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The Value of Third-Party Verified Green Residential Housing in the Chicagoland Area

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Abstract

In this investigation, I will be basing hypothesis testing on the hedonic pricing theory. Essentially, this theory states that the price of a good is determined by the various characteristics of that good. Therefore, more desirable characteristics will lead to a higher price of the good. In the case of this study, third-party verification is the characteristic of interest, which is essentially a written guarantee of quality. By bringing in a third-party to verify a building's claim of sustainability, the risk of whether the property is truly environmentally friendly or not is taken away. This then leads me to my hypothesis that green-certified houses that are third-party verified will carry a higher price premium than green-certified houses without this verification.

This article is based on Mr. Bolton's fall semester senior seminar project. His Honors project of the same title is available online.

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I. Introduction

High efficiency houses, environmentally friendly houses, sustainable houses, energy efficient houses, zero energy houses; these are just a few of the many terms that have appeared in the real estate industry in recent years that refer to a type of residential home that is in some way green. Houses that are considered "green" have received one of many different certifications attesting to the building's sustainability aspects, or contain some environmentally friendly feature that leads to a smaller overall carbon footprint of the house. This could be better energy efficiency, improved ventilation, more natural lighting, or a host of other sustainable features. This report will investigate the value of green certifications in the Chicagoland residential real estate market. Specifically, do green-certified houses that have third-party verification sell for a market price premium when compared to green-certified houses without this verification? The green certificates that will be examined include the Leadership in Energy and Environmental Design (LEED) for Homes, Energy Star Homes, Chicago Green Homes, and the National Association of Home Builders (NAHB) Green.

In this investigation, I will be basing hypothesis testing on the hedonic pricing theory. Essentially, this theory states that the price of a good is determined by the various characteristics of that good. Therefore, more desirable characteristics will lead to a higher price of the good. In the case of this study, third-party verification is the characteristic of interest, which is essentially a written guarantee of quality. By bringing in a third-party to verify a building's claim of sustainability, the risk of whether the property is truly environmentally friendly or not is taken away. This then leads me to my hypothesis that green-certified houses that are third-party verified will carry a higher price premium than green-certified houses without this verification.

To fully test this hypothesis and analyze the research question, I will begin by providing some insight into the green housing market in the Background section. This will include a look at the history of sustainable building practices overall, and a short review of relevant literature that has been written in this field. I will then move on to the Theory section, in which I will further explain the hedonic pricing model, and how this theory leads into a workable empirical model. After that, I will explain my data source and empirical model that I will be using to test my hypothesis in the Data and Methodology section. Finally, I will present my findings in the Results section, followed by a Con-

clusion section where the relevance of these results is shown.

II. Background

The idea of sustainable building has been gaining ground ever since the Industrial Revolution, but really picked up after the energy crisis of the 1970s (Stone, 2011). When whole countries became worried about having enough energy for day-to-day operations, it became obvious that a complete reliance on coal and oil could easily lead to disaster. As a result, a higher importance was given to the search for renewable energy sources, and an overall reduction in total energy usage. One way energy consumption was reduced was by implementing better building standards that required greater efficiency in newly-built structures. This included a host of factors such as building materials, insulation, and ventilation. By requiring better standards, buildings were made stronger and more efficient while reducing their overall energy consumption.

However, these standards were just a beginning. Today, buildings still account for 40 percent of the world's energy usage (USGBC, 2017). The residential sector alone accounts for 33 percent of energy consumption in the United States (Kahn & Kok, 2014). By building structures that go beyond basic regulations, we can significantly reduce the amount of energy we use and the amount of pollution we create. For comparison, buildings that are green-certified are found to consume 15-25 percent less energy than buildings that are not (Suh, Tomar, Leighton, & Kneifel, 2014). My study into the value of verified green certification in the housing market will help the construction industry as a whole progress further with sustainable building.

Aside from the benefits of environmental preservation and reduced energy dependency, green housing provides financial benefits. Multiple studies have been done into various housing markets across the U.S. that prove a price premium exists for green-certified housing. One study into the value of green certifications in the California housing market found that there is a statistically significant premium of 2.1 percent (Kahn & Kok, 2014). This study further showed that this premium (amounting to about $8,400) was significantly higher than the added input costs of a more energy-efficient house, which further lends to the credibility of a true price premium. One of the most important concepts that was presented in this study was that of consumer ignorance in energy literacy. Homebuyers are often unaware of each house's energy costs per year, and so cannot properly account for these costs when considering which home to buy. With green certifications, consumers are provided more information about long-run energy consumption and how much this will add to the cost of the house in comparison to a similar non-green home.

A related study of green certification in residential housing was conducted in 2017, again finding a significant price premium when compared to non-cer-

tified houses (Hallman, 2017). This study used the same empirical design that Kahn and Kok (2014) used, but with transaction data from the Austin-Round Rock area of Texas. The results showed a 6 percent premium for green-certified houses, and an even greater 8 percent premium when LEED-specific houses were the only ones considered. While green homes remain only a small percentage of the total homes in this real estate market, their numbers have been increasing over time as green certifications and the premiums they carry with them become increasingly well known.

This type of quantitative analysis has even been done in the real estate market I will be examining. Once again, a green premium is shown when the Chicagoland area is analyzed (Eco Achievers, 2017). While using a slightly different statistical approach than the one used in Hallman (2017) and Kahn and Kok (2014), the design is appropriate and comparable. This study found a 4 percent increase in sales price of basic green-certified homes, and even larger premiums for more rigorous levels of certification. Beyond these conclusions, this investigation explained more qualitative benefits of green-certified houses, such as increased overall health of occupants and better reported comfort in the home.

The presented studies all point towards a green premium to housing prices, but there are different drivers behind this added value. The most obvious one is the financial savings that come with owning an energy efficient house. Lower monthly utility bills and fewer repair costs help to boost the price of these houses. However, this is not the only benefit that consumers value. The increased health that comes with green-certified houses also factors into the price premium. One Canadian study conducted on energy efficient houses in 2004 found that the rate of asthma and other air quality related ailments declined considerably for occupants over a one-year period (Leech, Raizenne, & Gusdorf, 2004). The study also found that other comfort levels, such as overall irritability, headaches, and difficulty concentrating, also fell more than occupants of conventional homes.

Another report by the company E4TheFuture found similar results. When examining data from the U.S. and Canada, it was found that many indicators of health showed marked improvement (E4TheFuture, 2016). In low-income households, the rate of asthma decreased 12 percent when the families moved to an energy efficient building with good building sealing and ventilation. These families also realized an average decline of $400 in annual Medicaid costs. The total population of surveyed households reported 9 percent fewer persistent colds, a 48 percent decline in the days during the previous month residents reporting their physical or mental health being “not good”, 7 percent fewer reported headaches, and a host of other health improvements. Health benefits were the main findings of this study, but overall comfort levels

were also found to be higher when a home was energy efficient.

These different studies show that environmental sustainability features in houses are valued in the housing market, but there has been little research into whether third-party verification affects this price premium. In general, third-party verification guarantees that whatever claim is being made has been tested by an outside group and found to be true. Absent third-party verification, any builder could claim sustainable building practices without actually doing so. In this study, I will investigate the third-party aspect of green certification, and whether this carries with it its own price premium.

III. Theory

The grounding theory in this investigation is the hedonic pricing model. This theory is, "the method of pricing a good by estimating the value of the individual characteristics that form the good," (Black, Hashimzade, & Myles, 2009). A hedonic theory in economics was first considered in the work of Court (1939) who looked at different prices for sources of utility, which he then said would be determinants of the final price in a given commodity (Xiao, 2017). This early work pioneered the use of multivariate statistical techniques, and led to the model's consideration in other areas of economics. Most relevant to this study, Court's work led directly to the use of this model as a common way of measuring housing prices.

In terms of housing, this theory means the final selling price of the house is dependent on what characteristics the house has, such as square footage and number of bathrooms. Individually, each aspect of the house can't be shown to have a specific and constant added value to the overall price. In other words, it is impossible to predict the price of a house with a patio against a similar house with a garden. Even if a patio cost more to add to a house, this doesn't necessarily mean it will add more to the final price than a garden would. The hedonic pricing model avoids this basic flaw when valuing a house based on input costs by considering each characteristic jointly, and measuring the predicted effect on price. The basic theory of hedonic pricing also states that the producer of a good will add various characteristics to that good until the marginal benefit gained equals the added input cost. This way the producer will maximize their profit and the consumer will maximize their benefit so long as information in the market remains open. Therefore, this theory assumes a free market with relatively open and equal information to all parties.

IV. Data and Methodology

The theory of a hedonic pricing model leads directly into the empirical design I will use to test my hypothesis. The theory states that characteristics of a good affect the overall value of the good. It then follows that I need an empirical model where the final price of the good is a function of its various character-

istics. A simple OLS regression is the design that can best estimate this relationship. From this I derived the following regression equation:

$$SPrice_i = \beta_0 + \beta_1(GDocs) + \beta_2(C_2) + \ldots + \beta_n(C_n)$$

In this equation, $SPrice_i$ is the sold price of house i, and β_n is the added value for house i from C_n, which is the characteristic n of the house. From this equation, I will be able to hold all the variables I identify as having a significant effect on selling price of the house constant, while testing for the added value from third-party verification specifically. By doing so, I will be able to test the hypothesis that third-party verification adds to the overall value of a house after controlling for other determinants of housing value.

To test my hypothesis, I will be using the statistical software R. R is an open-source programming language, written specifically for statistical computing. The software is free for anyone to install and use, and is straightforward to learn. I chose this software because of its universal access and the ease of replicability. Therefore, if any reader was so inclined they would be able to recreate my results without having to buy an expensive statistical software package. Using this software will also allow me to run my regression whenever I need to, rather than having to wait until I have the opportunity to use a computer that has a different statistical software package installed.

To test my hypothesis about third-party verification in the green housing market, I will use data collected from the Multiple Listing Service (MLS) database. This database is designed for real estate brokers so that they are able to quickly and accurately view housing trends and compare various housing characteristics to value. Specifically, I will be using the Midwest Real Estate Database (MRED), which is provided through MLS and gives detailed data on housing transactions in the American Midwest. For my study, I am only interested in the Chicagoland area, which I define as the city of Chicago and surrounding suburbs. This area was chosen due to the high concentration of green housing that is found here. Also note that I will only be using data on houses that claim to be green-certified. Comparable non-green housing will not be used in this study.

This database allowed me to search for numerous variables that I identified as having a possible effect on the final selling price of houses. The final selling price and its natural log, labeled "SPrice" and "lSPrice", are my dependent variables. The independent variable of particular interest in this study is labeled "GDocs", which is a dummy variable indicating whether the house has supporting documentation of the claimed green certification. Other control variables that I identified as having a possible significant effect on the final selling price of a house were location, number of bedrooms, number of bathrooms, approximate square footage, type of house, age, presence of a basement, and presence of an attached garage.

The number of days on market was also included as a control variable in an attempt to capture any changes in selling price not already accounted for in the control variables. A full list of these variables is presented in Table 1 below, with their short names, descriptions of what each variable is, and their expected signs with relation to the dependent variables.

Table 1: Variables and Descriptions

Variable Name		Description	Expected Sign
Dependent:			
	SPrice	Final selling price of house	N/A
	lSPrice	Log of the final selling price of house	N/A
Independent:			
	GDocs	1 = Has third-party verification 0 = Does not have third-party verification	+
	Loc	1 = Within the City of Chicago 0 = Suburb of Chicago	+
	Beds	Number of bedrooms in the house	+
	FBaths	Number of full bathrooms in the house	+
	HBaths	Number of half bathrooms in the house	+
	Type	Number of stories	+
	New	1 = The house was built less than one year ago 0 = Not	+
	Less10yr	1 = The house was built less than 10 years ago but more than one year ago 0 = Not	+
	ASF	Approximate square footage	+
	Bsmt	1 = The house has a basement 0 = The house does not have a basement	+
	AGar	1 = House has an attached garage 0 = House has a detached garage	Unknown
	DoM	Days the house was on the market for	-

To get a better understanding of this dataset, some initial descriptive statistics were compiled. Of interest to this study is how each of the identified variables changes when a house has third-party verification. To show this, the means and standard deviations of third-party verified houses were compared with those of houses without verification, and are displayed in Table 2 below. An initial overview of the data suggests a higher value assigned to third-party verified houses. This can be seen from the mean selling price for verified houses, which is over a $100,000 difference. However, this price difference may also be due to a variable or variables not yet controlled for, so any conclusions must await the regression analysis. The standard deviation is larger for verified houses, meaning it varies within a larger range, but this difference is far smaller than the mean selling price difference. Also, the mean days on market for third-party verified houses is considerably smaller than for non-verified houses. This would suggest that verified houses sell quicker than non-verified, either implying they were priced more accurately or that they were demanded more in the housing market. These initial summary statistics seem to be in favor of the hypothesis, but a true statistical test must be run to make any claims about the data.

Table 2: Descriptive Statistics

Variable	Mean		Standard Deviation	
	With GDocs	Without GDocs	With GDocs	Without GDocs
SPrice	613,690.90	494,525.70	384,073.60	345,233.40
Beds	3.9	3.8	1.0	0.8
FBaths	2.8	2.4	1.0	0.8
HBaths	0.7	0.9	0.5	0.5
Type	1.9	2.1	0.6	0.6
ASF	2,915	2,843	1,160	1,081
DoM	68.8	107.7	78.8	129.8

V. Results

I decided that a simple OLS regression would be the model that could best estimate the relationship between verification and housing prices. I ran two different OLS regressions to find the dollar and percentage change in selling price of the house from my independent variables. The first regression I will call Model A, and examines the final selling price in dollars as a function of my defined independent variables. The second regression I will call Model B, and examines the natural log of the final selling price as a function of the independent variables. By running this

second regression and making one additional transformation, I am able to estimate each variable's effect on the final selling price in terms of a percent change.

From Model A, I was able to examine the relationship between the selling price of a house and whether it has third-party verification, while controlling for other determinants of housing value. The estimation equation was as follows:

$$SPrice_i = \beta_{0i} + \beta_1(GDocs) + \beta_2(Loc) + \beta_3(Beds) + \beta_4(FBaths) + \beta_5(HBaths) + \beta_6(Type) + \beta_7(New) + \beta_8(Less10yr) + \beta_9(ASF) + \beta_{10}(Bsmt) + \beta_{11}(AGar) + \beta_{12}(DoM)$$

The output from running this regression is displayed in Table 3 below. I found that third-party verification had a positive and statistically significant effect on the final selling price of a house in the Chicagoland area in the amount of $63,943.33. In other words, if a green-certified house has third-party verification, it will sell for about $64,000 more than a similar green-certified house that does not have third-party verification. This coefficient estimate was significant at the 95 percent confidence interval, which further supports the hypothesis that third-party verification adds value.

Table 3: Regression Results for Model A

Command in R	lm(SPrice~GDocs+Loc+Beds+FBaths+HBaths+Type+New+Less10yr +ASF+Bsmt+AGar+DoM, data=CHI)		
Variable	**Coefficient Estimate**	**Standard Error**	**P-Value**
(Intercept)	-154259.29 (-1.742)	88539.86	0.082723 .
GDocs	63943.33 (2.122)	30129.03	0.034819 *
Loc	154811.66 (3.210)	48229.55	0.001506 **
Beds	-75495.45 (-3.988)	18929.86	8.8e-05 ***
FBaths	147549.12 (6.477)	22779.34	5.1e-10 ***
HBaths	120356.81 (3.950)	30472.35	0.000102 ***
Type	25528.38 (0.817)	31252.04	0.414808
New	-48555.11 (-1.216)	39915.87	0.224994
Less10yr	-84848.72 (-2.052)	41351.05	0.041246 *
ASF	185.50 (9.924)	18.69	< 2e-16 ***
Bsmt	-52961.70 (-0.830)	63775.02	0.407099
AGar	-55417.96 (-1.319)	42029.08	0.188552
DoM	-89.31 (-0.847)	105.45	0.397871
R-Squared	0.7403		
Adjusted R-Squared	0.7275		
F-Statistic	57.97 on 12 and 244 DF, p-value: < 2.2e-16		

NOTE: t-statistics are given in parentheses beneath the coefficient estimates. According to the standard output in R, degree of significance is shown as (.) = 90%, (*) = 95%, (**) = 99%, and (***) = 99.9%

Model B estimated the relationship between the natural logarithm of the final selling price of a house and third-party verification, controlling for the same variables as in Model A. The estimation equation was as follows:

$$lSPrice_i = \beta_{0i} + \beta_1(GDocs) + \beta_2(Loc) + \beta_3(Beds) + \beta_4(FBaths) + \beta_5(HBaths) + \beta_6(Type) + \beta_7(New) + \beta_8(Less10yr) + \beta_9(ASF) + \beta_{10}(Bsmt) + \beta_{11}(AGar) + \beta_{12}(DoM)$$

The output from this second model is shown in Table 4. Again, I found that third-party verification has a positive and statistically significant effect on the final selling price of the house. This regression showed a coefficient estimate of 0.1633. To transform this estimate into a percent change, I took the exponent of the coefficient and subtracted one (e^{β}-1). After doing this, I find a coefficient estimate of 0.1774,

meaning that having third-party verification raises the final selling price of a house by 17.74 percent. This value was found to be statistically significant at the 99 percent confidence interval, again implying a real and positive effect from third-party verification on selling p

Table 4: Regression Results for Model B			
Command in R	lm(lSPrice~GDocs+Loc+Beds+FBaths+HBaths+Type+New+Less10yr+ASF+Bsmt+AGar+DoM, data=CHI)		
Variable	**Coefficient Estimate**	**Standard Error**	**P-Value**
(Intercept)	11.61 (72.289)	0.1606	< 2e-16 ***
GDocs	0.1633 (2.988)	0.05465	0.003099 **
Loc	0.1758 (2.01)	0.08749	0.045550 *
Beds	-0.1292 (-3.762)	0.03434	0.000211 ***
FBaths	0.3423 (8.284)	0.04132	57.96e-15 ***
HBaths	0.2078 (3.759)	0.05528	0.000213 ***
Type	0.1158 (2.043)	0.05669	0.042141 *
New	0.1153 (1.592)	0.07241	0.112571
Less10yr	-0.01048 (-0.14)	0.07501	0.888951
ASF	0.0001905 (5.619)	0.00003391	5.23e-8 ***
Bsmt	0.009289 (0.08)	0.1157	0.93607
AGar	-0.1388 (-1.821)	0.07624	0.0698 .
DoM	-0.0002350 (-1.229)	0.0001913	0.22044
R-Squared	0.6966		
Adjusted R-Squared	0.6817		
F-Statistic	46.68 on 12 and 244 DF, p-value: < 2.2e-16		
NOTE: t-statistics are given in parentheses beneath the coefficient estimates. According to the standard output in R, degree of significance is shown as (.) = 90%, (*) = 95%, (**) = 99%, and (***) = 99.9%			

VI. Conclusions

Both estimated equations suggest that third-party verification adds value to a house, thus supporting my original hypothesis that green-certified houses that are third-party verified will carry a higher price premium than green-certified houses without this verification. This is seen both through its positive coefficient in both equations and by the fact that it was statistically significant both times. It then stands to reason that if a seller is going to claim to have a green-certified house, it is worthwhile to also invest in getting third-party verification.

The results I obtained are consistent with the previous literature on green-certified housing. In the real estate markets of California state, Austin-Round Rock, and Chicagoland a significant price premium has been shown for housing that is green-certified when compared to similar houses that do not have this certification. Based on the hedonic pricing theory, this then suggests that green-certification is a valuable characteristic of a house that adds to the final selling price. My results show that within the green-certified housing market, third-party verification is another valuable characteristic that significantly adds to the final selling price of a house. These results will be of particular interest to homeowners and homebuilders interested in pursuing green certification. While the value of green housing has been proven in previous studies, little to no research has been done into whether third-party verification has a similar price premium on the final selling price of a house. This study shows that spending to get third-party verified is worth the extra cost. These results do only apply to the Chicagoland housing market, so further research would be necessary to examine the effects of third-party verification in other housing markets.

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