DISCUSSION PAPER

July 2013 ■ RFF DP 13-18

Is Energy Efficiency Capitalized into Home Prices?

Evidence from Three US Cities

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RESOURCES FOR THE FUTURE

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Abstract

We look for evidence of capitalization of energy efficiency features in home prices using data from real estate multiple listing services (MLS) in three metropolitan areas: the Research Triangle region of North Carolina; Austin, Texas; and Portland, Oregon. These home listings include information on Energy Star certification and, in Portland and Austin, local green certifications. Our results suggest that Energy Star certification increases the sales prices of homes built between 1995 and 2006 but has no statistically significant effect on sales prices for newer homes. The local certifications appear to have larger effects on sales prices, and that effect holds for both newer and older homes. The estimated home price premiums from certification imply annual energy cost savings that are sizeable fractions of estimated annual energy costs for homes in our sample, in some cases even above 100 percent. This suggests that the certifications either embody other attributes beyond energy efficiency that are of value to homebuyers or that buyers are overpaying for the energy savings. Further research is needed to better understand how consumers interpret home certifications and how they value the combination of "green" characteristics that many of those certifications embody.

Key Words: Energy Star homes, energy efficiency, green certifications, hedonic model

JEL Classification Numbers: L94, L95, Q40

Contents

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Introduction

One oft-cited explanation for underinvestment in residential energy efficiency is that homeowners do not expect to occupy their homes long enough to realize energy savings benefits that offset their investment costs. If energy efficiency features of a home are capitalized in the selling price, then homeowners could recoup their costs when they sell their homes, but it is unclear whether this is indeed the case. One barrier is a lack of information. Homebuyers may be unable to accurately observe a home's energy efficiency as features such as wall and attic insulation, air ducts, and even heating and cooling equipment efficiencies are difficult to see or fully understand. Moreover, sellers may not be able to credibly signal that they are selling an energy efficient home.

The federal government's Energy Star program was designed, in part, to overcome some of these information problems. New homes certified under the program are designed and built to be 15 percent more efficient than new homes that meet most current building codes. To obtain the Energy Star label, the home must go through a process of inspections, testing, and verification set up by the US Environmental Protection Agency (EPA). The EPA estimates that over 360,000 Energy Star homes were built nationwide over the first 10 years of the program, 1995–2005 (US EPA 2005). More recent studies put the figure at over 1.2 million (Energy Programs Consortium 2011), and the EPA states that in 2011, 26 percent of all housing starts were Energy Star homes (US EPA 2012a). In addition to Energy Star, the US Green Building Council has the more rigorous LEED certification program, and many localities have their own certifications.[1]

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* Margaret Walls and Karen Palmer are both Research Directors and Senior Fellows at Resources for the Future. Todd Gerarden is a Ph.D. student at the Kennedy School of Government at Harvard University. The authors appreciate the helpful research assistance of Shefali Khanna and Adam Stern and are grateful for funding from RFF's Center for Climate and Electricity Policy.

[1] LEED stands for Leadership in Energy and Environmental Design. See http://www.usgbc.org/leed for more information on the program.

In this study, we analyze the effect of Energy Star and two local "green" certifications on sales prices of homes in three urban areas: Austin, Texas; Portland, Oregon; and the Research Triangle area of North Carolina. These three cities are chosen because realtors participating in the multiple listing services (MLS) in these regions have agreed to report a set of "green" characteristics on home listing sheets. These data include information on green and energy efficiency certifications that could reduce the extent of imperfect information in the market for residential real estate.[2] We examine over 170,000 housing transactions over the 2005–2011 time period and estimate separate hedonic price models for the three cities, including zip code and sales month/year fixed effects to control for unobserved factors that affect sales prices. To identify the treatment effect of certification, we match houses on the basis of vintage; in other words, we compare noncertified to certified houses that were built in the same year. We focus our analysis on single-family homes.

Our results suggest that Energy Star certification increases the sales prices of single-family homes that were built during the first 10 years of the program but has no statistically significant effect on prices for homes built after that (post-2006). This finding is consistent across the three markets, though the magnitude of the effect for the 1995–2006 homes varies slightly. This suggests that, as the energy efficiency of new homes has improved and building codes have tightened over time, the value of Energy Star certification has decreased.

The local certifications in Austin and Portland appear to have larger effects on sales prices than Energy Star, and the effect holds for newer homes as well as older ones. In Austin, certified homes sell for 9–20 percent more, all else equal, than noncertified homes, with the effects varying by house vintage. In Portland, certified homes sell for 5–12 percent more, depending on vintage. These certifications go beyond energy efficiency to encompass other green attributes such as water efficiency, landscaping choices, and "green" building materials, and these factors could account for some of the price premium. Our study is unable to tease out exactly which factors are most important, but we interview individuals at the certification agencies as well as local builders in the two cities to assess their views. In both cities, these market participants feel that the certifications are more a symbol of overall quality in materials

[2] A "greening the MLS" movement by some energy efficiency advocates is pushing to have green certifications and a host of energy-related and other green features of homes included on sales listing sheets. See http://www.usgbc.org/advocacy/campaigns/greening-mls for more information (accessed May 16, 2013). Although the listing sheets can include more information than just certifications, we found that other information was generally absent in the three MLS programs we analyzed.

and construction than a reflection of any specific "green" factor, particularly energy efficiency. These findings highlight the relatively coarse information signal provided by certifications.

To put these findings in perspective, we compute implied annual energy cost savings from our estimated selling price premiums and compare those numbers to estimates of annual energy costs. The annualized value of the premium for Energy Star homes built between 1995 and 2006, amortized over 30 years at a 5 percent discount rate, is $688 per year in Portland, $899 per year in Austin, and $2,734 per year in Triangle. These numbers should represent the average annual energy savings from Energy Star certifications; thus, we compare them to estimated energy expenditures in each city for noncertified homes with similar characteristics and similar vintages. These estimates are obtained using results from a previously published econometric study of residential energy demand (Alberini et al. 2011), combined with information on house size and other characteristics, local weather variables, and local electricity and natural gas prices. We find that, depending on the year from which baseline energy expenditure calculations are drawn, implied savings from our regression results are equal to 34 to 38 percent of the estimated average annual energy costs of a home in Portland, 39 to 42 percent in Austin and 115 to 127 percent in the Research Triangle housing market. Since Energy Star homes are required to be, depending on the year built, 15–30 percent more energy efficient than noncertified homes, the estimated premiums are either capturing attributes beyond energy savings, such as home comfort, or buyers are overpaying for certification.

The ratios are significantly higher for the local certification programs in Austin and Portland, typically exceeding 60 percent, and, in the case of the Austin certification program, above 100 percent for most vintages of homes. Only for homes with energy costs well above the average are the ratios of a more reasonable magnitude. The green certifications embody more than energy; they also cover building materials choice, water efficiency, landscaping, and a host of other attributes. Our results suggest either these other attributes are of substantial value or buyers may be overpaying for the certification. It may be the case, as the certification experts and builders in Austin and Portland contend, that homebuyers are paying for the signal of overall quality that the certifications embody. Further research is needed to better understand how consumers interpret home certifications and how they value the combination of "green" characteristics incorporated in those certifications.

The next section of the paper provides a brief review of the literature on building certifications and their impacts on measures of building value such as sales prices and rents. We follow that with a description of the Energy Star program and the two certification programs in Austin and Portland. We then describe our data, including some summary statistics for house sales in the three cities, the hedonic model, and results. We follow the results with our calculations of energy savings and a discussion of those findings. The final section of the paper provides some concluding remarks.

Literature Review

The effects of Energy Star and other certifications for commercial buildings have received a relatively large amount of attention in recent years. In a 2010 study, Eichholtz et al. (2010) use data on US office buildings from the 2004–2007 time period to examine the effects of Energy Star and LEED certifications on contract rents, effective rents (contract rent multiplied by occupancy), and sales prices. In their rental rate regressions, they have data from 8,100 properties, 694 of which are either LEED or Energy Star certified. Their sales sample is much smaller: a total of slightly over 1,800 buildings, only 199 of which are certified. Results show that certified buildings have contract and effective rents that are 3 percent and 6 percent higher, respectively, than noncertified buildings, and that certification increases sales prices by 16 percent. The authors also find that the relative premium for certification is greater in lower-priced markets. These findings are similar to findings in Fuerst and McAllister (2011), but the identification strategy in the Eichholtz et al. (2010) study is more robust as the authors match treatment and control buildings by geographic "clusters."

Eichholtz et al. (2013) update their 2010 study on US office buildings using a larger data set over additional years, including data after the 2008 real estate crash. They estimate a panel regression of the difference in rents between 2007 and 2009, and separately employ a propensity score matching estimator on sales and rents for a cross section of buildings in 2009. Sample sizes are much larger than in the earlier study: 21,000 property rentals and 6,000 building sales. They find that while rents in noncertified buildings declined between 2007 and 2009, certified building rents remained roughly constant. In the cross section analysis, they find that contract rents are approximately 3 percent higher for certified than for noncertified buildings, and effective rents are 8 percent higher. Sales prices are approximately 13 percent higher for certified buildings. Thus these updated findings support the authors' earlier results. Eichholtz et al. (2013) also compare these price premiums to the discounted stream of energy savings from certifications based on Energy Star requirements. Results suggest that the energy savings are fully capitalized into rents and sales prices (though it is not clear whether they are overcapitalized).

Some work has been done on building ratings in Europe. In a study of 1,100 rental transactions in the Netherlands, Kok and Jennen (2012) estimate a 6.5 percent discount for buildings with low ratings on the European Union energy performance certificate. Fuerst et al.

(2012) look at the effects of the United Kingdom's Energy Performance Certification ratings and find a significant rental premium for the highest-rated buildings. However, in this study, the rated buildings tend to be newer and thus the effect of the rating alone is difficult to disentangle.

Work by Jaffee, Stanton, and Wallace (2011a,b) calls some of these findings for commercial buildings into question. They argue that the structure of leases—in particular, the commonly used "triple net leases" that include energy costs as part of building operating costs but then net them out as a component of tenant lease payments—and commercial underwriting practices provide no incentive for building owners to make their buildings more efficient. In Jaffee et al. (2011b), the authors use data on over 15,000 office building sales in the United States and estimate an asset pricing model that includes, in addition to building characteristics (as in other studies that rely on the hedonic property model approach), operating expenses, net operating income, and the capitalization rates at sale. They find that Energy Star labels have no effect on sales prices.

Early studies of energy efficiency in residential buildings include Dinan and Miranowski (1986), who use data on house sales in Des Moines, Iowa, to see if utility bills have an effect on sales prices, and Laquatra (1986), who uses a measure of "thermal integrity" and estimates a hedonic price model of house sales in Minnesota. Although the sample size is quite small, Laquatra finds that reductions in a home's thermal integrity factor, which is an improvement in energy efficiency, increases a home's sales price, all else equal. Dinan and Miranowski also have a very small sample size, but they have actual utility bills for the homes in their sample. They find that higher bills lead to lower house prices, all else equal. Specifically, the average home price increases by approximately $12 for each $1 decrease in the fuel expenditures necessary to maintain an indoor temperature of 65 degrees during an average heating season. The findings are roughly equivalent to findings in an earlier study by Johnson and Kaserman (1983) for the Knoxville, Tennessee, market.

Two recent studies of residential markets have focused on the impact of solar photovoltaic installations on home sales prices. Dastrup et al. (2012) use data from San Diego and Sacramento counties in California and both hedonics and repeat sales approaches to show that solar panels result in a 3 to 4 percent premium in home prices. They also find that the sales price premium is larger in communities with more registered Prius hybrid vehicles and in communities with a larger share of college graduates. Hoen et al. (2011) analyze home sales across California and find that the average sales price premium on homes with solar panels is roughly compensatory for the installed cost of the photovoltaic system, not accounting for electricity cost savings. They also find that the average premium is larger for existing homes than for new homes. More recent studies of residential property markets that focus on the impacts of energy certification tend to find a sales price premium from these programs. Using data on California real estate transactions between 2005 and 2012, Kok and Kahn (2012) estimate a 9 percent average sales price premium for homes with Energy Star, LEED, and/or Green Point Ratings (a California program). Bloom et al. (2011) study a small sample of homes in Fort Collins, Colorado, and find a price premium of $8.66 per square foot for Energy Star homes. Brounen and Kok (2011) use data from the Netherlands to look at the effect of a “green rating” under the EU Energy Performance Certificates residential labeling program on housing values. This system provides an energy efficiency grade between A (high) and G (low) to residential properties, and homes with a rating of A, B, or C qualify as “green.” They find that homes with a green rating sell for 3.7 percent more than homes with lower efficiency ratings.

Our study follows on these analyses of the impacts of energy and green certifications on residential sales prices. We assess the impacts of Energy Star and local green certifications on home sales prices in three independent real estate markets. This allows a comparison across markets that are very different in climate, home characteristics and prices, and, arguably, household preferences. Incorporation of local green certifications provides an interesting comparison with the well-known national Energy Star program. Use of MLS data from markets where the certifications are explicitly incorporated on house sales listing sheets provides more assurance that prospective homebuyers know whether homes are certified. In general, while certification may be clear for new homes, where builders often advertise it, this is not necessarily the case for sales of existing homes. However, in the three markets studied here, we feel that the information is readily available to homebuyers, and we observe the same information potential buyers have access to when searching for homes. Finally, our econometric approach compares homes of similar vintage, improving on earlier studies that do not include this restriction.

Green Certifications

Energy Star

The Energy Star certification program for new homes has been in existence since 1995 and has evolved over time as state and local building codes, appliance standards, and building practices have evolved.[3] Version 1 of the program was in existence from 1995 through part of 2006. While it specified that new homes had to be 30 percent more efficient than a home built to the 1992 Model Energy Code, there were no inspection checklists for this first version. Version 2.0 strengthened the guidelines and added a thermal bypass checklist, which required an insulation inspection and specified that air gaps and duct work be sealed at points frequently missed in the construction process. Version 2.0 also added efficiency requirements for heating, ventilation, and air conditioning (HVAC) systems and more effectively promoted efficient lighting and appliances for qualified homes. Homes certified under version 2.0 are at least 15 percent more efficient than homes built to the 2004 International Residential Code (IRC). This version was phased in from July 2006 to July 2007, with the nature of the requirements depending on when the building permit was granted. The transition to version 3.0 of the program (termed version 2.5 during the transition period) started in April of 2011, and the requirements for version 3.0 became fully effective on July 1, 2012 (January 1, 2012, in some areas of the country). Homes certified under this version of Energy Star are designed to be at least 15 percent more efficient than the 2009 International Energy Conservation Code (IECC).

There are two paths to Energy Star certification: a "performance path" and a "prescriptive path" (US EPA 2012b). For the former, homebuilders must use the Home Energy Rating System (HERS) software package and show that the home has achieved the same score as the Energy Star model reference home (with size adjustments). The prescriptive path lays out a long checklist of specific requirements that homes must meet to be Energy Star certified, including efficiency requirements for heating, air conditioning, and water heating equipment; specifications for windows and doors; requirements for insulation and ductwork; and lighting and appliance standards. Some requirements vary by climate zone.

Energy Star certification is voluntary, but there are incentives for making homes compliant. For example, Progress Energy, one of the large electric utilities in the Carolinas and now part of Duke Energy, offers a 5 percent discount extended indefinitely on the energy part (as opposed to the distribution charges) of a household electricity bill for any home built after 2001 that is Energy Star certified. In addition, the utility offers a small incentive payment to

[3] It is possible for an existing home to be certified as an Energy Star Home, but it is generally not cost effective to do so. See http://energystar.supportportal.com/link/portal/23002/23018/ArticleFolder/963/New-Homes (accessed June 26, 2012). Thus the certification almost always applies to new homes.

builders for each Energy Star Home constructed in their service territory.[4] Also, since 2006, homebuilders who achieve 50 percent energy savings for heating and cooling over the 2006 IECC, with at least one-fifth of the energy savings coming from building envelope improvements, have been entitled to a federal tax credit of $2,000 per home.[5]

Earth Advantage

The Earth Advantage New Homes certification is a green certification scheme in Oregon and parts of Washington operated by Earth Advantage Institute, a nonprofit organization that promotes building energy efficiency. The program began in 2000 and was originally operated by the local utility, Oregon General Electric. Earth Advantage Institute was spun off into a separate entity in 2005 and runs the certification program, along with other programs and initiatives.

The Earth Advantage New Homes standard requires homes to achieve a minimum number of points on a scoring sheet covering five categories, including energy efficiency (using Northwest Energy Star as a guide), indoor air quality, resource efficiency, environmental responsibility and water conservation. Depending on the number of points earned, the projects may qualify for different levels of certification: Silver, Gold, or Platinum. Verification that the requirements have been met is conducted over the course of two inspection visits. There are 179 individual items to which points are assigned, organized into 10 categories that include land use and site planning (e.g. lot size, trees, stormwater controls, etc.); several categories that cover energy use, such as building envelope, foundation, and framing (with quite detailed specifications for insulation, for example); HVAC equipment, appliances, and windows; and several items related to construction materials (e.g., recycled content, use of formaldehyde, low VOC paints and adhesives, etc.). Requirements tightened in 2008 and again in January 2012.

Like Energy Star, Earth Advantage certified homes must be 15 percent more efficient than homes built to code. This means that, in theory, all Earth Advantage certified homes should also have Energy Star certification. This is not always the case, however, as some builders in the region find it difficult to meet Energy Star requirements for window glazing (Brown 2012a).

[4] For more information see https://www.progress-energy.com/carolinas/home/save-energy-money/energy-efficiency-improvements/residential-energy-conservation-discount.page? (accessed May 7, 2013).

[5] These benefits originally expired at the end of 2011 but have recently been reinstated in the American Taxpayer Relief Act of 2012 (H.R. 8) and can be retroactively applied for 2012. The act tightened some of the original requirements and currently expires at the end of 2013.

Earth Advantage thus allowed a "plan B" in which homes that demonstrated a HERS score of 76 or below—15 percent below the score of 85 achieved by a home built to Oregon code—could be certified without having Energy Star certification (Brown 2012a).

Austin Energy Green Building Program

The Austin Energy Green Building (AEGB) program was started by the city of Austin in 1991 and thus predates Energy Star. In 1998, the program became part of Austin Energy, the municipal utility that operates in Austin. Milestones in the program occurred in 2001 when the city of Austin adopted the IECC as a building code and in 2007 and 2010, when requirements in the green building rating program tightened; in 2010, AEGB adopted improved efficiency requirements for HVAC systems and required builders to demonstrate energy savings above code by submitting a Texas Climate Vision score for each home (AEGB 2011).[6]

The single-family home rating system for AEGB has five levels indicated by stars; one star is the entry level and five stars is the highest, or "greenest," level.[7] Like the Earth Advantage program, AEGB focuses not just on energy efficiency but also material use, water efficiency, and other factors. Points are assigned for several green characteristics, including various site selection criteria, home design features, material efficiency (which includes house size), construction waste management, a variety of factors related to the thermal envelope, energy efficiency of equipment and appliances, water efficiency, lighting and other electrical efficiency factors, interior materials and paint, and landscaping.

MLS Data

In this paper, we employ real estate data from multiple listing services in the Research Triangle region of North Carolina, Austin, and Portland. MLSs provide a centralized location for real estate agents to advertise and select homes for their clients. We elected to use MLS data because they represent the primary information sources for market participants (i.e., real estate

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[6] The score is obtained using a software program developed by Texas A&M researchers (AEGB 2011).

[7] Because the one and two star ratings require no percentage of energy efficiency above code, we do not assume those homes are "certified" in our econometric analysis; almost all of the AEGB rated homes in our sample have three or more stars.

brokers and potential homebuyers) and provide highly detailed house characteristics useful for hedonic analysis. Moreover, the MLSs in these three housing markets have agreed to include information on green and energy certifications, which few MLSs contain. This ensures that such information is readily available to prospective buyers. There is an ongoing movement to incorporate these data into MLSs across the country; as of mid-2012, at least 28 markets in the have facilitated reporting of some green information (Green Resource Council, 2012).

We have home sales over the 2005–2011 time period in Portland, 2008–2011 in Austin, and the last quarter of 2009 through 2011 in the Research Triangle market. We use only data on single-family detached homes to focus on a more consistent set of house types and because these form the majority of certified residential properties. To eliminate geographical outliers (i.e., homes outside the metropolitan area), we retained only homes sold in a zip code that had at least five sales during our periods of observation. The Portland sample includes house sales well outside the Portland metro area, so in that case we retained only sales in the inner counties of the Portland-Vancouver-Hillsboro, OR-WA Metropolitan Statistical Area: Multnomah, Washington, and Clackamas counties in Oregon and Clark County in Washington. To remove likely data coding entry errors and deal with missing observations, we deleted observations from our data set with unrealistic values for particular data fields containing house characteristics employed in our analysis. We also eliminated very high-priced (above $2 million) and low-priced homes (below $100,000) in an effort to remove the effect of outliers on our econometric results and to limit the possibility of including nonarms-length transactions in our sample. Our lower bound of $100,000 is relatively high as a significant number of sales occur below that level in each market (between 5 and 10 percent of all single-family home sales), but virtually no certified homes exist below $100,000. To identify the effects of certification, we want to ensure that our analysis is focused on the most relevant cohort of homes, so we exclude these lower-priced properties.[8] These changes reduced the size of the original data set from 425,685 total residential property sales across the three markets to 171,087 sales of single-family homes.[9]

[8] We performed a series of robustness checks on our home price cutoff points, expanding the range of house values to go between the first and 99th percentile and also the 2.5th and 99th percentile. In general, we find that the coefficients change very little for Austin and Portland; the Energy Star coefficients for recent vintage homes in Portland vary the most, but those coefficients are statistically insignificant in all cases.

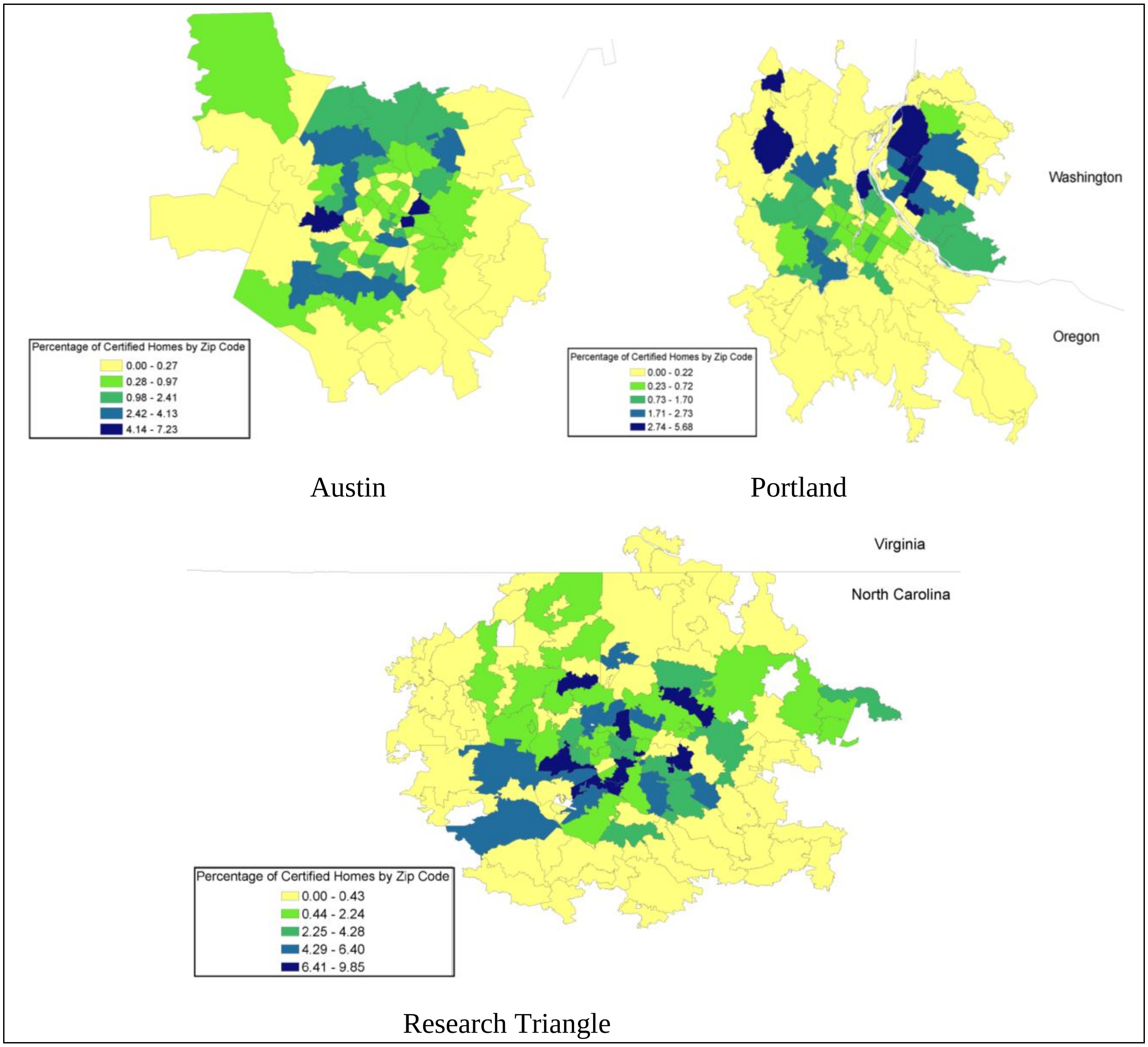
[9] It is not unusual in hedonic property analyses to lose quite a lot of observations because of missing data.

Green fields were first listed in the Portland MLS in 2007 and in the Austin MLS in 2008; the first certified homes in our Austin sample were sold in the third quarter of 2008. In contrast, the Research Triangle sample includes only house transactions since the establishment of green fields in its MLS. Table 1 shows the percentage of certified homes (either the local certification or Energy Star or both) in our sample by sales year and quarter. In each of the markets, certified home sales are a small percentage of total home sales. The largest percentage is in the Research Triangle market, where nearly 8 percent of the sample is Energy Star certified. Certified homes are approximately 1 percent of home sales in the Portland and Austin housing markets over this time period. Figure 1 shows the distribution of certified home sales as a percentage of all home sales by zip code in each market. There is some geographic dispersion of certified home sales, but certification is more common in some zip codes than others.

Table 1. Penetration of Green Certifications by Quarter/Year of Sale

	Austin percent certified	Triangle percent certified	Portland percent certified
2005–2006	-	-	0.00
2007Q1	-	-	0.04
2007Q2	-	-	0.52
2007Q3	-	-	1.62
2007Q4	-	-	1.78
2008Q1	0.00	-	1.93
2008Q2	0.00	-	2.03
2008Q3	0.10	-	1.73
2008Q4	1.18	-	1.36
2009Q1	1.43	-	2.74
2009Q2	0.84	-	2.04
2009Q3	1.22	-	1.77
2009Q4	1.53	4.11	1.67
2010Q1	1.51	5.13	2.22
2010Q2	1.05	5.84	2.13
2010Q3	1.27	7.33	1.53
2010Q4	0.98	11.68	2.23
2011Q1	1.15	7.54	2.46
2011Q2	1.20	8.23	3.13
2011Q3	1.37	9.26	3.30
2011Q4	-	-	2.28
Overall penetration	0.93	7.21	0.98

Figure 1. Certified Home Sales as a Percentage of All Home Sales, by Zip Code



Summary statistics for sales in each of the three markets are shown in Tables 2, 3, and 4 separated by certified and noncertified homes. The first row of Tables 2, 3, and 4 shows the mean sales price in each market. Interestingly, Energy Star homes have a higher mean price than uncertified homes in Austin and the Research Triangle area but are slightly lower in Portland. Homes in Austin and Portland that have local certifications (AEGB and Earth Advantage) have higher average prices, though the difference in Portland is not large.

Table 2. House Characteristics by Certification Type—Austin, Texas

	No certifications		ENERGY STAR		AEGB	
	Mean	Sd	Mean	Sd	Mean	Sd
Sales price (real)	258,807	183,299	325,451	160,867	421,537	253,088
List price (real)	268,954	197,843	343,059	175,603	444,949	299,810
Cumulative days on market	95.6	112	137	131	129	142
Age	17.2	18.1	1.01	1.63	8.22	19.4
Square feet	2,224	879	2,903	860	2,292	785
Acres	.644	28.7	.272	.593	.208	.434
# Stories	1.44	.505	1.62	.495	1.67	.498
# Bedrooms	3.45	.745	3.85	.698	3.32	.617
# Full baths	2.24	.646	2.72	.709	2.35	.592
# Half baths	.397	.509	.581	.516	.593	.569
Private pool (Y/N)	.0754	.264	.011	.104	.0267	.162
Fireplace (Y/N)	.712	.453	.752	.432	.533	.501
Garage (Y/N)	.912	.283	.98	.139	.793	.406
Waterfront (Y/N)	.0229	.15	.00439	.0662	.02	.14
New (Y/N)	.127	.333	.836	.371	.467	.501
Observations	59,797		456		150	

Note: Data from Austin Central Texas Realty Information Services (ACTRIS), based on information from the Austin Board of REALTORS® for the period 1/1/2008 through 9/23/2011.

Table 3. House Characteristics by Certification Type—Research Triangle Region, North Carolina

	No certifications		ENERGY STAR	
	Mean	Sd	Mean	Sd
Sales price (real)	249,922	149,054	327,095	158,845
List price (real)	258,964	161,376	332,594	164,305
Cumulative days on market	127	149	124	140
Age	15	18.4	.424	.761
Square feet	2,283	955	2,703	800
Acres	.999	45.4	3.81	143
# Stories	1.68	.516	1.92	.383
# Bedrooms	3.5	.74	3.89	.784
# Full baths	2.28	.682	2.68	.771
# Half baths	.602	.526	.671	.504
Private pool (Y/N)	.0119	.108	.00653	.0806
HOA pool (Private) (Y/N)	.144	.351	.314	.464
Fireplace (Y/N)	.894	.308	.914	.281
Garage (Y/N)	.764	.425	.979	.143
New (Y/N)	.242	.428	.978	.147
Observations	21,675		1,685	

Note: Based on information from the Triangle MLS, Inc. for the period 10/1/2009 through 9/30/2011.

Table 4. House Characteristics by Certification Type—Portland, Oregon

	No certifications		ENERGY STAR		Earth Advantage	
	Mean	Sd	Mean	Sd	Mean	Sd
Sales price (real)	336,789	191,037	319,805	137,924	352,362	139,044
List price (real)	343,857	201,891	325,591	144,192	359,338	146,592
Cumulative days on market	92.8	125	172	194	182	197
Age	38.7	31.2	.639	1.06	.734	1.15
Square feet	2,082	905	2,268	680	2,322	659
Acres	1.65	90.9	.156	.339	.137	.221
# Stories	1.83	.706	1.95	.481	2.02	.417
# Bedrooms	3.3	.827	3.59	.706	3.5	.676
# Full baths	1.92	.7	2.2	.471	2.21	.494
# Half baths	.437	.618	.818	.636	.814	.402
Private pool (Y/N)	.0182	.134	0	0	0	0
HOA pool (Private) (Y/N)	.0172	.13	.00626	.079	.0411	.199
Fireplace (Y/N)	.764	.425	.756	.43	.852	.355
Garage (Y/N)	.882	.322	.992	.0911	.979	.145
Waterfront (Y/N)	.0262	.16	.00835	.0911	.00657	.0808
New (Y/N)	.119	.324	.983	.128	.954	.21
Observations	86,514		479		609	

Note: Based on information provided by Regional Multiple Listing Services Inc.™ Portland, Oregon, for the period 1/1/2005 through 11/28/2011.

There are systematic differences in the property characteristics of certified and noncertified homes. Certified homes are substantially newer than noncertified homes, which is understandable since the certification schemes have not been around for a long time. In the Triangle market, certified homes in our sample are almost exclusively newly built homes. Certified homes tend to be larger, on average, in each of the markets; as home sizes have increased over the years and the certified homes in our sample are newer, this is not a surprise. Finally, average lot sizes for certified homes are larger in the Triangle market but smaller in Austin and Portland. This may be a feature of the location of the certified homes within these markets. Homes with the local certifications in Austin and Portland have the smallest average lot sizes; as we pointed out above, smaller lot sizes contribute to higher ratings in both the AEGB and Earth Advantage programs.

Hedonic Model and Results

A hedonic pricing model expresses the price of a differentiated product, such as a house or a car, as a function of the characteristics of that product. Early work by Rosen (1974) showed that the hedonic price function can be interpreted as the locus of equilibrium points that result from the interactions between many buyers and many sellers in the marketplace. The marginal implicit price of a characteristic of the product is found by differentiating the hedonic price function with respect to the characteristic. Evaluated at an individual's optimal choice, this implicit price represents the individual's marginal willingness-to-pay for the attribute.

In this study we estimate a log-linear hedonic price equation of the following form:

$$\ln P_{ijt} = c + \alpha_v ES^v_{ijt} + \beta_v AEGB^v_{ijt} + \gamma_v EA^v_{ijt} + \delta X_{ijt} + \eta_j + \tau_t + \varepsilon_{ijt}$$

where P_{ijt} is the price of house i in zip code j sold in quarter t. The primary variables of interest are ES^v_{ijt}, a dummy variable identifying homes of vintage v that are in the Energy Star treatment group, and $AEGB^v_{ijt}$ and EA^v_{ijt}, dummy variables that identify homes of vintage v that are in the AEGB and Earth Advantage certification treatment groups, respectively. Specifying separate dummies by vintage ensures that we are matching certified and noncertified houses based on the year they were built. This allows a cleaner identification of the effects of certification than pooling across vintages.[10] The coefficients $\alpha_v, \beta_v,$ and γ_v capture the marginal effects of the certifications on house prices, all else equal. The regression includes a vector of house characteristics, X_{ijt}; sales quarter fixed effects, τ_t, to control for time trends and seasonal effects on house prices; zip code fixed effects, η_j, to control for unobserved neighborhood characteristics; and an idiosyncratic error term, ε_{ijt}.

Results are shown in Table 5. In Austin and the Research Triangle area, Energy Star certified homes built between 1995 (when the program began) and 2006 have higher sales prices than noncertified homes built during those same years, all else equal. In Austin, the premium is approximately 5 percent, and in Triangle, it is 18 percent. For homes built after 2006, Energy Star certification has no statistically significant effect on sales prices. And Energy Star has essentially no significant effect on sales prices in Portland for any vintage of home. This difference in effects for Energy Star certification by house vintage may reflect the fact that newer noncertified homes are becoming more energy efficient. As a result, Energy Star certification

[10] We also used a propensity score matching approach to test for the presence of price premiums from the different certifications. The results that we obtained from this approach were very similar to those reported in Table 6.

tends to provide less benefit for newer homes in terms of absolute savings. In Portland, where building codes were more stringent, even in the 1995–2006 time period, this same effect holds: the benefits of Energy Star certification are smaller because more stringent building codes reduce the absolute financial benefit of Energy Star certification.

Table 5. Hedonic Regression Results

Y: Log (real sales price)	**Austin**		**Triangle**		**Portland**	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
Vintage						
Energy Star certification						
1995–2006	0.058***	(0.02)	0.180***	(0.06)	0.032	(0.04)
2007	-0.003	(0.05)	0.054	(0.06)	0.016	(0.03)
2008	-0.035	(0.03)	0.034	(0.03)	0.014	(0.02)
2009	-0.041	(0.03)	-0.002	(0.02)	-0.005	(0.03)
2010	-0.053**	(0.02)	0.004	(0.02)	-0.036*	(0.02)
2011–2012	-0.090	(0.06)	0.005	(0.02)	-0.031	(0.03)
AEGB						
2000–2006	0.049	(0.03)				
2007	0.096***	(0.03)				
2008	0.193***	(0.07)				
2009	0.148*	(0.07)				
2010	0.261***	(0.08)				
2011–2012	0.076	(0.06)				
Earth Advantage						
2000–2005					0.104*	(0.06)
2006					0.034	(0.03)
2007					0.022	(0.03)
2008					0.044*	(0.03)
2009					0.061**	(0.03)
2010					0.071**	(0.03)
2011–2012					0.030	(0.03)
Age	.0002738	(.0014464)	-.0008286	(.0011194)	-.0048137***	(.0007796)
Age squared	.0000302**	(.000012)	.0000249**	(9.87e-06)	.0000383***	(6.01e-06)
# Bedrooms	-0.049***	(0.00)	-0.048***	(0.01)	0.004	(0.01)
# Full baths	0.109***	(0.01)	0.105***	(0.01)	0.097***	(0.01)
Table 5 (cont.)	**Austin**		**Triangle**		**Portland**	
	Coef.	Std. error	Coef.	Std. error	Std. err.	Std. error
# Half baths	0.040***	(0.00)	0.044***	(0.01)	0.046***	(0.01)
Log (square feet)	0.724***	(0.02)	0.759***	(0.04)	0.417***	(0.07)

Fireplace (Y/N)	0.036***	(0.01)	0.039***	(0.01)	0.045***	(0.01)
Garage (Y/N)	-0.001	(0.01)	0.072***	(0.01)	0.059***	(0.00)
Waterfront (Y/N)	0.379***	(0.04)	–	–	0.098***	(0.02)
# Stories	-0.090***	(0.01)	-0.067***	(0.01)	-0.009	(0.01)
New (Y/N)	0.054***	(0.01)	0.052***	(0.01)	0.028***	(0.00)
Log (acres)	0.027***	(0.00)	0.039***	(0.01)	0.124***	(0.01)
Private pool (Y/N)	0.164***	(0.01)	0.073***	(0.02)	0.045***	(0.01)
HOA pool (private) (Y/N)	–	–	0.035***	(0.01)	0.111***	(0.03)
Constant	6.527***	(0.17)	6.440***	(0.23)	9.430***	(0.46)
Quality effects	Yes		–		–	
Year/quarter effects	Yes		Yes		Yes	
Vintage effects	Yes		Yes		Yes	
Zip code fixed effects	Yes		Yes		Yes	
R-squared within	0.722		0.741		0.696	
R-squared between	0.280		0.427		0.402	
R-squared overall	0.563		0.682		0.609	
N	60,361		23,360		87,366	
N. groups (zip codes)	113		109		101	

The local certification schemes in Portland and Austin appear to have a larger impact on prices. Depending on vintage, a home with an AEGB rating has a sales price that is approximately 10 to 26 percent higher than a similar home without a rating. [11] In Portland, Earth Advantage certified homes sell for between 4 and 10 percent more than noncertified homes, depending on vintage (though the effect for some vintages is not statistically significant).[12]

Many of the coefficients on house characteristics are statistically significant, and some are important determinants of house prices, particularly amenities such as a pool or waterfront location. House size, the presence of a fireplace or garage, and the number of bathrooms are also important determinants. In addition, newly built homes sell at a premium in all three markets. We note, however, that there are significant differences in the coefficients across the three markets (as there is for the coefficients on the certification variables). This calls into question results from hedonic studies that pool observations across a wide geographic area and provides

[11] The price premium that we identified here is higher than the findings in a master's thesis by Amando (2007), who found a 5.6 percent price premium for homes that were certified under the AEGB program based on an analysis of 824 new homes sold between 1997 and 2004.

[12] These results are somewhat higher than the findings of Griffin et al. (2009), who found that Earth Advantage certified homes in the Portland area sold for 3–5 percent more than noncertified homes. That study did not control for many other house attributes in comparing certified to noncertified homes.

support for our approach of studying markets independently. Housing market segmentation and the proper extent of the market is a long-standing issue in hedonic property value studies (Straszheim 1974).

Putting the Price Premiums in Context: Comparing to Estimated Energy Expenditures

The results above suggest that local certifications in Austin and Portland have significant value for homes of all vintages and Energy Star certification has value for homes that were built in 2006 or before. In this section, we use the econometric results to infer a discounted present value of implied energy savings from each of the certifications, annualize these numbers, and compare them to estimates of annual energy expenditures for typical noncertified single-family homes in the each of the three markets. This exercise should provide a sense of whether the estimated price premiums from certification are capitalizing future energy savings. If they are, then the ratio of the implied annualized energy cost savings to annual energy expenditures should be roughly equivalent to the percentage of energy savings expected from achieving certification. As we explained in our discussion of the certifications above, energy savings are typically in the neighborhood of 15 to 30 percent.

To calculate average annual energy cost savings consistent with the house price premiums estimated by our regressions, we solve for the stream of constant annual payments that yield a present discounted value equivalent to the average home price premium. We use a 5 percent discount rate and consider three possible time horizons: 7, 15, and 30 years. We perform this calculation for each vintage category of home and each certification program in each city that we found to have a statistically significant and positive effect on home prices.[13] Table 6 shows the results for an average home. The implied annual energy cost savings vary across the cities, with implied savings in Portland of just under $700 per year, when evaluated over a 30-year time period; implied savings in Austin of about $900 per year, again over 30 years; and implied savings in Triangle of close to $2,750 per year. Using shorter time periods increases the energy savings embodied in the estimated price premiums. Using only a 7-year time period,

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[13] We also include the implied energy savings for the Energy Star Program in Portland, Oregon, even though the coefficient on that variable was only significant at the 60 percent level. We also did calculations for higher discount rates (up to 15 percent) but we do not report those results here.

which is the average length of time a household lives in a single house in the United States, implied savings are $2,387 in Austin and as high as $7,289 in Triangle.

We do not have actual energy expenditures for the houses in our data set. Instead, we estimate them using electricity and natural gas demand modeling results from Alberini et al. (2011) combined with retail price data for electricity and natural gas from the US Energy Information Administration (EIA). The Alberini et al. equations predict monthly electricity and natural gas consumption based on energy prices, house characteristics (vintage, square feet, number of rooms, and others), appliance stock (type of heat, AC, etc.), occupant characteristics (age, income), and heating and cooling degree days. The results of the Alberini et al. model are reproduced in the appendix. We use the individual house characteristics in our data set, city-specific average electricity and natural gas prices and heating and cooling degree days, and average demographic factors, including income, for our cities, and predict monthly electricity and gas consumption for our houses. Annual expenditures are calculated by multiplying monthly consumption by 12 and multiplying by average retail price for each type of energy and then summing together. We calculate baseline annual energy expenditures for two years, 2007 and 2010, for all of the certified homes included in our data set for each city to provide estimates of energy consumption for these homes if they were not certified. We consider 2007, the last year of data used in the Alberini et al. study, and 2010, a more recent year covered by our sample of home sales data in all three cities and a year with lower natural gas prices and consequentially lower average household energy costs.

Table 6. Price Premiums from Certification and Implied Annual Household Energy Savings for Average Home

Program	Sales price premium ($)	Implied annual energy savings ($) (5% discount rate)		
		7-year horizon	15-year horizon	30-year horizon
Energy Star, 1995–2006				
Austin	14,504	2,387	1,331	899
Triangle	44,287	7,289	4,064	2,744
Portland	11,105	1,828	1,019	688
Local certifications				
Austin, 2007	28,894	4,756	2,651	1,790
Austin, 2008	58,444	9,619	5,362	3,621
Austin, 2009	38,756	6,379	3,556	2,401
Austin, 2010	64,854	10,674	5,951	4,018
Portland, 2000–2005	36,478	6,004	3,347	2,260
Portland, 2008	17,943	2,953	1,646	1,112
Portland, 2009	20,586	3,388	1,889	1,275
Portland, 2010	22,944	3,776	2,105	1,421

The results of these calculations are displayed in Table 7, along with the implied energy savings in Table 6 as a share of these baseline estimated energy costs, using the results for the 30-year time horizon. In all cases, the implied savings values are a substantial fraction of annual average energy expenditures ranging from 34–41 percent for older homes in Portland and Austin, respectively, to 127 percent for older homes in the Research Triangle area. The ratios are typically larger for the local certification programs. For example, the premiums associated with AEGB ratings range from 85 to 211 percent of the level of annual energy expenditures in Austin, depending on the vintage of the home. Annualized Earth Advantage certification premiums are between 63 and 123 percent of average annual energy expenditures in homes in Portland.[14]

[14] We should also note that many houses that have AEGB or Earth Advantage certifications are also Energy Star certified. The numbers in the table represent the effects of the individual certifications, holding all else constant.

Table 7. Estimated Average Annual Energy Expenditures per Household and Implied Energy Savings as a Fraction of Energy Expenditures

		2007					
		Austin		Triangle		Portland	
Program	Vintage	Expenditures	Implied savings as a share of expenditures	Expenditures	Implied savings as a share of expenditures	Expenditures	Implied savings as a share of expenditures
Energy Star	1995–2006	$2,322	0.387	$2,389	1.148	$2,051	0.335
AEGB	2007	$2,105	0.850				
EA	2000–2005					$2,071	1.091
		2010					
Energy Star	1995 – 2006	$2,151	0.418	$2,164	1.268	$1,832	0.375
AEGB	2007	$1,946	0.919				
	2008	$2,000	1.810				
	2009	$1,968	1.220				
	2010	$1,904	2.110				
EA	2000–2005					$1,833	1.233
	2008					$1,766	0.629
	2009					$1,724	0.740
	2010					$1,742	0.816

Note: Implied savings in dollars, computed from the estimated price premiums in the hedonic regression, are shown in Table 6.

The comparisons in Table 7 are for the average annual energy consumption in the absence of certification across all certified homes in each vintage category. However, within each vintage category there is a distribution of annual energy expenditure predictions that varies across the three cities. For example, in Austin, annual energy expenditures in 2007 in the absence of certification for homes with identical characteristics to the Energy Star certified homes built between 1995 and 2006 range from $2,097 to $2,599, a difference of about 24 percent, with the 10th and 90th percentiles of expenditures at $2,129 and $2,570, respectively. In Portland, the difference in expenditures between the most and least energy intensive home is roughly 13 percent. In Triangle, the most energy intensive home has annual energy costs of $3,559 in 2007, roughly twice the $1,766 energy expenditures of the least energy intensive home. In light of these differences, the amortized implied energy costs savings that we calculate represent a smaller share of total expenditures for those homes at the high end of the annual energy cost distribution. In particular, the implicit annual energy costs savings from Energy Star certification in Portland and Austin are roughly 34 percent of the total energy expenditures for homes at the 90th percentile of annual household energy expenditures, which is closer to the level of savings one might expect from this type of certification. For average homes, it appears that buyers (of pre-2006 Energy Star certified homes) may either be overpaying for the energy savings embodied in the Energy Star certification, may place a large premium on increased comfort that can come from building shell features required for certification, or may be using this certification as a proxy for other house attributes.

The green certification schemes in Austin and Portland are clearly capturing something other than energy savings. As explained in our descriptions of the programs above, a home meeting either the Earth Advantage or AEGB certification standards is meeting a large number of requirements related to water efficiency, types of materials used in construction, landscaping, and a host of other specifications. These could account for the large premiums associated with sale (and resale) of these homes. According to the certification agencies themselves and local builders in Austin and Portland, there is a strong sense that the certifications are more a symbol of overall home quality than any single green feature of the homes, including energy efficiency.

Conclusion

Residential buildings are responsible for about 22 percent of US carbon dioxide emissions, and improving energy efficiency of the housing stock is seen as a way to help reduce those emissions and do so cost-effectively. However, homeowners may be reluctant to invest in more energy efficient houses because they are uncertain that they will be able to recover that investment when they sell. Energy and green certification programs provide a way to signal to the real estate market that a house is more energy efficient or has other green characteristics. One way to make this signal more salient is to include this information in the MLS data sheets that sellers and realtors use to report information on house characteristics and that buyers use to learn about the homes that are on the market.

In this paper, we analyze data on housing transactions in three cities: Portland, Oregon, Austin, Texas, and the Research Triangle region of North Carolina, where the MLS listing sheets incorporate information on Energy Star certification and, in the case of Portland and Austin, on local green certifications as well. We use a hedonic approach to compare prices of certified homes to noncertified homes of similar vintages. We find that Energy Star certification results in an increase in the price of homes that were built in the first 10 years of the Energy Star program but not for homes of more recent vintages. We hypothesize that the lack of a sales price premium on more recent vintages of homes may be due to more stringent building codes in recent years narrowing the difference between Energy Star and uncertified homes. We find even bigger sales price premiums for homes certified under local certification programs. These certification programs give points for a wider range of green attributes beyond energy use and thus might be expected to have a higher value than the value of energy savings alone.

When we annualize these estimated price premiums and compare to annual energy costs in the three cities, we find that homebuyers seem to either overpay for energy savings or value other aspects of certified homes beyond energy. More research is needed to better understand the factors that determine consumers' valuation of home certifications.

Appendix. Equations and Data Used to Estimate Energy Expenditures

The model that we use to estimate electricity and natural gas demand by city comes from equations 9 and 10, respectively, in Alberini et al. (2011). Alberini et al. use data from multiple years of the American Housing Survey between 2000 and 2007 to estimate monthly household level demand for electricity and natural gas in several cities, two of which overlap with the cities in our study and one of which is a close proxy. The estimated coefficients are reported in Table A1.

Table A1. Coefficients and T-statistics from Energy Consumption Equations 9 and 10 Alberini et al (2011)

	Electricity consumption		Natural gas consumption	
Variables	Coefficient	T-statistic	Coefficient	T-statistic
Log electricity price	-0.860***	(-9.374)	0.150*	(2.152)
Log gas price	0.117*	(2.024)	-0.693***	(-6.567)
Log square feet	0.216***	(11.045)	0.189***	(9.882)
Age of home	0.00553***	(8.377)	0.00383***	(5.869)
Age of home squared	-0.0000540***	(-7.555)	-0.00000911	(-1.305)
Owns the home	0.0696***	(4.857)	0.0322*	(2.558)
Number of rooms	0.0659***	(14.743)	0.0549***	(18.606)
Number of floors	-0.0171*	(-2.069)	0.00974	(1.177)
Log household income	0.0225***	(8.826)	0.00357	(1.610)
Young child	0.0963***	(15.060)	0.0711***	(12.006)
Elderly	-0.0390***	(-4.200)	0.0640***	(7.228)
Log CDD	0.0727***	(3.582)	-0.00384	(-0.132)
Log HDD	0.00350	(0.069)	0.0991	(1.665)
Dishwasher	0.0849***	(6.553)	-0.0166	(-1.257)
Gas heat	-0.0990**	(-2.786)	0.215***	(4.204)
Electric heat	0.154***	(4.722)	0.0211	(0.470)
Heating oil heat	-0.0971*	(-2.282)	-0.938***	(-11.467)
Any A/C	0.161***	(7.998)	-0.0147	(-0.941)
Gas A/C	0.00624	(0.497)	0.0441**	(2.758)
Dryer	-0.0137	(-1.139)	0.0409***	(6.650)
Electric stove	0.0719***	(7.912)	-0.0291**	(-3.428)
2007 dummy	0.0891*	(2.509)	0.196***	(3.667)
Austin	0.157	(1.227)	0.184	(1.341)
Portland	0.0708	(0.417)	0.446*	(2.479)
Raleigh-Durham	-0.102	(-0.654)	0.538**	(3.172)
Constant	1.422**	(2.716)	0.214	(0.350)

We solve each of the equations for all of the certified houses in our data set from the perspective of 2007 and 2010 to predict energy consumption in the absence of certification. The data for the house characteristic variables in the equation come from the MLS data and thus are specific to each home. The energy price data come from EIA. For electricity, the retail price is average revenue per residential kilowatt-hours (kWh) and is calculated at the utility level, or, if the region covered by the MLS data is served by multiple utilities, the price is averaged across those utilities. Prices of natural gas are calculated similarly using data from EIA. Data on heating and cooling degree days comes from the National Oceanic and Atmospheric Administration and is calculated at the regional level so does not vary by house but does vary over time. Sociodemographic information on the presence of an elderly person or child in the home is based on averages at the city level from Census information, and data on average household income is from the Internal Revenue Service.

We solve these equations for houses in each of our three cities in 2007 and 2010 to obtain monthly consumption of electricity and natural gas (adjusting from natural logs using the regression mean square error). In Table A2, we compare the estimated annual average consumption of natural gas and electricity to state level averages from the US EIA.

Table A2. Comparison of Annual Energy Expenditures per Household City-Level Estimates and State-Level Data from EIA

	City-specific estimate*		EIA State-level average	
	Electricity (kWh)	Natural gas (Mcf)	Electricity (kWh)	Natural gas (Mcf)
2007				
Austin	14,610	46	13,627	48
Triangle	12,273	51	13,713	55
Portland	12,791	51	12,109	64
2010				
Austin	14,301	54	14,382	53
Triangle	11,885	65	14,851	67
Portland	11,850	59	11,564	60

*Expenditure estimates are averaged for homes built after 1994.
Sources: US Energy Information Administration, *Electricity Data Browser*

http://www.eia.gov/electricity/data/browser/#/topic/5?agg=1,0&geo=000000040202&endsec=8&freq=A&start=2001&end=2010&ctype=linechart&ltype=pin&pin=&rse=0&maptype=0; US Energy Information Administration, *1990–2011 Number of Retail Customers by State by Sector (EIA-861)* http://www.eia.gov/electricity/data/state/; and US Energy Information Administration, *Natural Gas* http://www.eia.gov/naturalgas/data.cfm#consumption.

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