The Value of "Green:"

Evidence from the First Mandatory Residential Green Building Program

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Abstract

There has been recent interest in green building and development practices and research. Resulting from growing environmental awareness and concerns, mandatory residential green building programs have been implemented nationally at the municipal level and Texas has passed legislation to create a statewide program. However, the impact of greenness on residential property values has not been rigorously evaluated. This study examines residential transaction prices in two cities and finds a statistically significant premium associated with "green" properties. Additionally, there is evidence of a larger premium associated with green properties located in Frisco, Texas, the nation's first mandatory residential green building program.

Keywords: Green development, Mandatory residential green building program, Real estate valuation, Hedonic model

1. Introduction

Interest in green building is growing. Indeed, the intensity of interest expressed by many sectors of the real estate and the land development industry is a sign of acceptance of green investment and acknowledgement of the need for green building and development practices. There is also concern regarding quality improvement of new home construction from both environmental and sustainability perspectives. With allocation of $5 billion towards weatherizing homes by the American Recovery and Reinvestment Act (ARRA), significant resources will be channeled into green development projects (Committee on Appropriations, 2009). This investment combined with green building programs will further accelerate the American green revolution.

Since zoning, building codes, and most development regulations are enacted and enforced through municipal police powers, local governments are at the forefront in developing and updating green ordinances and policies. Nationwide, a few communities have taken leadership roles and have implemented formal mandatory green building best management practices programs.[1] See Table 1 for an overview of selected mandatory green building programs.

[Place Table 1 here]

[1] Green building programs could be either mandatory or voluntary. In this study, we focus on mandatory green building programs.

Even though smaller municipalities developed the earliest green building policies, the increasing acceptance of green building practices is reflected in the adoption of policies by cities, counties, and states. For example, the State of Texas has recently adopted legislation to adopt a statewide mandatory green building program to begin January 2012 for single-family residential dwellings.[2]

A mandatory green building program is a coordinated, systems approach to green development rather than a component-by-component approach to building (Bynum and Rubino, 1998). Since all builders are mandated to follow green building practices in a mandatory program, the community will experience dramatic shifts in sustainable construction practices and an accelerated implementation of green development.

Existing green research has focused on commercial buildings and the impact of voluntary third party green rating systems. As discussed in the literature review, there has been some evidence that quantifies the economic benefits of green commercial buildings; however, limited research exists on the real estate market's response to residential green development and building practices. In addition, the market may recognize price premiums for the coordinated systems required of mandatory green building policies. Prior research on green building codes addressed the impact of

[2] For more information on this legislation please see the Texas Register, Adopted Rules, June 4, 2010, 35, 4727-4729. http://www.sos.state.tx.us/texreg/pdf/backview/0604/0604adop.pdf

mandatory household energy and water consumption regulations and did not address green valuation influences or green building programs.

This leads to two research questions. First, do single-family residential markets reflect and capitalize green investment practices in transaction prices? And second, does the market recognize the coordinated and mandatory aspects of a municipal green development program? These questions are of interest to homeowners, developers, investors, brokers, appraisers, policy makers, and researchers.

In this study, we investigate the price effects of green on residential transaction prices in two similar Texas cities: Frisco and McKinney. Frisco has implemented the country's first residential mandatory green building program and McKinney has no green mandates, although properties with green features have been voluntarily developed.

The findings of this study reveal a positive and statistically significant effect on transaction prices of green residential properties. Furthermore, there appears to be a modestly stronger price premium associated with green transaction prices of residential properties associated with the mandatory green building program.

The next section provides background on the study setting, including an overview of Frisco's mandatory green building program. This section is followed by a review of the extant literature leading to research hypotheses. Next, sample data is

described, including the selection criteria used to identify green transactions, and the empirical models are developed. Finally, the statistical results are presented, followed by a discussion of the findings and conclusion.

2. Setting

For comparison, the cities of Frisco and McKinney, Texas were selected because these adjacent cities are similar in terms of demographics, employment, and housing market activity. The Frisco-McKinney area is one of the fastest developing regions of the Dallas-Fort Worth Metroplex. Land that once was dedicated to the production of wheat and livestock feed is now demanded for new homes, schools, offices, and parks. The populations of both cities have been growing at steady rates for the past two decades, creating stable and steady housing demand. See Table 2.

[Place Table 2 here]

To manage housing growth and promote sustainability, Frisco implemented a residential green building program in May 2001. A primary difference between these two cities is Frisco's mandatory green building program, as McKinney does not have any green municipal initiative. Therefore, the Frisco-McKinney pairing provides a natural experimental setting for the study of residential transaction prices, green features, and the nation's first mandatory green building program.

The green development process is a paradigm shift from traditional building practices and developers and builders can be apprehensive, at first, towards mandatory programs. Mandatory programs require developers and builders to deviate from customary construction practices to test new methods and materials that could reduce development feasibility. In fact, this was the initial concern from the local building industry when Frisco's proposed a mandatory green building program. In response to industry concern, Frisco implemented a performance based mandatory residential green building program. A performance-based program sets minimum sustainability standards, but gives developers and builders flexibility in how they meet green development requirements (Witt et al., 2005).

With this initiative, Frisco, Texas became the first United States city to adopt a mandatory residential green building program. According to an ordinance passed on May 2, 2001, all residential plats accepted after May 23, 2001 were required to meet or exceed the mandatory green building program standards. After five years, the city restructured and enhanced the residential green building program. The revised program was put into effect for all homes receiving building permits on, or after, July 1, 2007. Frisco's Residential Green Building Program mandates minimum energy efficiency, water conservation, indoor air quality, and waste recycling standards for all residential construction. Frisco's assessment of "green" is consistent with the explanation given by

Heekin and Meyers (2001).[3] Additional details of Frisco's mandatory green building program are provided in Appendix A.

3. Literature review and research questions

The hedonic pricing method is based on the premise that the value of a good or service can be decomposed into specific benefits/features. If the market recognizes these individual characteristics, then the contributor value of these benefits/features can be quantified (Rosen, 1974). In the real estate literature, hedonic methods have been used to study a wide range of attributes including school districts (Walden, 1990), conservation districts (Diaz, et al. 2008), and age-restricted and gated communities (Allen 1997). Despite a relatively developed body of hedonic real estate literature, there appears to be little published research examining the valuation impact of green, an attribute of residential development that is gaining in importance due to social, environmental, and ethical concerns.

Previous research addressing environmental attributes has been primarily focused on the issue of contamination and property values. These studies addressed how proximity to environmental contamination, such as superfund sites, leaking underground storage tanks (LUSTs), landfills, air and water pollution, and others, influence residential property values (Simons and Saginor, 2006). In another meta

[3] Green building can be identified as development and construction that endorses less energy consumption, promotes water conservation, propagates the best use of building materials, uses renewable resources, encourages competent waste management techniques, preserves the natural environment, and incorporates health and environmental standards (Heekin and Meyers, 2001).

analysis, Boyle and Kiel (2001) evaluated 30 hedonic price studies organized into air pollution, water quality, undesirable land uses, and multiple pollution sources. This study found that these environmental variables were important influences on residential property values.

Other prior hedonic studies have estimated transaction price discounts that consumer's demand for properties located proximate to negative environmental factors such as poor air quality, poor water quality, and undesirable land use (see Reichert et.al., 1992; Smolen et.al., 1992; Flower and Ragas, 1994; Benjamin et.al., 1996). This present study differs from these reviewed papers by examining consumer responses to residential green building, a property feature that minimizes the negative impact of human created improvements on the environment resulting in potential operating cost savings to the owner and society.[4] In other words, this study evaluates "green" as a building characteristic rather than an environmental externality. The majority of the available published research with this perspective is on commercial buildings and takes a normative, rather than a positive perspective (Ellison et al, 2007).

Empirical research of green commercial properties primarily sample the CoStar© database of commercial and industrial property listings and transactions. These studies have evaluated the effects of voluntary green certifications on transaction

[4]The founder of Leadership in Energy and Environmental Design (LEED), the United States Green Building Council, describes 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 such as sustainable site planning, safeguarding water and water efficiency, energy efficiency and renewable energy, conservation of materials and resources, and indoor environmental quality" (USGBC, 2001).

prices or rental rates (Miller, et al., 2008; Fuerst and McAllister, 2009; Fuerst and McAllister, 2011; Eichholtz, Kok, and Quigley, 2010; Wiley, Benefield, and Johnson, forthcoming). Miller, et al. (2008) is a pioneering study of green features in commercial buildings and investigated the benefits of investing in energy savings and environmental certifications. This study used the U.S. based EnergyStar rating system and the LEED-certified office building certifications as "green" metrics and found evidence of sale price premiums of approximately 6% and 11% for Energy Star and LEED certified office building transactions, respectively. A similar effort by Fuerst and McAllister (2011), using the same data, reported rental premiums of approximately 5% for LEED certification and 4% for EnergyStar. For sales prices, they found price premiums of 25% for LEED-certified and 26% for EnergyStar office buildings.

Wiley, Benefield, and Johnson (forthcoming), also using a hedonic pricing approach, found rental premiums ranging from 7% to 9% for EnergyStar qualified buildings and 15% to 18% for LEED certified commercial buildings. Eichholtz, Kok, and Quigley (2010) studied the financial performance of EnergyStar labeled and LEED certified commercial buildings and a control group, consisting of all commercial properties located within 1,300 feet of a green property. They find evidence of economic benefits associated with green certified commercial buildings with green rated buildings achieving rental rates that are 3% higher per square foot than comparable but non-green buildings. From these studies, we have initial evidence of

rental and sale price premiums associated with green *commercial* buildings, defined as building with the EnergyStar designation and/or LEED certification, at all levels.

Despite this commercial property research, we were unable to find similar published research on the price impact of green features and development processes on residential transaction prices. This study addresses this literature void by examining and quantifying the market's response to residential green development. However, our research expectations are rooted in the theory and findings of the green commercial literature.

Fuerst and McAllister (2011) provide a theoretical framework for the market's expected response to green features, which is displayed in Figure 1. The demand for green and non green properties are given by D_G and D_{NG} and the supply for green and non green properties are given by S_G and S_{NG}. Assuming that green properties and non green properties are almost perfect substitutes, an increase in the demand of green properties will result in the decrease in demand of non green properties. The demand increase for green properties will result in a price increase from P_{NG} to P_G and the short run inelasticity in supply results in a premium (P_G - P_{NG}) for green properties. This leads to our first research expectation that green features will result in residential transaction price premiums.

[Place Figure 1 here]

A combination of mandatory government regulation and voluntary industry standards has evolved to promote and regulate green development. As a consequence,

general building standards are becoming more rigorous and ubiquitous (Fuerst and McAllister, 2011) and municipalities are now using mandatory building codes to set minimum energy and water consumption requirements for new construction. As a result, a research interest in the relationship between household electricity consumption and building codes has recently developed (Aroonruengsawan, Auffhammer and Sanstad, 2009; Costa and Kahn, 2009; Jacobsen and Kotchen, 2009).

Aroonruengsawat, Auffhammer, and Sanstad (2009) examined mandatory state level building codes and identified the impact of these codes on residential electricity consumption. Jacobsen and Kotchen (2009) used residential billing data on electricity and natural-gas consumption and concluded that a mandatory change in energy-code requirements, implemented in Florida in 2002, was associated with a 4% decrease in electricity consumption and a 6% decrease in natural-gas consumption.

Costa and Kahn (2009) concluded that building codes increased the electricity efficiency of dwellings. In this study of building energy efficiency, they investigated homeowners' asset returns to mandatory energy efficiency investment. Using residential transaction prices from Sacramento, California from 2003 to 2009, they found that energy efficient homes sell at a premium.

A mandatory green building program can dramatically change market standard and accelerate the demand for the green properties. As a result, demand for green properties shifts further to the right in Figure 1, from D_G to D_M and the existing supply of the green properties S_G is not sufficient to meet this extra demand. Despite an

increase in green real estate development, the short-term supply of new green properties shown as S_M lags the change in demand for multiple reasons from the natural real estate development gestation period to builder hesitation or learning curve associated with the adoption of the green building process. As a result, the supply of green properties (S_G) shifts to the right but not to the magnitude as the shift in demand (D_G), resulting in an upward shift in prices to P_M.

Therefore, in the short run, the price of green properties in a mandatory green building program will experience a price premium of ($P_M - P_G$) above the green properties and a price premium of ($P_M - P_G$) above non green properties. We can see that the impact of green on residential transaction prices will be enhanced by the presence of a residential mandatory green building program, as has been found in the commercial property literature for the voluntary green building designations and certifications.

In the long run, the supply of the green properties will increase to $S_{M'}$ to match the demand, reducing the price of green properties to the level of P_G. Since it becomes mandatory that the new buildings be constructed green, a new market standard is set and the existing supply of non-green buildings is relatively inferior. Essentially, non-green becomes a form of functional obsolescence in a market that recognizes green development as the new market standard. We expect to find a relatively stronger price premium for green properties located within a mandatory green residential program as

the mandatory nature of these programs accelerates both the development of green properties within the community and the change to a new, greener market standard.

4. Method

Hedonic pricing studies have evaluated the relationships between housing prices, structural features, and situs characteristics (see Sirmans et. al, 2006 for an overview of this literature). In this tradition, we use a hedonic pricing method to estimate the marginal transaction price contribution of green features and development in residential property values. This section provides an overview of the sample, including a description of the sample data and the development of the variable of interest, residential "greenness."

4.1. Sample

Residential transaction price data were obtained from the North Texas Real Estate Information System (NTREIS) for the period from January 1, 2002 through July 1, 2009. This sample includes detached single-family residential transactions from the cities of Frisco and McKinney. As previously stated, Frisco enacted the mandatory residential green building program in May 2001 where all residential plats accepted after May 23, 2001 were required to meet or exceed the mandatory green building program standards. Therefore, the first sample (referred to as 'sample A ' hereafter) consists of newer buildings constructed after the green building program was first enacted and includes 14,055 transaction records. Frisco revised their mandatory green

building program in 2007 with the mandate that all homes receiving building permits on, or after, July 1, 2007 to follow minimum green building program standards. Therefore we include a second sample, (referred to as 'sample B' hereafter) of transaction of residential improvements constructed after the green building program was revised. Sample B consists of 867 residential transactions.

4.2. Defining green transactions - mandatory

All Frisco residential plats accepted after May 23, 2001 are required to build according to the mandatory green building program standards. Frisco maintains a public record of green subdivisions platted after 2001. A matching procedure and an Internet based GIS identifying all subdivisions were used to identify residential transaction in the 183 identified green Frisco subdivisions. These mandatory green property transactions were identified as both mandatory and green. Because Frisco required that all buildings constructed after July 2007 meet the mandatory green development requirements, all Frisco transactions with improvements constructed after July 2007 were also coded mandatory and green. These coding rules identified 5,991 and 332 mandatory green transactions based on Frisco's green building program policies in samples A and B, respectively.

4.3. Defining green transactions - choice

Frisco's 2001 requirement was applicable to subdivisions being platted; however, subdivisions exist that were platted before 2001 but developed after 2001.

Therefore, some construction during this time period was not mandated to be green, but could have been constructed green by choice of the developer or owner. For this reason, the Frisco sample was evaluated for transactions of properties that were built between 2001 and 2007 according to green principles due to private initiatives (choice). Also, the McKinney data also contained green construction by developer or owner choice. Therefore, additional database searches were made to identify green by "choice" property transactions. First, the transaction records that had green features in the fields "green certification" and "green features" of the MLS database were coded as green by choice transactions. Next, keyword searches were made to identify 'green' construction features. Please refer to Appendix B for the complete list of green key word terms. For sample A, we identified 485 and 305 choice green transactions for Frisco and McKinney, respectively. For sample B, we identified 57 choice green transactions for McKinney, and no green by choice for Frisco (as all Frisco new construction was mandatory green in this sample).

In conclusion, there were 6,476 residential green property transactions (5,991 mandatory and 485 by choice) in Frisco and 305 green property transactions (all by choice) in McKinney for sample A. For sample B, there were 389 green property transactions, 332 (all mandatory) in Frisco and 57 (all by choice) in McKinney.

4.4. Control variables

Model independent variables control for structural, site, quality, and situs features. Appendix C defines the variables and Tables 3a and 3b provides descriptive statistics for samples A and B.

[Place Tables 3a and 3b here]

Several of the independent variables warrant further discussion. To control for location differences, indicator variables for the county, either Collin or Denton County, control for significant differences in county demographics and other factors affecting residential transaction prices. We include an indicator variable for city (Frisco or McKinney) but as previously stated, the demographic similarities between these two neighboring cities were an important motivation in selecting this setting and our expectation is that this control variable will not be significant. The model also includes quality variables to identify foreclosure sales, homeowners association (HOA), age and age.^{2} Note that age and age^2 are not anticipated to be significant in sample B due to the limited variability in property ages. Because seasonality effects have been found in residential transaction price data (Goodman, 1992), we control for market trend and seasonality with annual and quarterly indicator control variables.

5. Models and results

To determine the effect of green on residential prices, we estimate the follow models:

$$\ln(salesprice)=\beta_0+\sum\beta X+\beta_{Green}+\varepsilon \quad (1)$$

$$\ln(salesprice)=\beta_0+\sum\beta X+\beta_{Mandatory}+\beta_{Choice}+\varepsilon \quad (2)$$

where X_i is a (n x k) matrix of traditional structural, site, quality, and situs variables. The statistical models are estimated using ordinary least squares (OLS). The dependent variable is the natural log of sale price. Sirmans, Macpherson, and Zietz (2005) discussed the advantages of using the semi-log specification in hedonic modeling. This specification allows for variation in the dollar value of each characteristic and coefficients are interpreted as the percentage change in the price per unit change associated with each characteristic. This specification also helps to minimize the problem of heteroskedasticity, although heteroskedasticity was found in the sample data, despite the semi-log specification. To control for heteroskedasticity we use White's heteroskedasticity-consistent standard errors and covariance procedure.

5.1. Model 1

Model 1 uses equation (1) from above. The variable of interest is *Green,* an indicator variable identifying all green property transactions. Table 4 presents the direct effects model for samples A and B.

[Place Table 4 here]

With an adjusted R^2 of 78% for sample A and an adjusted R^2 of 75% for sample B, the explanatory power of both models was acceptable and consistent with published

hedonic research of residential transaction prices. Coefficient estimates were of the expected signs. Note that the City independent variables were not statistically significant in both models. Also, the Age and Age^2 variables were not significant in Sample B, due to the limited age variability in this sample.

These results demonstrate a price premium associated with green properties. After controlling for price differences associated with structure size, property qualities, and situs, the green variables exhibit coefficients of 2.07% and 2.43% for samples A and B respectively, which were statistically significant at the 1% level.

5.2. Model 2

Model 2 uses equation (2) from above. The variables of interest in this model are variables identifying both mandatory and non-mandatory (referred to as 'choice') green transactions for samples A and B. Table 5 presents model 2 results.

[Place Table 5 here]

With adjusted R^2s of 78% and 75% for samples A and B, respectively, the explanatory power of both models was acceptable. Coefficient estimates were of the anticipated signs. Again, the City independent variables were not statistically significant in any model and the Age and Age^2 variables were not significant in Sample B, due to the limited age variability in this sample.

As compared to model 1, model 2 had similar explanatory power but revealed greater price premiums for green development located in a mandatory green building program and relatively lower price premium for green properties developed by choice. The mandatory-green variable coefficients are 4.69% for sample A and 3.03% for sample B. The choice-green variable coefficients are 1.05% for sample A and 0.17% for sample B. Since the mandatory variable serves as a proxy for residential green development in Frisco's mandatory green building program, this does provide initial evidence that the mandatory program may influence residential transaction prices.

6. Discussion

As a result of environmental and economic concerns, residential green building program have been enacted in many cities and counties throughout the country. Texas has passed legislation to establish statewide single-family green building requirements starting in 2012. Green development has stepped from the background to forefront of public policy initiatives.

Even if green building policy is enacted for environmental and social benefits, green development may certainly influence residential transaction prices and property values. In past decades, expenditures in green features were generally written off as no or very low return investments. These features were useful to the owner but the market would not necessarily recognize this investment. However, with increasing energy prices and subsequent changes in attitudes, consumers now consider green in their home

buying process and demand green features and development. As a result, academics, industry professionals, consumers, and policy makers are interested in identifying and measuring any value impacts from green residential development and a mandatory green building program.

However, green research has generally focused on valuation effects on commercial properties and voluntary green initiatives. In general, hedonic studies concerned with commercial green properties have found transaction price and rental premiums for green investment associated with voluntary green designations and certification programs (Miller et al., 2008; Eichholtz et al., 2010; Fuerst and McAllister, 2011; Wiley, Benefield and Johnson, forthcoming). From these results, it does appear that commercial real estate markets are generally responding to and recognizing green investment encouraged by programs such as Energy Star and LEED. The results of this present study parallel the commercial property findings and provide initial evidence that residential markets are recognizing green investment.

It is important to note that this study measures the market's valuation of green investment and does not quantify green investment cost. There is a perception of high costs associated with green building. For example, Kats (2003, 2005) found that there is an increase of about 2% in green commercial building construction costs. If Kats's can be generalized to residential green construction then the findings in this present

study may suggest that the market is approximately recognizing green construction costs.

However, we hesitate to presume that the value of green should equal the cost of green construction, as we know that cost rarely equals value in real estate markets and further research into green construction cost is warranted. Furthermore, green building features provide financial benefits in the form of lowering operating costs over the improvement's economic life. Reduced operating costs may include reduced energy consumption, water conservation, waste reduction, and better indoor air quality (Kohlhepp, 2006; RICS, 2005). The true value of cost saving benefits from energy saving construction also depends on assumed future energy prices at the time the transaction was negotiated. However, these benefits can be difficult to quantify and therefore difficult for the buyers and sellers to estimate and, therefore, the market to recognize.

Although this present study finds a modest price premium for residential green features, perhaps the market is acknowledging initial green construction costs. Going forward, markets may recognize and capitalize the long-term benefits, both financial and non-financial, of green features and building practices. This should be a fruitful area for future research.

7. Conclusion

This present study examines the value of green in residential properties and the market response to a mandatory green building program. The results of this study indicated a positive and statistically significant premium for transactions with green residential building features. Additionally, there is evidence presented of a more robust price premium for green properties located within a mandatory green building program. Although the findings from this present study parallel the commercial property literature, this is the first found study to document the valuation impact of green features and development on residential transaction prices.

Specifically, the contributions of these findings are three fold. First, this study introduces "green" into the residential hedonic pricing literature. It is anticipated that greenness will be a common consideration in the hedonic research paradigm. Second, this study is an initial effort to encourage additional research on the effects of green development on residential transaction prices. Wide scale green development is a relatively recent innovation and there has not been an opportunity to study the impact of green features on property values over an extended time period. This study shows a modest but significant impact on residential transaction prices; however, going forward, green price premiums could increase as markets recognize and capitalize the long-term benefits, both financial and non-financial, of green building ownership. Future research should also consider the costs as well as the value creating benefits of green development. This present study measured exclusively the value or the market's reaction to green features and development and not costs. Third, we evaluate the impact

of a mandatory green development program, as the two Texas cities used in this study provide a unique opportunity to examine the impact of a mandatory residential green building program. Further research is encouraged to better understand the relationship between residential property values, green development, and green building programs, both mandatory and voluntary. Research on green real estate is in an early stage of a research program with many important questions to consider.

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APPENDIX A

Residential Green Building Program Guidelines – City Of Frisco
(edited and summarized by the authors)

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:

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 at least 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 at least 60 inches from all the roofing materials.
d. HVAC plenums on the supply and 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 and 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
   a. In addition to the city's waste reduction and recycling regulations, 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.

APPENDIX B

List of Green Identifiers

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

APPENDIX C

Variable Definitions

Characteristics	Description
ln(*salesprice*)	Natural log of sales price
Green	Dummy variable value equals one if property is green
Mandatory	Dummy variable value equals one if property is in mandatory green program
Choice	Dummy variable value equals one if property is green by choice
lnSqft	Natural log of square foot
Beds	Number of beds
BedsMore	Dummy variable value equals one if number of beds more than 4
Fullbath	Number of full baths
Halfbath	Number of half baths
Pool	Dummy variable value equals one if pool is present
Age	Age
Age^2	Square of Age
City	Dummy variable value equals one if property is in Frisco
County	Dummy variable value equals one if property is in Collin County
School	Dummy variable value equals one if property is in Frisco ISD
Foreclosure	Dummy variable value equals one if property is foreclosed
HOA	Dummy variable value equals one if home owner's association
Q1	Dummy variable value equals one if sale is in First Quarter
Q2	Dummy variable value equals one if sale is in Second Quarter
Q3	Dummy variable value equals one if sale is in Third Quarter
Q4	Dummy variable value equals one if sale is in Fourth Quarter
Year_2002	Dummy variable value equals one if sale is in 2002
Year_2003	Dummy variable value equals one if sale is in 2003
Year_2004	Dummy variable value equals one if sale is in 2004
Year_2005	Dummy variable value equals one if sale is in 2005
Year_2006	Dummy variable value equals one if sale is in 2006
Year_2007	Dummy variable value equals one if sale is in 2007
Year_2008	Dummy variable value equals one if sale is in 2008
Year_2009	Dummy variable value equals one if sale is in 2009

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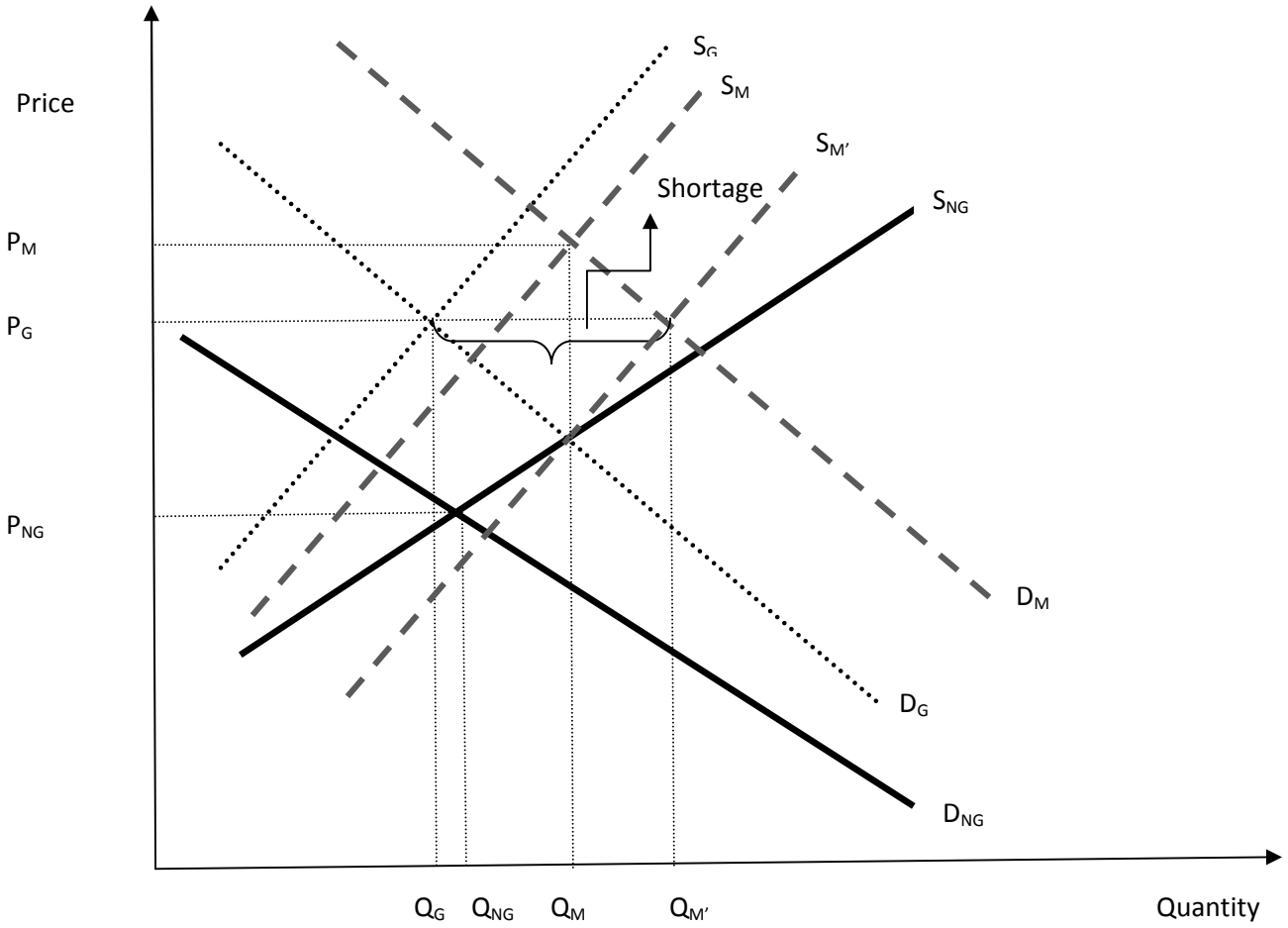
Figure 1: Model of Price Premiums for Green and Mandatory Green*



P – Price	Q – Quantity
G – Green	M – Mandatory program
NG – Non green	M' – Mandatory program – Long run

Note: D_G and D_{NG} denote the demand for green and non-green properties. S_G and S_{NG} denote the supply for green and non-green properties. An increase in demand for green properties will cause price to increase from P_{NG} to P_G resulting in a premium (P_G - P_{NG}) for green properties. A mandatory green building program, shifts demand for green properties from D_G to D_M. In the short run, the supply of green properties (S_G) shifts to the right to S_M resulting in an increased price P_M and will experience a price premium of (P_M – P_G) above the green properties and a price premium of (P_M – P_{NG}) above non green properties. In the long run the supply of the green properties will increase to S_M' to match the demand, reducing the price to the level of P_G.

(*adopted from Fuerst and McAllister (2011))

Table 1: A Survey of Mandatory Green Building Programs

Jurisdiction	State	Program	Year enacted/revised
Frisco	TX	Residential	2001/2007
Boulder	CO	Residential	2001/2008
Marin County	CA	Residential	2001/2008
Austin	TX	Residential and Commercial	2003
Aspen/Pitkin County	CO	Residential and Commercial	2003/2008
Pleasanton	CA	Residential and Commercial	2003/2006
Arlington County	VA	Residential and Commercial	2004
Pasadena	CA	Residential and Commercial	2006/2008
Long Beach	CA	Residential and Commercial	2006
Santa Cruz	CA	Residential and Commercial	2006
Montgomery County	MD	Residential and Commercial	2006
Boston	MA	Residential and Commercial	2007

Table 2: Demographic, Employment, and Housing Statistics - Frisco and McKinney

	Frisco	McKinney
Population	33,714	54,369
Median age (years)	30.9	30.6
Female persons	50.50%	49.40%
Persons per household	2.78	2.89
Population in labor force		
Civilian labor force	78.90%	70.10%
Employed	77.10%	67.60%
Unemployed	1.80%	2.40%
% of civilian labor force	2.30%	3.50%
Armed forces	0.10%	0.00%
Not in labor force	21.10%	29.80%
Mean travel time to work	27.3 minutes	25.4 minutes
College/Graduate School	16.40%	16.80%
Land area (square miles)	70	58
Housing units	13,683	19,462
1-unit, detached	75.80%	73.20%
1-unit, attached	2.40%	1.40%
2 units	1.50%	2.00%
3 or 4 units	1.30%	3.30%
5 to 9 units	3.20%	4.20%
10 to 19 units	8.50%	5.10%
20 or more units	5.30%	8.50%

Source: QuickFacts from the US Census Bureau 2000
(www.infoplease.com/us/census/data/texas)

Table 3a: Descriptive Statistics – Improvements constructed after green building program enactment (sample A)

	Full Sample (n = 14,055)			Frisco (n = 6555)			McKinney (n = 7500)		
Characteristics	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
ln(salesprice)	12.15	12.61	11.52	12.25	12.61	11.70	12.06	12.61	11.52
Green	0.48	1.00	0.00	0.99	1.00	0.00	0.04	1.00	0.00
Mandatory	0.43	1.00	0.00	0.91	1.00	0.00	0.00	0.00	0.00
Choice	0.06	1.00	0.00	0.07	1.00	0.00	0.04	1.00	0.00
lnSqft	7.91	8.54	6.19	7.94	8.54	6.58	7.88	8.46	6.19
Beds	3.72	8.00	0.00	3.84	8.00	2.00	3.62	6.00	2.00
BedsMore	0.60	1.00	0.00	0.59	1.00	0.00	0.60	1.00	0.00
Fullbath	2.36	5.00	1.00	2.46	5.00	1.00	2.27	5.00	1.00
Halfbath	0.41	5.00	0.00	0.43	5.00	0.00	0.40	3.00	0.00
Pool	0.04	1.00	0.00	0.04	1.00	0.00	0.04	1.00	0.00
Age*	3.27	8.00	-1.00	3.36	8.00	0.00	3.20	8.00	-1.00
Age^2	17.49	64.00	0.00	18.08	64.00	0.00	16.97	64.00	0.00
City	0.47	1.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
County	0.84	1.00	0.00	0.65	1.00	0.00	1.00	1.00	0.00
School	0.54	1.00	0.00	0.95	1.00	0.00	0.19	1.00	0.00
Foreclosure	0.10	1.00	0.00	0.09	1.00	0.00	0.10	1.00	0.00
HOA	0.89	1.00	0.00	0.89	1.00	0.00	0.89	1.00	0.00
Q1	0.22	1.00	0.00	0.21	1.00	0.00	0.22	1.00	0.00
Q2	0.28	1.00	0.00	0.28	1.00	0.00	0.29	1.00	0.00
Q3	0.26	1.00	0.00	0.26	1.00	0.00	0.26	1.00	0.00
Q4	0.24	1.00	0.00	0.25	1.00	0.00	0.24	1.00	0.00
Year_2002	0.03	1.00	0.00	0.03	1.00	0.00	0.03	1.00	0.00
Year_2003	0.15	1.00	0.00	0.16	1.00	0.00	0.14	1.00	0.00
Year_2004	0.16	1.00	0.00	0.16	1.00	0.00	0.16	1.00	0.00
Year_2005	0.18	1.00	0.00	0.18	1.00	0.00	0.18	1.00	0.00
Year_2006	0.17	1.00	0.00	0.16	1.00	0.00	0.18	1.00	0.00
Year_2007	0.14	1.00	0.00	0.14	1.00	0.00	0.14	1.00	0.00
Year_2008	0.12	1.00	0.00	0.12	1.00	0.00	0.12	1.00	0.00
Year_2009	0.05	1.00	0.00	0.05	1.00	0.00	0.05	1.00	0.00

*One record had an age of -1 because it was placed under contract before construction had finished.

Table 3b: Descriptive Statistics – Improvements constructed after green building program revision (sample B)

	Full Sample (n = 867)			Frisco (n = 332)			McKinney (n = 535)		
Characteristics	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
ln(salesprice)	12.17	12.61	11.52	12.29	12.61	11.75	12.09	12.61	11.52
Green	0.45	1.00	0.00	1.00	1.00	1.00	0.11	1.00	0.00
Mandatory	0.38	1.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
Choice	0.07	1.00	0.00	0.00	0.00	0.00	0.11	1.00	0.00
LnSqft	7.75	8.54	6.19	7.73	8.54	6.19	7.76	8.53	6.19
Beds	3.76	8.00	2.00	3.94	8.00	2.00	3.64	6.00	2.00
BedsMore	0.58	1.00	0.00	0.57	1.00	0.00	0.59	1.00	0.00
Fullbath	2.41	5.00	1.00	2.57	5.00	1.00	2.31	5.00	0.00
Halfbath	0.44	5.00	0.00	0.49	5.00	0.00	0.42	3.00	0.00
Pool	0.01	1.00	0.00	0.01	1.00	0.00	0.01	1.00	0.00
Age*	1.18	3.00	-1.00	1.22	3.00	0.00	1.16	3.00	-1.00
Age2	2.68	9.00	0.00	2.77	9.00	0.00	2.62	9.00	0.00
City	0.38	1.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00
County	0.84	1.00	0.00	0.59	1.00	0.00	1.00	1.00	0.00
School	0.53	1.00	0.00	0.94	1.00	0.00	0.28	1.00	0.00
Foreclosure	0.08	1.00	0.00	0.08	1.00	0.00	0.07	1.00	0.00
HOA	0.89	1.00	0.00	0.89	1.00	0.00	0.89	1.00	0.00
Q1	0.22	1.00	0.00	0.21	1.00	0.00	0.22	1.00	0.00
Q2	0.26	1.00	0.00	0.25	1.00	0.00	0.26	1.00	0.00
Q3	0.25	1.00	0.00	0.25	1.00	0.00	0.25	1.00	0.00
Q4	0.27	1.00	0.00	0.28	1.00	0.00	0.26	1.00	0.00
Year_2007	0.50	1.00	0.00	0.52	1.00	0.00	0.49	1.00	0.00
Year_2008	0.40	1.00	0.00	0.40	1.00	0.00	0.40	1.00	0.00
Year_2009	0.10	1.00	0.00	0.09	1.00	0.00	0.11	1.00	0.00

*One record had an age of -1 because it was placed under contract before construction had finished.

Table 4: Model 1 – Hedonic Model with Variable of Interest "Green"

	Sample A: Program Enactment		Sample B: Program Revision	
Characteristics	β	p-value	β	p-value
Green	0.02	0.00	0.02	0.00
LnSqft	0.89	0.00	0.65	0.00
Beds	0.12	0.00	0.12	0.00
BedsMore	-0.04	0.00	-0.05	0.00
Fullbath	0.09	0.00	0.07	0.00
Halfbath	0.01	0.00	0.00	0.00
Pool	0.13	0.00	0.14	0.00
Age	0.00	0.00	-0.01	0.11
Age^2	0.00	0.00	0.00	0.85
City	-0.01	0.45	-0.01	0.29
County	0.05	0.00	0.05	0.00
School	0.05	0.00	0.05	0.00
Foreclosure	-0.12	0.00	-0.11	0.00
HOA	0.03	0.00	0.05	0.00
Q2	-0.01	0.00	0.01	0.00
Q3	0.01	0.00	0.02	0.00
Q4	-0.01	0.01	-0.01	0.00
Year_2002	-0.04	0.00	-	-
Year_2003	-0.02	0.00	-	-
Year_2004	-0.04	0.00	-	-
Year_2005	-0.01	0.04	-	-
Year_2006	0.01	0.05	-	-
Year_2007	0.01	0.13	0.01	0.33
Year_2008	0.01	0.13	0.00	0.68
Intercept	5.61	0.00	6.53	0.00
R^2	0.79		0.75	
Adjusted R^2	0.78		0.75	
F-statistic	1234.33		663.81	
p-value	0.00		0.00	

Notes: The dependent variable was the natural logarithm of sale price. Samples A and B consists of 14,055 and 867 residential transactions, respectively. Sample A corresponds to the transactions after the mandatory program enactment (2001) and consists of 6781 green transactions (6476 in Frisco and 305 in McKinney) and Sample B corresponds to the transactions after the mandatory program revision (2007) and consists of 389 green transactions (332 in Frisco and 57 in McKinney)

Table 5: Model 2 - Hedonic Model with Variables of Interest "Mandatory" and "Choice"

	Sample A: Program Enactment		Sample B: Program Revision	
Characteristics	β	p-value	β	p-value
Mandatory	0.05	0.00	0.03	0.00
Choice	0.01	0.00	0.00	0.03
LnSqft	0.89	0.00	0.65	0.00
Beds	0.11	0.00	0.12	0.00
BedsMore	-0.07	0.00	-0.05	0.00
Fullbath	0.09	0.00	0.07	0.00
Halfbath	0.02	0.01	0.00	0.00
Pool	0.14	0.00	0.14	0.00
Age	-0.06	0.00	-0.01	0.16
Age2	0.00	0.32	0.00	0.77
City	-0.01	0.45	-0.01	0.24
County	0.03	0.00	0.05	0.00
School	0.04	0.00	0.05	0.00
Foreclosure	-0.12	0.00	-0.11	0.00
HOA	0.02	0.01	0.05	0.00
Q2	-0.01	0.00	0.01	0.00
Q3	0.01	0.00	0.02	0.00
Q4	-0.01	0.00	-0.01	0.00
Year_2002	-0.03	0.01	-	-
Year_2003	-0.01	0.00	-	-
Year_2004	-0.01	0.00	-	-
Year_2005	0.05	0.00	-	-
Year_2006	0.01	0.00	-	-
Year_2007	0.00	0.05	0.00	0.61
Year_2008	0.01	0.35	-0.01	0.47
Intercept	5.45	0.00	6.44	0.00
R2	0.79		0.75	
Adjusted R2	0.78		0.75	
F-statistic	1188.78		664.07	
p-value	0.00		0.00	

Notes: The dependent variable was the natural logarithm of sale price. Samples A and B consists of 14,055 and 867 residential transactions, respectively. Sample A corresponds to the transactions after the mandatory program enactment (2001) and consists of 6781 green transactions(5991 mandatory in Frisco and 790 by choice both in Frisco and McKinney) and Sample B corresponds to the transactions after the mandatory program revision (2007) and consists of 389 green transactions (332 mandatory in Frisco and 57 by choice in McKinney)