15	.358
D_2003	24591	0	1	.14	.346
D_2002	24591	0	1	.03	.157
Valid N (listwise)	24591				

6.3 Multiple Linear Regression

"Hedonic pricing theory postulates that the value of a house is a function of the quantitative and qualitative attributes that are components of the house. Hedonic pricing theory is tested using a multiple regression analysis" (Dotzour & Levi, 1991), where:

Sales Price of a house = $f\ (Xi, Yi)$, where

Xi = vector of quantitative factors such as age, size, baths, fireplaces, and garage;

Yi = vector of qualitative factors such as neighborhood condition, physical property condition, and school district. To test the hypothesis a multiple regression was constructed according to the following form:

Sales Price of a house = $f(Xi, Yi, Z)$,where

Z = 1, if house was green, and Z = 0 otherwise.

This study uses SPSS (Statistical Package for the Social Sciences) Statistics Version 17.0.1 for all the statistical analyses.

6.3.1 Ordinary Least Squares Method

Ordinary least squares method is the most commonly used technique to generate estimators and other statistics in regression analysis. This method of best fit produces a line that minimizes the sum of the squared vertical distances from the line to the observed data points. The data has to be analyzed and checked for any potential problems and has to be corrected and validated before running the regression.

The first task was to check for multicollinearity. Multiple regression analysis requires no multicollinearity. So the primary task is to evaluate if there exists any multicollinearity among the chosen variables. The presence of collinearity among two or more independent variables can create difficulty in measuring the influence of one specific variable, here the green variable in the dependent variable, here the sales price. If the specific variable of interest is highly correlated with other variables in the model, hypothesis testing of the influence becomes problematic. One potential issue is that the individual p values can be misleading in that a p value can be high, even though the variable is important. Another issue is that the confidence intervals on the regression coefficients will be very wide. The confidence intervals may even include zero that creates an inconclusive relationship between the variables in that it creates confusion whether an increase in the independent variable is related with an increase, or a decrease, in the dependent variable. Because the confidence intervals are so wide, exclusion or inclusion of a new data point can dramatically affect the coefficients and sometimes may even alter the direction of the relationship.

In order to identify problems of multicollinearity, correlations between the independent variables were examined from the Pearson Correlation Matrix. It was found that three variables BEDS, BATH_FULL, BATH_HALF were highly correlated with the SQFT variable. Also another method of detecting severity of multicollinearity called the Variance Inflation factor (VIF) was used. It an indicator that measures how much the variance of a coefficient is increased because of collinearity. The VIF values corresponding to BEDS, BATH_FULL, BATH_HALF and SQFT also show evidence of multicollinearity between these variables. Hence these independent variables were removed from the model.

The next task was to check for any violations of regression assumptions in the database. The four regression assumptions that were tested are normality, linearity, heteroskedasticity and statistical independence. The first step to evaluate any violation is visual examination of the graphs produced by the residuals. The residual plots were examined to see if there are any patterns. The residual plots did not show any signs of curvilinear patterns and cyclical patterns and hence shows no evidence for violations of linearity or statistical independence commonly known as auto correlation. Durbin Watson test was conducted to statistically test for presence of auto correlation and the test showed no statistically significant evidence of auto correlation. The histogram plot of standardized residuals showed some violations in normality having around four standard deviations on either side of the tail.

The residual plots showed strong flared pattern that hinted on the presence of heteroskedasticity. Heteroskedasticity sometimes could also be one of the reasons why there could be violations in normality. After seeing some evidence of a possibility of heteroskedasticity through residual plots, a more valid test had to be performed to show statistically significant evidence of heteroskedasticity. In order to show statistically significant evidence of heteroskedasticity, White's general test of heteroskedasticity was performed using SPSS. Appendix A shows the SPSS result of the White's general test of heteroskedasticity and it can be seen that the null hypothesis that there is homoskedasticity is rejected at the given significance level of Chi Square. This shows statistically significant evidence of presence of heteroskedasticity.

As there is statistically significant evidence of heteroskedasticity, corrections have to be done before the regression analysis. There are studies that included age and the square of age to take into consideration the possible heteroskedasticity due to the nonlinear effect of age on price (Goodman and Thibodeau, 1997). So a new variable AGESQ was created and regression was done to check if the heteroskedasticity was eliminated as a result of inclusion of AGESQ. But it was shown that there was no significant change in the model both in terms of the explanatory power and also the reduction of heteroskedasticity and hence AGESQ was removed.

There are three universal corrections for heteroskedasticity. One way is to use a different specification for the model by transformations of variables. The variables were transformed to the natural logarithmic vales and then the regression was run and residuals were plotted. There was significant flared pattern in the residuals by visual detection and the White's test also showed statistically significant evidence of heteroskedasticity.

Another method of correction is using heteroskedasticity consistent standard errors (HCSE).This is also called as the White's correction. In general, HCSEs are greater than their OLS counterparts, resulting in lower t statistic and a reduced p value of statistically significant coefficients. The White method corrects for heteroskedasticity without varying the values of the coefficients but the estimates are still biased. Appendix B shows the estimated t statistic and p values after White's correction.

The third method is the application of weighted least squares estimation method, in which ordinary least squares method is applied to weighted values of dependent variables and the independent variable. Weighted least squares regression method corrects for any violation of the homoskedasticity assumption by weighting cases differentially. Those cases whose values on the dependent variable have large variances on one or more independent variables count less than those with small variances in estimating the regression coefficients. This implies that those cases with greater weights contribute more to the fit of the regression line.

6.3.2 Weighted Least Squares Method

The weighted least squares method incorporates the behavior of the random errors in the model. If the variance of the random errors in the data is not uniform across all levels of the independent variables, using weighted least squares method with weights that are inversely proportional to the variance at each level of the independent variables gives the most accurate parameter estimation possible.

The theory behind the weighted least squares method is based on the assumption that the weights are known exactly. This is quite impossible for datasets from the real and hence estimated weights must be used instead. The consequence of using estimated weights is tricky to evaluate, but it is most often seen that small variations in the weights due to estimation do not have an effect on the regression analysis or its interpretation. Moreover, when the weights are estimated from large number of observations, the results of the regression analysis are almost unaffected. Since the dataset used in the study has more than 25000 observations, the usage of weighted least squares method in estimating the coefficients of the independent variables is seldom questioned. Weighted least squares method is a two-step process. The first step involves determination of the weight estimates. Then the OLS regression is run on the weighted cases which will eliminate heteroskedasticity and provide better estimates of the coefficients of the independent variables.

6.3.2.1 Weight Estimation

Before estimating the weights, the independent variable or variables that is creating the heteroskedasticity should be identified. In order to identify the potential cause of heteroskedasticity from the candidate of independent variables, a scatter plot matrix of all the independent variables were drawn. The scatter plots were then analyzed and examined to see if there are any flared patterns, a sign of heteroskedasticity. The scatter plot of SQFT showed flared pattern providing some evidence of heteroskedasticity. Also the pattern was very much consistent to the pattern seen in the residual plot of the ordinary least square regression results. It should also be noted that the independent variable SQFT has the highest correlation with the dependent variable thereby providing the greatest explanatory power than all the other independent variables. So SQFT provides the greatest influence on the dependent variable. After identifying the predictor variable, here SQFT, weights should be estimated.

There are various methods of estimating the weights of the weighted least squares technique. One particular method that works extremely well for the weight estimation is the power function model. Also, the power function model is one of the most convenient methods when there is only one predictor variable. The power function model estimates the weights by checking for the power of the independent variable that maximizes the log-likelihood of the dependent variable. It uses the reciprocal of this power of the independent variable to weight the observations. Using SPSS's power function weight estimation procedure, the weights were estimated and the Table 6.3 shows the log likelihood function of various powers and the power used to estimate the weights.

When fitting the model for the estimation of the weights, it is imperative to make a note that the typical regression assumptions might not hold good. Particularly the variation of the random errors is not constant across the different sets of observations and their distribution does not assume normality. However, taking the natural log transformation stabilizes the variation. Hence the natural log transformation of the dependent variable LNSALES is used for the regression analysis using the weighted least squares method.

Table 6.3 Log-Likelihood Values

Power	-4.000	7467.394
	-3.500	9098.040
	-3.000	10617.354
	-2.500	12017.421
	-2.000	13289.623
	-1.500	14424.753
	-1.000	15413.144
	-.500	16244.853
	.000	16909.893
	.500	17398.545
	1.000	17701.740
	1.500	17811.497[a]
	2.000	17721.356
	2.500	17426.765
	3.000	16925.346
	3.500	16217.008
	4.000	15303.885

[a]Power that maximizes the log likelihood function = 1.5

CHAPTER 7

RESULTS

7.1 Model 1 - Main Effect

After the weight estimation, multiple linear regression analysis using the weighted least squares method is conducted to estimate the coefficients of the independent variables in the model. To statistically test for main effects hypothesis testing involves the property being green having an influence on the selling price of the property. The corresponding variable of interest is D_GREEN. To test the hypothesis a semi-log multiple regression analysis was constructed according to the following form:

$$\text{LNSALES} = f\ (W_i, X_i, Y_i, Z), \text{ where}$$

X_i = vector of quantitative factors such as age, size, baths, fireplaces etc

Y_i = vector of qualitative factors such as neighborhood condition etc

W_i = weights estimated by the weighted least square method.

Z = 1 if property is green and Z = 0 if property is not green

The model described for the multiple linear regression analysis using the weighted least square method is given in Table 7.1.

Multiple regression analysis was employed to measure the magnitude of the marginal contribution of greenness on the selling price, if any. To achieve this, multiple linear regression analysis was used with all the control variables and the variable of interest, the green variable using the Enter method in SPSS. From the candidate variables a stepwise regression model using SPSS was also employed to double check if any relevant independent variables with significant exploratory power were omitted in the original model.

Table 7.1 Model Description – Model 1: main effect

Dependent Variable		lnsales
Independent Variables	1	Age
	2	SqFt
	3	Pooldummy
	4	Fpdummy
	5	Fencedummy
	6	Countydummy
	7	GreenFinal
	8	jan_dummy
	9	feb_dummy
	10	mar_dummy
	11	apr_dummy
	12	may_dummy
	13	jul_dummy
	14	aug_dummy
	15	sep_dummy
	16	oct_dummy
	17	nov_dummy
	18	dec_dummy
	19	ys_09_dummy
	20	ys_08_dummy
	21	ys_07_dummy
	22	ys_06_dummy
	23	ys_04_dummy
	24	ys_03_dummy
	25	ys_02_dummy
	26	Days
	27	Schooldummy
	28	foreclosuredummy
	29	Acres
Weight	Source	SqFt
	Power Value	1.500

The descriptive statistics of the model variables used in the analysis are detailed in Table 7.2. Pearson Correlation Matrix shown in Table 7.3 was used to check for potential multicollinearity. Since the variables BEDS, BATH_FULL, BATH_HALF that were highly correlated with SQFT were eliminated from the model when the model was estimated using the ordinary least squares method, this model did not face any multicollinearity issues. A look at the VIF values also shows no evidence of multicollinearity.

Table 7.2 Descriptive Statistics – Model 1: main effect

	N	Minimum	Maximum	Mean	Std. Deviation
LNSALES	24591	11.52	12.61	12.12	0.25
SQFT	24591	988	5095	2424.36	655.16
ACRES	24591	0	150	0.11	1.88
AGE	24591	0	50	5.89	6.01
DOM	24591	0	884	99.13	68.20
D_FORECLOSURE	24591	0	1	0.09	0.29
D_POOL	24591	0	1	0.07	0.25
D_FP	24591	0	1	0.84	0.37
D_FENCE	24591	0	1	0.90	0.29
D_GREEN	24591	0	1	0.17	0.38
D_SCHOOL	24591	0	1	0.53	0.50
D_COUNTY	24591	0	1	0.88	0.33
D_JAN	24591	0	1	0.05	0.23
D_FEB	24591	0	1	0.07	0.25
D_MAR	24591	0	1	0.09	0.29
D_APR	24591	0	1	0.09	0.28
D_MAY	24591	0	1	0.10	0.30
D_JUN	24591	0	1	0.11	0.31
D_JUL	24591	0	1	0.10	0.29
D_AUG	24591	0	1	0.09	0.29
D_SEP	24591	0	1	0.07	0.26
D_OCT	24591	0	1	0.08	0.27
D_NOV	24591	0	1	0.07	0.26
D_DEC	24591	0	1	0.08	0.27
D_2009	24591	0	1	0.06	0.23
D_2008	24591	0	1	0.13	0.34
D_2007	24591	0	1	0.15	0.36
D_2006	24591	0	1	0.17	0.38
D_2005	24591	0	1	0.18	0.38
D_2004	24591	0	1	0.15	0.36
D_2003	24591	0	1	0.14	0.35
D_2002	24591	0	1	0.03	0.16
Valid N (listwise)	24591				

Table 7.3 Pearson Correlation Matrix

	LNSALES	AGE	SQFT	D_POOL	D_FP	D_FENCE	D_COUNTY	D_GREEN	D_JAN	D_FEB	D_MAR	D_APR
LNSALES	1.000	-0.302	0.820	0.171	0.186	0.093	-0.332	0.259	-0.009	-0.003	-0.011	-0.008
AGE	-0.302	1.000	-0.281	0.137	0.030	0.058	0.173	-0.224	-0.005	0.001	-0.004	0.013
SQFT	0.820	-0.281	1.000	0.093	0.111	0.035	-0.236	0.211	0.010	0.005	-0.005	-0.014
D_POOL	0.171	0.137	0.093	1.000	0.059	0.041	0.050	-0.054	-0.027	-0.008	-0.007	0.020
D_FP	0.186	0.030	0.111	0.059	1.000	0.463	-0.059	-0.042	-0.014	-0.006	-0.015	0.004
D_FENCE	0.093	0.058	0.035	0.041	0.463	1.000	-0.030	-0.049	-0.015	0.001	-0.005	0.011
D_COUNTY	-0.332	0.173	-0.236	0.050	-0.059	-0.030	1.000	-0.253	-0.012	-0.002	0.007	-0.004
D_GREEN	0.259	-0.224	0.211	-0.054	-0.042	-0.049	-0.253	1.000	0.007	0.010	0.000	-0.005
D_JAN	-0.009	-0.005	0.010	-0.027	-0.014	-0.015	-0.012	0.007	1.000	-0.063	-0.076	-0.074
D_FEB	-0.003	0.001	0.005	-0.008	-0.006	0.001	-0.002	0.010	-0.063	1.000	-0.086	-0.084
D_MAR	-0.011	-0.004	-0.005	-0.007	-0.015	-0.005	0.007	0.000	-0.076	-0.086	1.000	-0.101
D_APR	-0.008	0.013	-0.014	0.020	0.004	0.011	-0.004	-0.005	-0.074	-0.084	-0.101	1.000
D_MAY	-0.001	0.026	-0.010	0.010	0.001	0.006	-0.001	-0.002	-0.079	-0.089	-0.107	-0.104
D_JUN	0.017	0.020	0.003	0.018	0.019	0.025	0.005	-0.009	-0.082	-0.093	-0.112	-0.109
D_JUL	0.014	0.007	0.003	0.000	0.025	0.017	0.006	-0.017	-0.077	-0.087	-0.104	-0.101
D_AUG	0.022	0.007	0.015	0.029	0.008	0.001	0.002	0.003	-0.075	-0.085	-0.102	-0.099
D_SEP	-0.005	-0.003	-0.011	-0.001	-0.013	-0.027	0.000	0.007	-0.068	-0.077	-0.092	-0.090
D_OCT	-0.008	-0.013	-0.005	-0.013	0.001	0.001	0.003	-0.005	-0.069	-0.078	-0.093	-0.091
D_NOV	-0.003	-0.015	0.003	-0.005	0.001	0.000	-0.009	0.005	-0.065	-0.074	-0.088	-0.086
D_DEC	-0.013	-0.042	0.009	-0.027	-0.017	-0.024	0.000	0.013	-0.070	-0.079	-0.095	-0.092
D_2009	0.041	0.063	0.030	0.006	0.009	0.023	-0.024	0.065	0.043	0.072	0.092	0.082
D_2008	0.062	0.060	0.034	0.007	-0.008	0.025	-0.001	0.063	0.005	0.007	-0.010	-0.003
D_2007	0.063	0.059	0.001	0.010	0.002	0.009	0.021	0.022	0.010	0.008	0.006	0.008
D_2006	0.041	0.024	-0.022	-0.009	0.007	0.004	0.017	-0.011	-0.009	0.007	-0.006	-0.015
D_2005	-0.028	-0.042	-0.007	-0.015	-0.047	-0.027	-0.007	-0.005	-0.014	-0.016	-0.006	-0.014
D_2004	-0.065	-0.053	0.002	0.012	-0.017	-0.052	0.000	-0.045	0.004	-0.017	-0.008	0.010
D_2003	-0.085	-0.060	-0.020	-0.004	0.052	0.024	-0.013	-0.050	-0.004	-0.013	-0.010	-0.013
D_2002	-0.027	-0.049	-0.006	-0.005	0.022	0.014	-0.009	-0.023	-0.039	-0.044	-0.052	-0.051
DOM	0.070	-0.096	0.101	-0.040	-0.047	-0.053	-0.036	0.048	0.035	0.036	0.009	0.009
D_SCHOOL	0.224	-0.063	0.059	-0.025	0.053	0.031	-0.241	0.236	0.009	-0.001	0.007	0.008
D_FORECLOSURE	-0.111	0.016	0.054	0.003	-0.150	-0.181	0.032	-0.029	0.028	0.019	0.001	0.017
ACRES	-0.007	-0.001	-0.006	-0.001	-0.033	-0.024	0.000	-0.006	-0.004	0.023	-0.005	-0.005

Table 7.3 – *Continued*

	D_MAY	D_JUN	D_JUL	D_AUG	D_SEP	D_OCT	D_NOV	D_DEC	D_2009	D_2008	D_2007	D_2006	D_2005
LNSALES	-0.001	0.017	0.014	0.022	-0.005	-0.008	-0.003	-0.013	0.041	0.062	0.063	0.041	-0.028
AGE	0.026	0.020	0.007	0.007	-0.003	-0.013	-0.015	-0.042	0.063	0.060	0.059	0.024	-0.042
SQFT	-0.010	0.003	0.003	0.015	-0.011	-0.005	0.003	0.009	0.030	0.034	0.001	-0.022	-0.007
D_POOL	0.010	0.018	0.000	0.029	-0.001	-0.013	-0.005	-0.027	0.006	0.007	0.010	-0.009	-0.015
D_FP	0.001	0.019	0.025	0.008	-0.013	0.001	0.001	-0.017	0.009	-0.008	0.002	0.007	-0.047
D_FENCE	0.006	0.025	0.017	0.001	-0.027	0.001	0.000	-0.024	0.023	0.025	0.009	0.004	-0.027
D_COUNTY	-0.001	0.005	0.006	0.002	0.000	0.003	-0.009	0.000	-0.024	-0.001	0.021	0.017	-0.007
D_GREEN	-0.002	-0.009	-0.017	0.003	0.007	-0.005	0.005	0.013	0.065	0.063	0.022	-0.011	-0.005
D_JAN	-0.079	-0.082	-0.077	-0.075	-0.068	-0.069	-0.065	-0.070	0.043	0.005	0.010	-0.009	-0.014
D_FEB	-0.089	-0.093	-0.087	-0.085	-0.077	-0.078	-0.074	-0.079	0.072	0.007	0.008	0.007	-0.016
D_MAR	-0.107	-0.112	-0.104	-0.102	-0.092	-0.093	-0.088	-0.095	0.092	-0.010	0.006	-0.006	-0.006
D_APR	-0.104	-0.109	-0.101	-0.099	-0.090	-0.091	-0.086	-0.092	0.082	-0.003	0.008	-0.015	-0.014
D_MAY	1.000	-0.116	-0.108	-0.105	-0.095	-0.096	-0.091	-0.098	0.063	0.009	-0.001	0.018	-0.022
D_JUN	-0.116	1.000	-0.113	-0.110	-0.100	-0.101	-0.096	-0.103	0.059	0.010	-0.003	0.006	-0.003
D_JUL	-0.108	-0.113	1.000	-0.102	-0.093	-0.094	-0.089	-0.095	-0.076	0.013	0.007	0.002	0.021
D_AUG	-0.105	-0.110	-0.102	1.000	-0.091	-0.092	-0.087	-0.093	-0.074	0.012	0.016	0.007	0.020
D_SEP	-0.095	-0.100	-0.093	-0.091	1.000	-0.083	-0.079	-0.085	-0.067	0.000	0.000	0.010	0.022
D_OCT	-0.096	-0.101	-0.094	-0.092	-0.083	1.000	-0.080	-0.085	-0.068	-0.002	-0.004	-0.013	0.018
D_NOV	-0.091	-0.096	-0.089	-0.087	-0.079	-0.080	1.000	-0.081	-0.065	-0.030	-0.018	-0.005	0.002
D_DEC	-0.098	-0.103	-0.095	-0.093	-0.085	-0.085	-0.081	1.000	-0.069	-0.014	-0.030	-0.005	-0.010
D_2009	0.063	0.059	-0.076	-0.074	-0.067	-0.068	-0.065	-0.069	1.000	-0.089	-0.099	-0.108	-0.110
D_2008	0.009	0.010	0.013	0.012	0.000	-0.002	-0.030	-0.014	-0.089	1.000	-0.160	-0.175	-0.177
D_2007	-0.001	-0.003	0.007	0.016	0.000	-0.004	-0.018	-0.030	-0.099	-0.160	1.000	-0.193	-0.195
D_2006	0.018	0.006	0.002	0.007	0.010	-0.013	-0.005	-0.005	-0.108	-0.175	-0.193	1.000	-0.214
D_2005	-0.022	-0.003	0.021	0.020	0.022	0.018	0.002	-0.010	-0.110	-0.177	-0.195	-0.214	1.000
D_2004	-0.015	-0.017	0.018	0.007	0.013	-0.010	0.011	0.006	-0.099	-0.160	-0.177	-0.194	-0.196
D_2003	-0.004	-0.005	0.010	0.007	0.015	0.005	0.000	0.012	-0.096	-0.155	-0.171	-0.187	-0.190
D_2002	-0.054	-0.057	-0.053	-0.051	-0.047	0.110	0.174	0.191	-0.038	-0.062	-0.068	-0.075	-0.076
DOM	-0.019	-0.027	-0.007	-0.024	-0.009	-0.004	-0.008	0.026	0.016	0.008	-0.032	-0.057	-0.001
D_SCHOOL	0.009	-0.010	0.001	-0.009	-0.007	0.001	-0.001	-0.006	0.028	0.025	0.009	-0.004	-0.020
D_FORECLOSURE	-0.011	-0.018	-0.027	-0.020	0.003	0.006	0.003	0.013	0.083	0.105	0.023	-0.021	-0.048
ACRES	-0.006	-0.006	-0.004	-0.005	0.021	-0.005	-0.003	0.002	0.004	0.015	-0.007	-0.008	-0.010

Table 7.3 – *Continued*

	D_2004	D_2003	D_2002	DOM	D_SCHOOL	D_FORECLOSURE	ACRES
LNSALES	-0.065	-0.085	-0.027	0.070	0.224	-0.111	-0.007
AGE	-0.053	-0.060	-0.049	-0.096	-0.063	0.016	-0.001
SQFT	0.002	-0.020	-0.006	0.101	0.059	0.054	-0.006
D_POOL	0.012	-0.004	-0.005	-0.040	-0.025	0.003	-0.001
D_FP	-0.017	0.052	0.022	-0.047	0.053	-0.150	-0.033
D_FENCE	-0.052	0.024	0.014	-0.053	0.031	-0.181	-0.024
D_COUNTY	0.000	-0.013	-0.009	-0.036	-0.241	0.032	0.000
D_GREEN	-0.045	-0.050	-0.023	0.048	0.236	-0.029	-0.006
D_JAN	0.004	-0.004	-0.039	0.035	0.009	0.028	-0.004
D_FEB	-0.017	-0.013	-0.044	0.036	-0.001	0.019	0.023
D_MAR	-0.008	-0.010	-0.052	0.009	0.007	0.001	-0.005
D_APR	0.010	-0.013	-0.051	0.009	0.008	0.017	-0.005
D_MAY	-0.015	-0.004	-0.054	-0.019	0.009	-0.011	-0.006
D_JUN	-0.017	-0.005	-0.057	-0.027	-0.010	-0.018	-0.006
D_JUL	0.018	0.010	-0.053	-0.007	0.001	-0.027	-0.004
D_AUG	0.007	0.007	-0.051	-0.024	-0.009	-0.020	-0.005
D_SEP	0.013	0.015	-0.047	-0.009	-0.007	0.003	0.021
D_OCT	-0.010	0.005	0.110	-0.004	0.001	0.006	-0.005
D_NOV	0.011	0.000	0.174	-0.008	-0.001	0.003	-0.003
D_DEC	0.006	0.012	0.191	0.026	-0.006	0.013	0.002
D_2009	-0.099	-0.096	-0.038	0.016	0.028	0.083	0.004
D_2008	-0.160	-0.155	-0.062	0.008	0.025	0.105	0.015
D_2007	-0.177	-0.171	-0.068	-0.032	0.009	0.023	-0.007
D_2006	-0.194	-0.187	-0.075	-0.057	-0.004	-0.021	-0.008
D_2005	-0.196	-0.190	-0.076	-0.001	-0.020	-0.048	-0.010
D_2004	1.000	-0.171	-0.069	0.047	-0.022	-0.020	0.011
D_2003	-0.171	1.000	-0.066	0.030	0.001	-0.062	-0.002
D_2002	-0.069	-0.066	1.000	-0.002	-0.007	-0.041	-0.001
DOM	0.047	0.030	-0.002	1.000	-0.033	-0.043	-0.002
D_SCHOOL	-0.022	0.001	-0.007	-0.033	1.000	-0.037	-0.020
D_FORECLOSURE	-0.020	-0.062	-0.041	-0.043	-0.037	1.000	0.002
ACRES	0.011	-0.002	-0.001	-0.002	-0.020	0.002	1.000

The full model is given by

$$
\begin{aligned}
LNSALES = {} & b_0 + b_1 \times AGE + b_2 \times ACRES + b_3 \times SQFT + b_4 \times DOM \\
& + b_5 \times D\_FORECLOSURE + b_6 \times D\_POOL + b_7 \times D\_FP + b_8 \times D\_FENCE \\
& + b_9 \times D\_SCHOOL + b_{10} \times D\_COUNTY + b_{11} \times D\_JAN + b_{12} \times D\_FEB \\
& + b_{13} \times D\_MAR + b_{14} \times D\_APR + b_{15} \times D\_MAY + b_{16} \times D\_JUN + b_{17} \times D\_JUL \\
& + b_{18} \times D\_AUG + b_{19} \times D\_SEP + b_{20} \times D\_OCT + b_{21} \times D\_NOV + b_{22} \times D\_DEC \\
& + b_{23} \times D\_2009 + b_{24} \times D\_2008 + b_{25} \times D\_2007 + b_{26} \times D\_2006 + b_{27} \times D\_2005 \\
& + b_{28} \times D\_2004 + b_{29} \times D\_2003 + b_{30} \times D\_2002 + b_{31} \times D\_GREEN + \in_t
\end{aligned}
$$

The reduced model is given by

$$
\begin{aligned}
LNSALES = {} & b_0 + b_1 \times AGE + b_2 \times ACRES + b_3 \times SQFT + b_4 \times DOM \\
& + b_5 \times D\_FORECLOSURE + b_6 \times D\_POOL + b_7 \times D\_FP + b_8 \times D\_FENCE \\
& + b_9 \times D\_SCHOOL + b_{10} \times D\_COUNTY + b_{11} \times D\_JAN + b_{12} \times D\_FEB \\
& + b_{13} \times D\_MAR + b_{14} \times D\_APR + b_{15} \times D\_MAY + b_{16} \times D\_JUN + b_{17} \times D\_JUL \\
& + b_{18} \times D\_AUG + b_{19} \times D\_SEP + b_{20} \times D\_OCT + b_{21} \times D\_NOV + b_{22} \times D\_DEC \\
& + b_{23} \times D\_2009 + b_{24} \times D\_2008 + b_{25} \times D\_2007 + b_{26} \times D\_2006 + b_{27} \times D\_2005 \\
& + b_{28} \times D\_2004 + b_{29} \times D\_2003 + b_{30} \times D\_2002 + \in_t
\end{aligned}
$$

The null hypothesis, H_0 to be tested is given by

H_0 : The property being green does not add premium to the sales price

$H_0 : \beta_{31} = 0.$

The alternative hypothesis, H_1 is given by

H_1 : The property being green adds premium to the sales price

$H_1 : \beta_{31} > 0.$

Tables 7.4, 7.5, 7.6 show the results of the model regression analysis. This model has an R square of 77.9% and an Adjusted R square of 77.9%. This means that the independent variables added in the model explain 77.9% of the variation in the dependent variable. The F statistic of the model is 2990.541 and the p value corresponding to the F statistic is 0.000 at the 5% significance level. Since the F statistic is too large and the p value corresponding to the F statistic is too small, the model is powerful in explaining the relationship between the variables.

The final regression equation is given by

$$
\begin{aligned}
LNSALES &= 11.415 - .004 \times AGE + .000 \times ACRES + .000 \times SQFT + .000 \times DOM \\
&- .125 \times D\_FORECLOSURE + .123 \times D\_POOL + .042 \times D\_FP - .001 \times D\_FENCE \\
&+ .065 \times D\_SCHOOL - .085 \times D\_COUNTY - .019 \times D\_JAN - .014 \times D\_FEB \\
&- .014 \times D\_MAR - .007 \times D\_APR - .006 \times D\_MAY + .000 \times D\_JUN + .003 \times D\_JUL \\
&+ .000 \times D\_AUG + .001 \times D\_SEP - .001 \times D\_OCT + .000 \times D\_NOV - .008 \times D\_DEC \\
&+ .048 \times D\_2009 + .048 \times D\_2008 + .056 \times D\_2007 + .046 \times D\_2006 + .000 \times D\_2005 \\
&- .027 \times D\_2004 - .038 \times D\_2003 - .037 \times D\_2002 + .009 \times D\_GREEN + \in_t
\end{aligned}
$$

From this regression analysis, the selection of the D_GREEN variable suggests that the null hypothesis is rejected at the 5% significance level. This shows evidence of support of alternative hypothesis that there exists a premium in the sales price if the property is green. The beta coefficient is 0.009 and the p value associated with the t statistic of the beta coefficient is low thereby rejecting the null hypothesis. Therefore, the model clearly reveals there is a statistically significant change in value because of the property being green. Out of the 30 control variables entered in the model, only 19 variables were statistically significant. Also, as a quick check we can look at the t values of the independent variables. If they are greater than 2, then they will be statistically significant at the 5% significance level. We see that out of the 31 variables included in the model including the variable of interest only 20 variables had a t statistic greater than 2 at the 5% significance level.

In a weighted analysis, the distribution of the residuals can vary substantially with the different values of the predictor variables. So we have to use weighted residuals (Graybill and Iyer, 1994) to check for any violation in the assumptions. SPSS do not compute and return weighted residuals when a weighted fit is done, so the residuals were weighted manually in an additional step. After computing he weighted residuals they were plotted and it could be seen in Figure 1 that the flared pattern of residuals had been dramatically eliminated by using the weighted least squares method. Thus the model fitted by the weighted least squares method is a better estimate of the coefficients of the independent variables than that estimated by the model fitted by the ordinary least squares model.

Table 7.4 Model Summary – Model 1: main effect

Multiple R	.883
R Square	.779
Adjusted R Square	.779
Std. Error of the Estimate	.000
Log-likelihood Function Value	17811.497

Table 7.5 ANOVA – Model 1: main effect

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.011	29	.000	2990.541	.000
Residual	.003	24561	.000		
Total	.014	24590			

Table 7.6 Coefficients – Model 1: main effect

	Unstandardized Coefficients		Standardized Coefficients			
	B	Std. Error	Beta	Std. Error	t	Sig.
(Constant)	11.415	.006			2036.693	.000
Age	-.004	.000	-.101	.003	-30.691	.000
SqFt	.000	.000	.742	.003	224.868	.000
Pooldummy	.123	.003	.121	.003	39.283	.000
Fpdummy	.042	.002	.067	.003	19.431	.000
Fencedummy	-.001	.003	-.001	.003	-.342	.733
Countydummy	-.085	.003	-.104	.003	-32.066	.000
GreenFinal	.009	.002	.013	.003	4.072	.000
jan_dummy	-.019	.004	-.018	.004	-4.947	.000
feb_dummy	-.014	.004	-.014	.004	-3.891	.000
mar_dummy	-.014	.003	-.017	.004	-4.284	.000
apr_dummy	-.007	.003	-.008	.004	-2.024	.043
may_dummy	-.006	.003	-.007	.004	-1.822	.068
jul_dummy	.003	.003	.003	.004	.822	.411
aug_dummy	.000	.003	.000	.004	-.067	.946
sep_dummy	.001	.003	.001	.004	.361	.718
oct_dummy	-.001	.003	-.001	.004	-.382	.702
nov_dummy	.000	.004	.000	.004	-.093	.926

Table 7.6 – *Continued*

dec_dummy	-.008	.003	-.009	.004	-2.283	.022
ys_09_dummy	.048	.004	.044	.003	12.876	.000
ys_08_dummy	.048	.003	.066	.004	17.901	.000
ys_07_dummy	.056	.003	.083	.004	21.924	.000
ys_06_dummy	.046	.002	.073	.004	18.910	.000
ys_04_dummy	-.027	.003	-.040	.004	-10.652	.000
ys_03_dummy	-.038	.003	-.056	.004	-14.893	.000
ys_02_dummy	-.037	.005	-.025	.003	-7.418	.000
Days	.000	.000	-.002	.003	-.813	.416
Schooldummy	.065	.002	.136	.003	43.022	.000
foreclosuredummy	-.125	.003	-.146	.003	-46.796	.000
Acres	.000	.000	.003	.003	1.062	.288

7.2 Model 2 - Interaction effect

To statistically test for interaction effects hypothesis testing involves the property being green and being in the City of Frisco having an influence on the selling price of the property. The corresponding variable of interest is D_GREENCITY. To test the hypothesis a semi-log multiple regression analysis was constructed according to the following form:

$$LNSALES = f\ (W_i, X_i, Y_i, Z), \text{ where}$$

X_i = vector of quantitative factors such as age, size, baths, fireplaces etc

Y_i = vector of qualitative factors such as neighborhood condition etc

W_i = weights estimated by the weighted least square method.

Z = 1 if property is green and in the City of Frisco and Z = 0 otherwise

The interaction variable D_GREENCITY was created by multiplying D_GREEN and D_CITY.

The model described for the multiple linear regression analysis using the weighted least square method is given in Table 7.7.

Multiple regression analysis was employed to measure the magnitude of the marginal contribution of green properties in Frisco on the selling price, if any. To achieve this, multiple linear regression analysis was used with all the control variables and the variable of interest, the interaction variable using the Enter method in SPSS. From the candidate variables a stepwise regression model using SPSS was also employed to double check if any relevant independent variables with significant exploratory power were omitted in the original model.

Table 7.7 Model Description – Model 2: Interaction effect

Dependent Variable		lnsales
Independent Variables	1	Age
	2	SqFt
	3	Pooldummy
	4	Fpdummy
	5	Fencedummy
	6	Countydummy
	7	green_city
	8	jan_dummy
	9	feb_dummy
	10	mar_dummy
	11	apr_dummy
	12	may_dummy
	13	jul_dummy
	14	aug_dummy
	15	sep_dummy
	16	oct_dummy
	17	nov_dummy
	18	dec_dummy
	19	ys_09_dummy
	20	ys_08_dummy
	21	ys_07_dummy
	22	ys_06_dummy
	23	ys_04_dummy
	24	ys_03_dummy
	25	ys_02_dummy
	26	Days
	27	Schooldummy
	28	foreclosuredummy
	29	Acres
Weight	Source	SqFt
	Power Value	1.500

The descriptive statistics of the model variables used in the analysis are detailed in Table 7.8.

Table 7.8 Descriptive Statistics – Model 2: Interaction effect

	N	Minimum	Maximum	Mean	Std. Deviation
LNSALES	24591	11.52	12.61	12.1159	.24771
AGE	24591	0	50	5.89	6.009
SQFT	24591	988	5095	2424.36	655.162
D_POOL	24591	0	1	.07	.251
D_FP	24591	0	1	.84	.369
D_FENCE	24591	0	1	.90	.294
D_COUNTY	24591	0	1	.88	.330
D_GREENCITY	24591	0	1	.15	.360
D_JAN	24591	0	1	.05	.226
D_FEB	24591	0	1	.07	.251
D_MAR	24591	0	1	.09	.290
D_APR	24591	0	1	.09	.283
D_MAY	24591	0	1	.10	.298
D_JUN	24591	0	1	.11	.311
D_JUL	24591	0	1	.10	.293
D_AUG	24591	0	1	.09	.290
D_SEP	24591	0	1	.07	.263
D_OCT	24591	0	1	.08	.266
D_NOV	24591	0	1	.07	.256
D_DEC	24591	0	1	.08	.273
D_2009	24591	0	1	.06	.229
D_2008	24591	0	1	.13	.338
D_2007	24591	0	1	.15	.357
D_2006	24591	0	1	.17	.376
D_2005	24591	0	1	.18	.382
D_2004	24591	0	1	.15	.358
D_2003	24591	0	1	.14	.346
D_2002	24591	0	1	.03	.157
DOM	24591	0	884	99.13	68.199
D_SCHOOL	24591	0	1	.53	.499
D_FORECLOSURE	24591	0	1	.09	.290
ACRES	24591	.0000	150.0000	.106658	1.8790594
Valid N (listwise)	24591				

The full model is given by

$$\begin{aligned}
LNSALES &= b_0 + b_1 \times AGE + b_2 \times ACRES + b_3 \times AGE + b_4 \times DOM \\
&+ b_5 \times D_FORECLOSURE + b_6 \times D_POOL + b_7 \times D_FP + b_8 \times D_FENCE \\
&+ b_9 \times D_SCHOOL + b_{10} \times D_COUNTY + b_{11} \times D_JAN + b_{12} \times D_FEB \\
&+ b_{13} \times D_MAR + b_{14} \times D_APR + b_{15} \times D_MAY + b_{16} \times D_JUN + b_{17} \times D_JUL \\
&+ b_{18} \times D_AUG + b_{19} \times D_SEP + b_{20} \times D_OCT + b_{21} \times D_NOV + b_{22} \times D_DEC \\
&+ b_{23} \times D_2009 + b_{24} \times D_2008 + b_{25} \times D_2007 + b_{26} \times D_2006 + b_{27} \times D_2005 \\
&+ b_{28} \times D_2004 + b_{29} \times D_2003 + b_{30} \times D_2002 + b_{31} \times D_GREENCITY + \in_t
\end{aligned}$$

The reduced model is given by

$$\begin{aligned}
LNSALES &= b_0 + b_1 \times AGE + b_2 \times ACRES + b_3 \times AGE + b_4 \times DOM \\
&+ b_5 \times D_FORECLOSURE + b_6 \times D_POOL + b_7 \times D_FP + b_8 \times D_FENCE \\
&+ b_9 \times D_SCHOOL + b_{10} \times D_COUNTY + b_{11} \times D_JAN + b_{12} \times D_FEB \\
&+ b_{13} \times D_MAR + b_{14} \times D_APR + b_{15} \times D_MAY + b_{16} \times D_JUN + b_{17} \times D_JUL \\
&+ b_{18} \times D_AUG + b_{19} \times D_SEP + b_{20} \times D_OCT + b_{21} \times D_NOV + b_{22} \times D_DEC \\
&+ b_{23} \times D_2009 + b_{24} \times D_2008 + b_{25} \times D_2007 + b_{26} \times D_2006 + b_{27} \times D_2005 \\
&+ b_{28} \times D_2004 + b_{29} \times D_2003 + b_{30} \times D_2002 + \in_t
\end{aligned}$$

The null hypothesis, H_0 to be tested is given by

H_0 : The property being green and present in Frisco does not add premium to the sales price

$H_0 : \beta_{31} = 0.$

The alternative hypothesis, H_1 is given by

H_1 : The property being green and present in Frisco adds premium to the sales price

$H_1 : \beta_{31} > 0.$

Tables 7.9, 7.10 and 7.11 show the results of the model regression analysis. This model has an R square of 78% and an Adjusted R square of 77.9%. This means that the independent variables added in the model explain 78% of the variation in the dependent variable. The F statistic of the model is 2994.378 and the p value corresponding to the F statistic is 0.000 at the 5% significance level. Since the F statistic is too large and the p value corresponding to the F statistic is too small, the model is powerful in explaining the relationship between the variables.

Table 7.9 Model Summary – Model 2: Interaction effect

Multiple R	.883
R Square	.780
Adjusted R Square	.779
Std. Error of the Estimate	.000
Log-likelihood Function Value	17823.782

Table 7.10 ANOVA – Model 2: Interaction effect

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.011	29	.000	2994.378	.000
Residual	.003	24561	.000		
Total	.014	24590			

Table 7.11 Coefficients – Model 2: Interaction effect

	Unstandardized Coefficients		Standardized Coefficients			
	B	Std. Error	Beta	Std. Error	t	Sig.
(Constant)	11.414	.006			2039.031	.000
Age	-.004	.000	-.100	.003	-30.501	.000
SqFt	.000	.000	.741	.003	223.324	.000
Pooldummy	.123	.003	.121	.003	39.410	.000
Fpdummy	.042	.002	.067	.003	19.627	.000
Fencedummy	.000	.003	-.001	.003	-.176	.860
Countydummy	-.083	.003	-.102	.003	-31.324	.000
green_city	.016	.002	.022	.003	6.415	.000
jan_dummy	-.019	.004	-.018	.004	-4.984	.000
feb_dummy	-.014	.004	-.015	.004	-3.958	.000
mar_dummy	-.014	.003	-.017	.004	-4.295	.000
apr_dummy	-.007	.003	-.008	.004	-2.009	.045
may_dummy	-.006	.003	-.007	.004	-1.822	.069
jul_dummy	.003	.003	.003	.004	.821	.412
aug_dummy	.000	.003	.000	.004	-.082	.934
sep_dummy	.001	.003	.001	.004	.332	.740
oct_dummy	-.001	.003	-.002	.004	-.410	.682
nov_dummy	.000	.004	.000	.004	-.127	.899

Table 7.11 – *Continued*

dec_dummy	-.008	.003	-.009	.004	-2.333	.020
ys_09_dummy	.048	.004	.044	.003	12.911	.000
ys_08_dummy	.048	.003	.066	.004	17.896	.000
ys_07_dummy	.055	.003	.082	.004	21.850	.000
ys_06_dummy	.046	.002	.073	.004	18.884	.000
ys_04_dummy	-.027	.003	-.040	.004	-10.584	.000
ys_03_dummy	-.038	.003	-.055	.004	-14.838	.000
ys_02_dummy	-.037	.005	-.024	.003	-7.366	.000
Days	.000	.000	-.003	.003	-.868	.385
Schooldummy	.064	.002	.133	.003	41.642	.000
foreclosuredummy	-.125	.003	-.146	.003	-46.826	.000
Acres	.000	.000	.003	.003	1.067	.286

The final regression equation is given by

$$\begin{aligned}
&LNSALES = 11.414 - .004\times AGE + .000\times ACRES + .000\times SQFT + .000\times DOM \\
&- .125\times D_FORECLOSURE + .123\times D_POOL + .042\times D_FP + .000\times D_FENCE \\
&+ .064\times D_SCHOOL - .083\times D_COUNTY - .019\times D_JAN - .014\times D_FEB \\
&- .014\times D_MAR - .007\times D_APR - .006\times D_MAY + .000\times D_JUN + .003\times D_JUL \\
&+ .000\times D_AUG + .001\times D_SEP - .001\times D_OCT + .000\times D_NOV - .008\times D_DEC \\
&+ .048\times D_2009 + .048\times D_2008 + .055\times D_2007 + .046\times D_2006 + .000\times D_2005 \\
&- .027\times D_2004 - .038\times D_2003 - .037\times D_2002 + .016\times D_GREENCITY + \in_t
\end{aligned}$$

From this regression analysis, the selection of the D_GREENCITY variable suggests that the null hypothesis is rejected at the 5% significance level. This shows evidence of support of alternative hypothesis that there exists a premium in the sales price if the property is green. The beta coefficient is 0.016 and the p value associated with the t statistic of the beta coefficient is low thereby rejecting the null hypothesis. Therefore, the model clearly reveals there is a statistically significant change in value because of the property being green and also present in the City of Frisco. Out of the 30 control variables entered in the model, only 19 variables were statistically significant. Also, as a quick check we can look at the t values of the independent variables. If they are greater than 2, then they will be statistically significant at the 5% significance level. We see that out of the 31 variables included in the model including the variable of interest only 20 variables had a t statistic greater than 2 at the 5% significance level.

From both the models, Model 1 and Model 2, it is evident that the interaction variable D_GREENCITY adds more explanatory power to the dependent variable than the main variable D_GREEN. This means that a green property present in the City of Frisco adds premium to the sales price. Since the D_GREENCITY interaction variable serves as a proxy to the impact of mandatory green building program in Frisco, this study shows positive impact of the mandatory green building program on the sales price of the properties at 95% confidence level.

CHAPTER 8

CONCLUSION

Hedonic pricing model is generally used to empirically understand the relationship between various housing characteristics and the housing values. In the past hedonic studies have looked at the relationship between the housing prices and structural features, environmental amenities, neighborhood characteristics, time variables and even financing. But real estate researchers have greatly overlooked to study the impact of greenness on residential properties though there has been a huge interest among the researchers and practitioners on green buildings. This study poses the primary question of any potential relationship between greenness and property values. This study further extends the research question to find out if there is any impact on property values due to the mandatory green building programs.

In an attempt to answer the posed research questions, this study looks at sales in two cities Frisco and McKinney from 2002 to 2009. This study uses hedonic pricing technique in an attempt to capture the fraction of property prices that are derived from greenness which is a specific housing characteristic. The study finds significant positive relationship between the greenness and the residential property prices. The study also finds significant positive relationship between greenness in Frisco adding premium to the property values. This is in fact a proxy to understand the impact of mandatory green building programs on property values.

One potential limitation to this study is the possibility of a under representation of the green sales in McKinney. Since there is no mandatory green building program in McKinney, the only way of identifying green buildings is through the keyword searches from the MLS database. But we could assume to an extend that the builders that build green buildings in McKinney a city with no mandatory rules regarding green practices either are passionate about green building practices or are looking for reaping the premium. In both cases the builders would want to mention and market the buildings as green buildings so that they can earn the extra premium in the market. So the MLS database should contain most of the green sales in McKinney.

The contributions of this study are sketched below. (a) Firstly, this study could be one of the first studies that make an effort to open up a new area of studies focusing on green residential buildings.(b) Secondly this study looks at green building mandatory programs and attempts to evaluate the impact of these formal programs on property values. (c) Thirdly this study uses green variable as a hedonic variable in the hedonic pricing model.

This study could be extended further from various levels of analysis. The level of analysis of this study is currently city level. The study could also be conducted across various cities that have mandatory programs and a comparative analysis could be made. There always exists this difficulty in obtaining data about the greenness of the building. This study chose to use the secondary source, MLS database. As a future extension, primary data can be collected and a more detailed analysis on the impact of each important green feature could be analyzed.

APPENDIX A

WHITE'S GENERAL TEST OF HETEROSKEDASTICITY

White's General Test for Heteroskedasticity

Run MATRIX procedure:

RSS
7.00E+21

TSS
8.00E+21

R_SQ
1.00E-01

N
4.00E+03

P
1.00E+01

White's General Test for Heteroscedasticity (CHI-SQUARE df = P)
6.00E+02

SIGNIFICANCE LEVEL OF CHI-SQUARE df = P (H0 = homoscedasticity)
0.00E+00

------ END MATRIX -----

.

APPENDIX B

WHITE'S CORRECTION OF HETEROSKEDASTICITY

White's (Large Sample) Corrected Standard Errors	
CONSTANT	2.00E+03
Age	1.00E+02
SqFt	9.00E-01
Pooldumm	2.00E+03
citydumm	1.00E+03
green_ci	1.00E+03
jan_dumm	2.00E+03
mar_dumm	1.00E+03
nov_dumm	2.00E+03
Days	7.00E+00
FB	1.00E+03
Fpdummy	1.00E+03
Schooldu	1.00E+03
foreclos	1.00E+03

OLS Coefficients	
CONSTANT	7.00E+04
Age	-2.00E+03
SqFt	4.00E+01
Pooldumm	3.00E+04
citydumm	3.00E+04
green_ci	-8.00E+03
jan_dumm	-6.00E+03
mar_dumm	-4.00E+03
nov_dumm	-7.00E+03
Days	-5.00E+00
FB	1.00E+04
Fpdummy	8.00E+03
Schooldu	-1.00E+04
foreclos	-3.00E+04

t-values based on Whites (large sample) corrected SEs	
CONSTANT	3.00E+01
Age	-1.00E+01
SqFt	5.00E+01
Pooldumm	2.00E+01
citydumm	2.00E+01
green_ci	-6.00E+00
jan_dumm	-3.00E+00
mar_dumm	-3.00E+00
nov_dumm	-3.00E+00
Days	-7.00E-01
FB	9.00E+00
Fpdummy	7.00E+00

Schooldu	-8.00E+00
foreclos	-2.00E+01

Prob(t < tc) based on Whites (large n) SEs	
CONSTANT	0.00E+00
Age	0.00E+00
SqFt	0.00E+00
Pooldumm	0.00E+00
citydumm	0.00E+00
green_ci	9.00E-10
jan_dumm	7.00E-04
mar_dumm	2.00E-03
nov_dumm	8.00E-04
Days	5.00E-01
FB	0.00E+00
Fpdummy	4.00E-12
Schooldu	1.00E-14
foreclos	0.00E+00

OLS Standard Errors	
CONSTANT	2.00E+03
Age	1.00E+02
SqFt	8.00E-01
Pooldumm	2.00E+03
citydumm	1.00E+03
green_ci	1.00E+03
jan_dumm	2.00E+03
mar_dumm	1.00E+03
nov_dumm	2.00E+03
Days	6.00E+00
FB	1.00E+03
Fpdummy	1.00E+03
Schooldu	1.00E+03
foreclos	1.00E+03

OLS t-values	
CONSTANT	3.00E+01
Age	-2.00E+01
SqFt	5.00E+01
Pooldumm	2.00E+01
citydumm	2.00E+01
green_ci	-6.00E+00
jan_dumm	-4.00E+00
mar_dumm	-3.00E+00
nov_dumm	-3.00E+00
Days	-9.00E-01

FB	1.00E+01
Fpdummy	8.00E+00
Schooldu	-8.00E+00
foreclos	-3.00E+01

Prob(t < tc) based on OLS SEs	
CONSTANT	0.00E+00
Age	0.00E+00
SqFt	0.00E+00
Pooldumm	0.00E+00
citydumm	0.00E+00
green_ci	5.00E-10
jan_dumm	2.00E-04
mar_dumm	2.00E-03
nov_dumm	7.00E-04
Days	4.00E-01
FB	0.00E+00
Fpdummy	5.00E-14
Schooldu	6.00E-15
foreclos	0.00E+00

WESTIM					
	B	**SE**	**WHITE_SE**	**WT_VAL**	**SIG_WT**
CONSTANT	7.00E+04	2.00E+03	2.00E+03	3.00E+01	0.00E+00
Age	-2.00E+03	1.00E+02	1.00E+02	-1.00E+01	0.00E+00
SqFt	4.00E+01	8.00E-01	9.00E-01	5.00E+01	0.00E+00
Pooldumm	3.00E+04	2.00E+03	2.00E+03	2.00E+01	0.00E+00
citydumm	3.00E+04	1.00E+03	1.00E+03	2.00E+01	0.00E+00
green_ci	-8.00E+03	1.00E+03	1.00E+03	-6.00E+00	9.00E-10
jan_dumm	-6.00E+03	2.00E+03	2.00E+03	-3.00E+00	7.00E-04
mar_dumm	-4.00E+03	1.00E+03	1.00E+03	-3.00E+00	2.00E-03
nov_dumm	-7.00E+03	2.00E+03	2.00E+03	-3.00E+00	8.00E-04
Days	-5.00E+00	6.00E+00	7.00E+00	-7.00E-01	5.00E-01
FB	1.00E+04	1.00E+03	1.00E+03	9.00E+00	0.00E+00
Fpdummy	8.00E+03	1.00E+03	1.00E+03	7.00E+00	4.00E-12
Schooldu	-1.00E+04	1.00E+03	1.00E+03	-8.00E+00	1.00E-14
foreclos	-3.00E+04	1.00E+03	1.00E+03	-2.00E+01	0.00E+00

.

APPENDIX C

LIST OF SUBDIVISIONS PLATTED AFTER 2001 – CITY OF FRISCO

S.No	Subdivision / Phase
1	Austin Ridge at Lone Star Ranch Phase 1
2	Austin Ridge Village at Lone Star Ranch
3	Bella Casa, Phase 1
4	Bella Casa, Phase 2
5	Birmingham Esates Addition
6	Chapel Creek, Phase 1B
7	Chapel Creek, Phase 1C
8	Chapel Creek, Phase 2
9	Chapel Creek, Phase 2B
10	Cheyenne Village, Phase 2
11	Cheyenne Village, Phase 3
12	Christie Ranch, Phase 1A
13	Christie Ranch, Phase 1B
14	Christie Ranch, Phase 1C
15	Christie Ranch, Phase 2A
16	Cobb Farm, Phase 1
17	Cobb Farm, Phase 2
18	Copper Ridge, Phase 1
19	Country Club Ridge at the Trails, Phase 1
20	Country Club Ridge at the Trails, Phase 2
21	Creekside at Preston, Phase 2
22	Creekside at Preston, Phase 3
23	Creekside at Preston, Phase 4
24	Creekside at Preston, Phase 4A
25	Creekside at Preston, Phase 4B
26	Creekside at Preston, Phase 4C
27	Crown Ridge, Phase 1
28	Crown Ridge, Phase 1A
29	Crown Ridge, Phase 2
30	Cypress Creek, Phase 1
31	Cypress Creek, Phase 2
32	Dominion at Panther Creek, Phase 2
33	Dominion at Panther Creek, Phase 3
34	Dominion at Panther Creek, Phase 4
35	Eldorado Fairways at the Trails, Phase D

S.No	Subdivision / Phase
36	Estates at Cobb Hill, Phase 1
37	Estates at Cobb Hill, Phase 2
38	Frisco Lakes, Phase 1A
39	Frisco Lakes, Phase 1, Village 15
40	Frisco Lakes, Phase 1, Village 16
41	Frisco Lakes, Phase 1, Village 17
42	Frisco Lakes, Phase 1, Village 18
43	Frisco Lakes, Phase 1, Village 19
44	Frisco Lakes, Phase 1, Village 21
45	Frisco Lakes, Phase 1, Village 22
46	Frisco Lakes, Phase 1, Village 23
47	Frisco Lakes, Phase 1, Village 25
48	Frisco Lakes, Phase 1, Village 27
49	Frisco Lakes, Phase 1, Village 28
50	Frisco Lakes, Phase 1, Village 29
51	Frisco Lakes, Phase 2, Village 12
52	Frisco Lakes, Phase 2, Village 14
53	Frisco Lakes, Phase 2, Village 15
54	Frisco Lakes, Tract 10, Phase 1
55	Frisco Lakes, Tract 11, Phase 1
56	Frisco Square, Phase 1
57	Frisco Square, Phase 4
58	Frisco Square, Phase 5
59	Grayhawk, Phase 10
60	Grayhawk, Phase 11
61	Grayhawk, Phase 6 & 7
62	Grayhawk, Phase 8
63	Grayhawk, Phase 9
64	Grayhawk, Section 2, Phase 1
65	Grayhawk, Section 2, Phase 2
66	Grayhawk, Section 2, Phase 3
67	Grayhawk, Section 2, Phase 4
68	Grayhawk, Section 2, Phase 5
69	Grayhawk, Section 2, Phase 6
70	Griffin Estates, Phase 1

S.No	Subdivision / Phase
71	Griffin Parc, Phase 3
72	Griffin Parc, Phase 4
73	Griffin Parc, Phase 5
74	Griffin Parc, Phase 6
75	Griffin Parc, Phase 7
76	Heather Ridge Estates, Phase 3
77	Heather Ridge Estates, Phase 4
78	Heather Ridge Estates, Phase 5
79	Heritage Lakes, Phase 4 & 5
80	Heritage Village, Phase 2
81	Hills of Kingswood
82	Hunters Creek, Phase 5
83	Hunters Creek, Phase 6
84	Hunters Creek, Phase 7
85	Hunters Creek, Phase 8
86	Hunters Creek, Phase 9
87	King's Garden, Phase 4
88	Knolls of Frisco
89	Knolls of Frisco, Phase 2
90	Lake Hill Village, Phase 2
91	Lakeside at Lone Star Ranch
92	Landings at Waterstone, Phase 2
93	Latera (Creekside at Preston, Phase 1)
94	Latera Phase 2
95	Meadowcreek, Phase 2
96	Meadows of Preston, Phase 1
97	Meadows of Preston, Phase 2
98	Meadows of Preston, Phase 3
99	Meadows of Preston, Phase 4
100	Meadows of Preston, Phase 5
101	Newman Village
102	Northridge, Phase 1A
103	Northridge, Phase 3
104	Palomino Run, Phase 1
105	Panther Creek Estates, Phase 1

S.No	Subdivision / Phase
106	Panther Creek Estates, Phase 2
107	Panther Creek Estates, Phase 3
108	Panther Creek Estates, Phase 5
109	Panther Creek Estates, Phase 6
110	Park Place Estates
111	Parkview Townhomes
112	Pather Creek Estates, Phase 4
113	Pearson Farms, Phase 1A
114	Pearson Farms, Phase 1B
115	Pearson Farms, Phase 1C
116	Pearson Farms, Phase 2
117	Prairie Grove, Phase 1
118	Prairie Grove, Phase 2
119	Prairie View
120	Preston Highlands Village
121	Preston Vineyards North
122	Quail Meadow Village, Phase 1B
123	Queen's Gate, Phase 1
124	Queen's Gate, Phase 2
125	Rancho Real, Phase 1
126	Ridgeview at Panther Creek
127	Saddlebrook Village, Phase 1B
128	Sedona, Phase 2
129	Shaddock Creek Estates, Phase 4A
130	Shaddock Creek Estates, Phase 4B
131	Shaddock Creek Estates, Phase 5
132	Shaddock Creek Estates, Phase 6A
133	Shaddock Creek Estates, Phase 6B
134	Shepherd's Hill, 3B
135	Shores at Waterstone, Phase 1
136	Shores at Waterstone, Phase 2
137	Sorano
138	Starwood, Phase 5, Village 14
139	Starwood, Phase 6, Village 19 & 20
140	Stone Creek Village, Phase 2

S.No	Subdivision / Phase
141	Stonelake Estates West, Phase 1
142	Stonelake Estates West, Phase 2
143	Stonelake Estates, Phase 1
144	Stonelake Estates, Phase 2
145	Stonelake Estates, Phase 3
146	Stonewater Crossing, Phase 1
147	Stonewater Estates
148	Trails of West Frisco, Phase 13
149	Trails of West Frisco, Phase 14
150	Trails of West Frisco, Phase 15
151	Trails, Phase 5, Section B
152	Turnbridge Manor, Phase 3
153	Tuscany Meadows, Phase 1
154	Tuscany Meadows, Phase 2
155	Tuscany Square, Phase 1
156	Tuscany Square, Phase 2
157	Village at Cobb Hill
158	Village at Panther Creek, Phase 1
159	Village Lakes, Phase 1
160	Village Lakes, Phase 2
161	Villages at Willow Bay South, Phase 1
162	Villages at Willow Bay South, Phase 2
163	Villages at Willow Bay South, Phase 3
164	Villages at Willow Bay South, Phase 4
165	Villages at Willow Bay South, Phase 5
166	Villages at Willow Bay, Phase 1 & 2
167	Villages at Willow Bay, Phase 3
168	Villages at Willow Bay, Phase 4
169	Villages at Willow Bay, Phase 6
170	Villages of Stonebriar Park, Phase 2
171	Villages of Stonelake Estates
172	Villages of Stonelake Estates I-A
173	Villages of Stonelake Estates I-B
174	Villages of Stonelake Estates I-C
175	Vistas at Waterstone, Phase 1

S.No	Subdivision / Phase
176	Vistas at Waterstone, Phase 2
177	Wandering Trails, Phase 1A
178	Wandering Trails, Phase 1B
179	Willow Pond, Phase 2
180	Winding Creek Estates
181	Windsor Place, Phase 2
182	Wyndsor Pointe (The Bluffs)
183	Wynngate

APPENDIX D

GREEN FEATURES USED FOR KEYWORD SEARCHES

S No	Green Features List
1	Energystar
2	Greenbuilt
3	HERS
4	LEED
5	NGBP
6	Drought tolerant
7	Energy Recovery
8	Air Filtration
9	Irrigation Control
10	Geo Thermal HVAC
11	Low flow commode
12	Low flow fixtures
13	Mechanical fresh air
14	Rain freeze sensors
15	Rain water catchment
16	Recirculating hot water
17	Solar
18	Wind power

REFERENCES

1. Ahlfeldt GM, Maennig W (2009). “Arenas, arena architecture and the impact on location desirability: the case of “Olympic Arenas in Prenzlauer Berg, Berlin”, Urban Studies, 46(7), 1343-1362

2. Allen, P.R., Shilling, J.D. and Sirmans, C.F. (1987). “Contracting, Contingencies and Single-Family House Prices.”, Economic Inquiry, 25, 159–164.

3. Anglin, Paul M., Ronald Rutherford and Thomas M. Springer, (2003).The Trade-Off Between the Selling Price of Residential Properties and Time-on-the-Market: The Impact of Price Setting,’’ Journal of Real Estate Finance and Economics,26(1), 95–111.

4. Arguea, Nestor and Cheng Hsiao,(2000). Market Values of Environmental Amenities: A Latent VariableApproach, Journal of Housing Economics, 9(1/2), 104–126.

5. Asabere, EK. (1990). "The Value of a Neighborhood Street with Reference to the Cul-de-Sac," Journal of Real Estate Finance and Economics 3, 185-193.

6. Asabere, EK., and EE. Huffman. (1993). "Price Concessions, Time on the Market, and the Actual Sale Price of Houses" Journal of Real Estate Finance and Economics 6, 167-174.

7. Asabere P.K, Huffman, F.E. (2009) “The Relative Impacts of Trails and Greenbelts on Home Price”, The Journal of Real estate Finance and Economics, 38(4), 408-419

8. Baxter, V., & Lauria, M. (2000). Residential Mortgage Foreclosure and Neighborhood Change. Housing Policy Debate, 11, 675–699.

9. Belkin, J., Hempel, D.J. and McLeavey, D.W.(1976). “An Empirical Study of Time on Market Using Multidimensional Segmentation of Housing Markets.” AREUEA, 4, 57–75.

10. Benson E D, Hansen J L, Arthur J, Schwartz L, Smersh G T. (1998). “Pricing residential amenities: the value of a view", Journal of Real Estate Finance and Economics, 16, 55-73

11. Bowes, David R. and Keith R. Ihlanfeldt, (2001). Identifying the Impacts of Rail transit Stations on Residential Property Values,’’ Journal of Urban Economics, 50(1), 1–25.

12. Box, G.E.P. & Cox d. (1964). An Analysis of Transformations,Journal of the American Statistical Association, Society Series B, 26, 211-52.

13. Buck, A.J., J. Deutsch, S. Hakim, et al. (1991). "A Von Thunen Model of Crime, Casinos and Property Values in New Jersey," Urban Studies 28, 673-686.

14. Bynum, R.T. & Rubino, D.L. (1999). Handbook of Alternative Materials in Residential Construction. New York: McGraw-Hill.

15. Campbell, S. (1996). Green cities, growing cities, just cities?: Urban planning and the contradictions of sustainable development. Journal of the American Planning Association, 62(3):296-312.

16. Cassel E, Mendelsohn R. (1985). “The choice of functional forms for hedonic price equations: comments", Journal of Urban Economics, 18, 135-142

17. City of Austin http://www.austinenergy.com/energy%20efficiency/programs/green%20building/

18. City of Frisco, www.ci.frisco.tx.us

19. Clotfelter, C. (1975). “The effect of school desegregation on housing prices”, Review of Economics and Statistics, 57, 446-451

20. Cole, R. 2001. A building environmental assessment method for British Columbia, Final report to BC Green Buildings Ad-Hoc Committee. (www.buildsmart.ca/pdfs/ASSESSMENT%20REPORT.PDF).

21. Correll,M.R., Lillydahl,J.H., & Singell L.D. (1978). The effects of greenbelts on residential property values: Some findings on the political economy of open space, Land Economics, 54, 207-218.

22. Cubbins, J.S. (1974) “Price, Quality and Selling Time in the Housing Market”, Applied Economics, 6, 171–187.

23. Davis Langdon. 2007. Cost of Green Revisited. Davis Langdon.

24. Davis Langdon. 2004. Examining the Cost of Green. Davis Langdon.

25. DiMaggio PJ, Powell WW. (1983). “The iron cage revisited: institutional isomorphism and collective rationality in organizational fields”, American Sociology Review, 35, 147-60

26. Do A Q, Sirmans C F. (1994), “Residential property tax capitalization: discount rate evidence from California", National Tax Journal, 47,341-348

27. Do, A. Q, Wilbur, R, Short, J. (1994). “An Empirical Examination of the Externalities of Neighborhood Churches on Housing Values”, Journal of Real Estate and Urban Economics, 9, 127–36.

28. Dombrow, J., M. Rodriguez, and C.F. Sirmans.(2000). The Market Value of Mature Trees in Single-Family Housing Markets. Appraisal Journal 68(1), 39-43.

29. Dotzour, M. (1997). Groundwater Contamination and Residential Property Values, The Appraisal Journal, 65(3), 279-285

30. Dotzour, M.G., Levi, D. R., (1991) “The Impact of Corporate Ownership on Residential Transaction Prices”, The Journal of Real Estate Research, 7(2), 207-216

31. Downes, T., and J. E. Zabel. (1997). The Impact of School Quality on House Prices. Tufts University Working Paper, 97-104.

32. Eicholtz, P, Kok N, and Quigley J. (2009). “Doing Well By Doing Good? Green Office Buildings”, Working paper, Fisher Center for Real Estate and Urban Economics, UC Berkeley.

33. Hall, B.H. & Khan, B. (2002). Adoption of New Technology, New Economy Handbook.

34. Ellison, L., S. Sayce, and J. Smith, (2007).Socially Responsible Property Investment: Quantifying the Relationship between Sustainability and Investment Property Worth, Journal of Property Research, 24 (3), 191-219.

35. Forgey, F., Rutherford, R., & VanBuskirk, M. (1994). Effect of Foreclosure Status on Residential Selling Price. Journal of Real Estate Research, 9, 313–318.

36. Forgey, Fred A., Ronald C. Rutherford, and Thomas M. Springer, (1996). Search and Liquidity in Single-Family Housing,’’ Real Estate Economics, 24(3), 273–292.

37. Fuerst, F. and McAllister, P. (2008). “Pricing Sustainability: An Empirical investigation of the Value Impacts of Green Building Certification”, American Real estate Society Conference, Florida, USA.

38. Gamble, H.B., and R.H. Downing. (1982). "Effects of Nuclear Power Plants on Residential Property Values," Journal of Regional Science 22, 457-478.

39. Galster, George, Peter Tation, and Kathryn Pettit, (2004). Supportive Housing and Neighborhood Property Value Externalities,’’ Land Economics, 80(1), 33–54.

40. Gillard Q. (1981). “The effect of environmental amenities on house values: the example of a view lot", The Professional Geographer, 33, 216-220

41. Goldstein, I., Maggie, M., Al, P., & Daniel, U.-A. (2005). Mortgage Foreclosure Filings in Pennsylvania. Philadelphia: Reinvestment Fund. World Wide Web page <http://www.trfund.com/policy/PA_Foreclosures.htm> (accessed April 22, 2007).

42. Goodman, J. L. (1992). A Housing Market Matching Model of the Seasonality in Geographic Mobility. Journal of the Real Estate Research, 8(1), 117–137.

43. Goodman, A. C., & Thibodeau, T. G. (1997). Dwelling-Age-Related Heteroskedasticity in Hedonic House Price Equations: An Extension. Journal of Housing Research, 8(2), 299–317.

44. Goodman, Allen C. and Thomas G. Thibodeau, (1998). Housing Market Segmentation,’’ Journal of Housing Economics, 7(2), 121–143.

45. Graybill, F. A., H. K. Iyer. (1994). “Regression analysis: concepts and applications”. Duxbury Press, Belmont, California, USA.

46. Grether, D.M. and E Mieszkowski. (1974). "Determinants of Real Estate Values;' Journal of Urban Economics, 1, 127-145

47. Halverson, R., & Palmquist, R. (1980). The Interpretation of Dummy Variables in Semilogarithmic Regressions. American Economic Review, 70, 474–475.

48. Hardin, W., & Wolverton, M. (1996). The Relationship between Foreclosure Status and Apartment Price. Journal of Real Estate Research, 12, 101–109.

49. Harrison, D., and D. Rubinfeld. (1978). "Hedonic Housing Prices and Demand for Clean Air," Journal of Environmental Economics and Management 5, 81-102.

50. Heckman, J. (1979). Sample Selection Bias as a Specification Error. Econometrica, 47(1), 153–161

51. Heekin, D. and Meyers. D. (2001). Green Building: Principles and Practice. University of Florida Levin College of Law.

52. Heerwagen, Judith. (2000). "Do Green Buildings Enhance the Well Being of Workers?" Environmental Design and Construction Magazine.Available at: http://www.edcmag.com/CDA/ArticleInformation/coverstory/BNPCoverStoryItem/0,4118,19794,00.html.

53. Hellman, D.A., and J.L. Narroff. (1979). "The Impact of Crime on Urban Residential Property Values" Urban Studies 16, 105-112.

54. Heschong Mahone Group. (1999) "Daylighting in Schools: An Investigation into the Relationship Between Daylight and Human Performance," Available at: http://www.h-m-g.com

55. Hite, D., Chern,W, Hitzhusen, F, Randall,A. (2001). "Property value impacts of an environmental disamenity: The case of landfills", Journal of Real Estate Finance and Economics 22(2/3), 185-202.

56. Immergluck, D, Smith, G. (2006). "The Impact of Single-Family Mortgage Foreclosures on Neighborhood Crime." Housing Studies 21(6): 851–866.

57. Jud, G.D. (1985). "Further Note on Schools and Housing Values," AREUEA Journal 13, 452-462.

58. Kain, J.E, and J.M. Quigley. (1970). "Measuring the Value of Housing Quality," American Statistical Association Journal 65, 532-548.

59. Kats, G. (2006). Greening America's Schools: Costs and Benefits. Available at: http://www.cap-e.com/ewebeditpro/items/O59F12807.pdf

60. Kats, G. (2003). The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force. Available at: http://www.ciwmb.ca.gov/GreenBuilding/Design/CostBenefit/Report.pdf.

61. Kinnard, W., and M. Geckler. (199l). "The Effects on Residential Real Estate Prices from Proximity to Properties Contaminated with Radioactive Materials," Real Estate Issues 16, 25-36

62. Kohlhepp, D. (2006). “The Greening of One Potomac Yard”, Crescent Resources LLC

63. Kumar, S. and Fisk, W. (2002), “The role of emerging energy-efficient technology in promoting workplace productivity and health: final report”, available at: www.ihpcental.org

64. Lancaster, Kelvin J. (1966). A New Approach to Consumer Theory, Journal of Political Economy, 74,132-57.

65. Lancaster, Kelvin J.(1971). Consumer Demand: A New Approach. Columbia University Press.

66. Larsen, J.E. and Park, W.J.(1989). “Non-Uniform Percentage Brokerage Commissions and Real Estate Market Performance.” AREUEA, 17 (4), 423–438.

67. Li, M.M. and H.J. Brown. (1980). "Micro-Neighborhood Externalities and Hedonic Housing Prices," Land Economics 56, 125-141.

68. Lin Z, Rosenblatt E, Yao V.W., (2007). Spillover Effects of Foreclosures on Neighborhood Property Values, The Journal of Real Estate Finance and Economics, 38(4), 387-407

69. Ling, David C. and R. Wayne Archer. (2005). Real Estate Principles,A Value Approach. McGraw Hill Irwin.

70. Linneman P. (1981). “The Demand for Residence Site Characteristics”, Journal of Urban Economics 9 129-148.

71. Linneman, P. (1980). "Some Empirical Results on the Nature of the Hedonic Price Function for the Urban Housing Market," Journal of Urban Economics, 8(1), 47-68.

72. Loch, C. H., Huberman, B.A. (1999). ”A punctuated equilibrium model of technology diffusion”, Management Science, 45,160-178.

73. Loban Tom & Jones, Todd D. (2008). Valuation issues in a greening world, Journal of Green Building, 3(3),42-56

74. Mieszkowski, E, and A. Saper. (1978). “Estimate of the Effects of Airport Noise on Property Values," Journal of Urban Economics 5, 425-440.

75. Miller, N., Spivey, J. Florance, A. (2008): Does Green Pay Off? Journal of Real Estate Portfolio Management. 14/4, 385-399.

76. Miller, N.G. (1977). “The Influence of Market Transaction Phenomena on Residential Property Values” Unpublished doctoral dissertation, The Ohio State University.

77. Miller, N.G.(1978) “Time on the Market and Selling Price” AREUEA, 6, 164–174.

78. Nelson, J.P. (1977). “Accessibility and the Value of Time in Commuting”, Southern Economic Journal, 43, 1321–1324.

79. Nelson, J.E (1978). "Residential Choice, Hedonic Prices, and the Demand for Urban Air Quality," Journal of Urban Economics 5, 357-369.

80. Nelson, J.E (1980). “Airports and Property Values: A Survey of Recent Evidence," Journal of Transport Economics and Policy 14, 37-52.

81. Nelson, J.E (1981). "Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications," Land Economics 57, 363-372.

82. Nourse, H.O. (1970). "The Effect of Air Pollution on House Values," Land Economics 46, 435-446.

83. *Our Common Future: The Report of the World Commission on Environment and Development*. Available at: http://www.un-documents.net/wced-ocf.htm

84. Our Common Future (1987), Oxford: Oxford University Press.

85. Parsons G R. (1986). “An Almost Ideal Demand System for Housing Attributes”, Southern Economic Journal 53 347-363.

86. Pool, L.C. (1978). "Railway Externalities and Residential Property Prices," Land Economics 54, 218-277.

87. Plattner R H, Campbell T J. (1978), “A study of the effect of water view on site value'', Appraisal Journal, 46, 20-25

88. Quigley J M. (1982). “Nonlinear Budget Constrains and Consumer Demand: An Application to Public Programs for Residential Housing”, Journal of Urban Economics, 12, 177-201.

89. Real Estate Center, TAMU. http://recenter.tamu.edu/mreports/DallasFWArl.pdf

90. RESNET (2006). “Mortgage Industry National Home Energy Rating Systems Standards”.Available at http://www.resnet.us/standards/mortgage/RESNET_Mortgage_Industry_National_HERS_Standards.pdf

91. RICS(2005). “Green Value; Growing Assets”, London, UK.

92. Rodriguez M, Sirmans C F. (1994). “Quantifying the value of a view in single-family housing markets'', The Appraisal Journal, 62, 600-603

93. Rosen, S.(1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, Journal of Political Economy, 82(1), 34-55.

94. Sayce, S. and Ellison, L. (2003a) Towards sustainability indicators for commercial property occupiers and investors, Eighth Annual International Sustainable Research Conference, Nottingham, 24–25 March.

95. Sayce, S. and Ellison, L. (2003b) Integrating sustainability into the appraisal of property worth: identifying appropriate indicators of sustainability, The American Real Estate and

Urban Economics Association Conference, RICS Foundation Sustainable Development Session, 21–23 August, Skye, Scotland.

96. Sayce, S. and Ellison, L. (2004a) Sustainable Property Appraisal Project Working Paper 2, (available online at www.sustainableproperty.ac.uk)

97. Sayce, S. and Ellison, L. (2004b) Sustainability and commercial property investment understanding the impact of direct effects and policy development on asset values, IPF/IPD Annual Conference, 23–24 November, Brighton.

98. Sayce, S., Ellison, L. and Parnell, P. (2007) Understanding investment drivers for UK sustainable property, Building Research and Information, 287–304

99. Scheer, R, Woods R. (2007) “Is There Green in Going Green?” SBM

100. Schroder, M. (2003), “Socially responsible investments in Germany, Switzerland and the United States – an analysis of investment funds and indices”, Zentrum fu¨ r Europa¨ische Wirtschaftsforschung, available at: ftp://ftp.zew.de/pub/zew-docs/dp/dp0310.pdf

101. Sheppard, Stephen,(1999). Hedonic analysis of housing markets, Handbook of Regional and Urban Economics, 1(3), 1595-1635

102. Shlay, A., and G. Whitman. (2006) “Research for Democracy: Linking Community Organizing and Research to Leverage Blight Policy,” City & Community 5 (2): 153-171.

103. Sirmans,G S, MacDonald, L, Macpherson, D.A, Zietz E.N. (2006) “The Value of Housing Characteristics: A Meta Analysis”, Journal of Real Estate Finance and Economics, 33, 215-240

104. Sirmans, G. S., Macpherson, D. A., & Zietz, E. N. (2005). The composition of hedonic pricing models, Journal of Real Estate Literature, 13(1), 3–43.

105. Sirmans, G. S & Macpherson D.A. (2003). The Value of Housing Characteristics. National Association of Realtors, Washington, DC.

106. Skorpik, J. (1997). “BREEAM, a building environmental assessment method.” Canadian Eco-Architecture.

107. Smith T.M, Fischlein M, Suh S, Huelman P. (2006). ”Green Building Rating Systems: A comparison of the LEED and GREEN GLOBES systems in the US” Prepared for The Western Council of Industrial Workers. Available at http://www.dnr.state.md.us/ed/Green_Building_Rating_UofM.pdf

108. Smith, V. K., & Huang, J.C. (1995). Can markets value air quality? A meta-analysis of hedonic property value models. Journal of Political Economy, 103(1), 209–227

109. Smith, T R., (1971) “Multiple Regression and the Appraisal of Single Family Residential Properties”, The Appraisal Journal, 277-285

110. Stoneman, Paul (2001). The Economics of Technological Diffusion, Oxford: Blackwells (September).

111. Sustainability Matrix and Sustainability Report (2002). “Building for Sustainability: Six Scenarios for the David and Lucille Packard Foundation Los Altos Project,” prepared for the David and Lucille Packard Foundation. Available on-line at: http://www.packard.org/pdf/2002Report.pdf.

112. Talarico, W. (1998). The Nature of Green Architecture. Architectural Record, 186, 4, 149-152.

113. Tinker, A. (2003). “The Austin Green Building Program: An analysis of the program’s effectiveness” http://txspace.tamu.edu/ bitstream/1969.1/1492/1/etd-tamu-2003C-ARCH-Tinker-1.pdf

114. Tinker, A. & Burt, R. (2002).”Characterizing green residential construction for green builder programs and construction education”. Proceedings of the 38th Annual Conference, Virginia Polytechnic Institute and State University - Blacksburg, Virginia, April 11 - 13, 2002. University of Nebraska

115. Tinker, A., & Burt, R. (2003).”Waste management practices in United States green building programs” Proceedings of the 11th Rinker International Conference on Deconstruction and Material Re-use, Gainsville, FL, 7-10 May, 2003. University of Florida.

116. Tinker, A., & Burt, R. (2004).”Austin Green Building Program analysis: The effects of water-related green building features on residential water consumption” International Proceedings of the 40th Annual Conference of the Associated Schools of Construction, Brigham Young University, Provo, Utah, USA, April 8-10, 2004. University of Southern Mississippi.

117. Trippi, R.R. (1977). “Estimating the Relationship Between Price and Time of Sale for Investment Property” Management Science 23, 838–842.

118. Troy, A., & Romm, J. (2004). “Assessing the price effects of flood hazard disclosure under the California natural hazard disclosure law”, Journal of Environmental Planning and Management, 47(1), 137–162.

119. Tu, C.C. (2005). “How does a new sports stadium affect housing values? The case of FedEx Field”, Land Economics, 81, 379-395

120. Turner Construction (2005). 2005 Survey of Green Buildings, Available at: http://www.turnerconstruction.com/greenbuildings

121. US Census Bureau 2005 – 2007 http://factfinder.census.gov

122. US Environmental Protection Agency,(2003). Indoor Air Quality, Available at: http://www.epa.gov/iaq/.

123. U.S. Green Building Council, Washington, D.C. (2001). LEED reference guide, Version 2.0.

124. Walden,M.L. (1990). "Magnet Schools and the Differential Impact of School Quality on Residential Property Values," Journal of Real Estate Research, American Real Estate Society, 5(2), 221-230.

125. Waugh FV (1928) Quality factors influencing vegetable prices. Journal of farm economics 10,185–196

126. Weicher, J., and R. Zerbst. (1973). "The Externalities of Neighborhood Parks: An Empirical Investigation," Land Economics 49, 99-105.

127. Wilson, A., Uncapher, J., McManigal, L., Hunter Lovins, L., Cureton, M. and Browning, W.D. (1998), Green Development: Integrating Ecology and Real Estate, Wiley, New York, NY.

128. Witt J, Vasatka E, Cantrell T, Purvis J, Johnston D. (2005). "Boulder, Colorado and Frisco, Texas:A Tale of Two Green Cities" Available at http://www.bouldercolorado.gov/files/Environmental%20Affairs/Green%20Building/usgbc_pittsburg_1.pdf

129. World Commission on Environment and Development. (1987). Our Common Future, Report of the World Commission on Environment and Development, Published as Annex to General Assembly document A/42/427, Development and International Co-operation: Environment

130. Xenergy Inc. (2000). "Green City Buildings: Applying the LEED Rating System," prepared for the Portland Energy Office. Available at: http://www.sustainableportland.org/CityLEED.pdf.

BIOGRAPHICAL INFORMATION

Ramya Rajajagadeesan Aroul received her Master's in Science (technology) from Birla Institute of Technology and Science, Pilani, India in 2002. She went on to pursue her Masters in Business Administration specializing in Finance from ICFAI Business School, Hyderabad, India in 2005. She received her Master's in Science specializing in Real Estate from the University of Texas at Arlington in 2009 and she is currently pursuing her PhD in Finance at the University of Texas at Arlington. Her research interests include areas of international finance, corporate finance, corporate governance and corporate social responsibility.