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# The capitalization of green labels in the California housing market[☆]

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ABSTRACT

The residential sector accounts for 33% of electricity consumption in the U.S., with a total expenditure of $166 billion in 2010. Increasing the energy efficiency of the durable housing stock can thus provide significant cost savings for consumers. One promising trend is the rise of homes labeled by a third party as "green" or energy efficient. This paper documents evidence on the effects of providing information about the energy efficiency and "sustainability" of structures in affecting consumer choice. We conduct a hedonic pricing analysis of all single-family home sales in California over the time period 2007 to 2012, and find that homes labeled with a green label transact at a small premium relative to otherwise comparable, non-labeled homes. We show evidence of spatial variation in this capitalization such that both environmental ideology and local climatic conditions play a role in explaining the variation in the green premium across geographies.

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## 1. Introduction

Increased awareness of energy efficiency and the importance of the built environment therein, have turned public attention to more efficient, "green" building. The inventory of certified green *commercial* space in the U.S. has increased dramatically since the introduction of rating schemes (Kok et al., 2011). Importantly, tenants and investors seem to value the "green" features in such buildings. There is empirical evidence that "green" labels affect the financial performance of commercial office space: Eichholtz et al. (2010) study commercial office buildings certified under the LEED program of the U.S. Green Building Council and the Energy Star program of the EPA, documenting that these labels positively affect rents, vacancy rates and transaction prices.

Of course, private homeowners may be different from tenants and investors in commercial buildings, especially in the absence of standardized, publicly available information on the energy efficiency of homes. But in recent years, there has been an increase in the number of homes certified as energy efficient, based on national standards such as Energy Star and LEED, and local standards such as GreenPoint Rated in California. It is claimed that these "green" labeled homes have lower operational costs than conventional homes, with rating requirements going beyond standard efficiency levels prescribed by building codes. In addition, it is claimed that owners of such homes enjoy ancillary benefits beyond energy savings, such as greater comfort levels and better indoor environmental quality. If consumers observe and value these features, hedonic methods can be used to measure the price premium for such attributes, representing the valuation of the marginal buyer (Bajari and Benkard, 2005; Rosen, 1974).

In the European Union, the introduction of energy labels, following the 2003 European Performance of Buildings Directive (EPBD), has provided single-family homebuyers with information about how observationally identical homes differ with respect to thermal efficiency. Presumably, heterogeneity in thermal efficiency affects electricity and gas consumption. The EU energy label seems to be quite effective in resolving the information asymmetry in understanding the energy efficiency of dwellings: Brounen and Kok (2011) estimate hedonic pricing gradients for recently sold homes in the Netherlands and document that homes receiving an "A" grade in terms of energy efficiency sell for a 10% price premium. Conversely, dwellings that are labeled as inefficient transact for substantial discounts relative to otherwise comparable, standard homes. In Singapore, Yongheng Deng et al. (2012) document that homes labeled under the government-designed Green Mark scheme sell for a 4–6% price premium.

In the United States, few if any large sample studies have investigated the financial performance of "green homes." There is some information on the capitalization of solar panels in home prices — one study based in California documents that homes with solar panels sell for roughly 3.5% more than comparable homes without solar

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panels (Dastrup et al., 2012). But unlike findings in previous research on the commercial real estate sector, there is a dearth of systematic evidence on the capitalization of energy-efficiency and other sustainability-related amenities in asset prices of the residential building stock, leading to uncertainty among private investors and residential developers to invest in the construction and redevelopment of more efficient homes.[1]

This paper systematically addresses the impact of labels attesting to energy efficiency and other "green" features of single-family dwellings, on the value of these homes as observed in the marketplace, providing evidence on the private returns to the investments in energy-efficient single-family dwellings, an increasingly important topic for the U.S. housing market.

Using a large sample of transactions in California, consisting of some 4231 buildings certified by the USGBC, EPA, and a statewide rating agency, Build It Green, and a control sample of some 1.6 million non-certified homes, we relate transaction prices of these dwellings to their hedonic characteristics, controlling for geographic location and the time of the sale.

The results indicate the importance of a label attesting to the sustainability of a property in affecting the transaction price of recently constructed homes as observed in the marketplace, suggesting that an otherwise identical dwelling with a "green" certification will transact for about 2–4% more. The results are robust to the inclusion of a large set of control variables, such as dwelling vintage, size and the presence of amenities, to stratification of the sample by geography and vintage, and to the application of propensity-score matching.

In addition to estimating the average effect, we test whether the price premium is higher for homes located in hotter climates and in electric utility districts featuring higher average residential electricity prices. Presumably, more efficient homes are more valuable in regions where climatic conditions demand more cooling, and where energy prices are higher. In line with evidence on the capitalization of energy efficiency in commercial buildings (Eichholtz et al., 2013) our results suggest that a label appears to add more value in hotter climates, where cooling expenses are likely to be a larger part of total housing expenses. This provides some evidence on the rationality consumers in appropriately capitalizing the benefits of more efficient homes.

We also test whether the price of certified homes is affected by consumer ideology, as measured by the percentage of hybrid registrations in the neighborhood. A desire to appear environmentally conscious may increase the value of "green" homes, because it is a tangible signal of environmental virtue (Sexton and Sexton, 2011). The results show that the green premium is positively related to the environmental ideology of the neighborhood — green homes located in areas with a higher fraction of hybrid registrations sell for higher prices. Some homeowners seem to attribute non-financial utility to a green label (and its underlying features), which is in line with previous evidence on the private value of green product attributes (Kahn, 2007).

This paper contributes to an emerging literature on the economic value of labels in encouraging behavior that mitigates environmental externalities. Jin and Leslie (2003, 2009) document the role of labels indicating restaurant public health quality. They find that these labels induce supply and demand side behavioral change, so that public health improves. Shimshack and Ward (2010) study the role that mercury warnings on fish play in altering consumption patterns. Informed consumers are more likely to substitute to lower risk products. Graff Zivin and Neidel (2009) document that the population responds by avoiding smoggy inland areas when a given polluted day is labeled to be a "Smog Alert" day. Each of these examples highlights the role that trusted labels play in differentiating consumer products.

The remainder of this paper is organized as follows: Section 2 describes the empirical framework and the econometric models. Section 3 discusses the data, which represent a unique combination of dwelling-level transaction data with detailed information on "green" labels that have been assigned to a subsample of the data. Section 4 provides the main results of the analysis. Section 5 provides a discussion and policy implications of the findings.

## 2. Method and empirical framework

### 2.1. The definition of green homes

In the U.S., there are multiple programs that encourage the development of energy efficient and sustainable dwellings through systems of ratings to designate and publicize exemplary buildings. These labels are asset ratings: snapshots in time that quantify the thermal and other sustainability characteristics of the building, predicting its energy performance through energy models. The labels do not measure actual performance, and thus do not take occupant behavior into account. The Energy Star program, jointly sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy, is intended to identify and promote energy-efficient products, appliances, and buildings. The Energy Star label was first offered for residential buildings in 1995.[2]

The Energy Star label is an asset rating touted as a vehicle for reducing operational costs in heating, cooling, and water-delivering in homes, with conservation claims in the range of 20–30%, or $200–$400 in annual savings for a typical home. In addition, it is claimed that the label improves comfort by sealing leaks, reducing indoor humidity and creating a quieter environment. But the Energy Star label is also marketed as a commitment to conservation and environmental stewardship, reducing air pollution.

In a parallel effort, the U.S. Green Building Council, a private nonprofit organization, has developed the LEED green building rating system to encourage the "adoption of sustainable green building and development practices." Since adoption in 1999, separate standards have been applied to new buildings and to existing structures.

The LEED label requires sustainability performance in areas beyond energy use, and the requirements for certification of LEED buildings are substantially more complex than those for the award of an Energy Star rating. The certification process for homes measures six distinct components of sustainability: sustainable sites, water efficiency, materials and resources, indoor environmental quality, innovation, as well as energy performance. Additional points can be

[1] There are some industry-initiated case studies on the financial performance of "green" homes. An example is a study by the Earth Advantage Institute, which documents for a sample of existing homes in Oregon that those with a sustainable certification sell for 30% more than homes without such a designation, based on sales data provided by the Portland Regional Multiple Listing Service. However, the sources of the economic premiums are diverse, not quantified, and not based on rigorous econometric estimations.

[2] Under the initial rating system, which lasted until 2006, buildings could receive an Energy Star certification if improvements were made in several key areas of the home, including high-performance windows, tight constructions and ducts, and efficient heating and cooling equipment. An independent third-party verification by a certified Home Energy Rater was required. Homes qualified under Energy Star Version 1 had to meet a predefined energy efficiency score ("HERS") of 86, equating more than 30% energy savings as compared to a home built to the 1992 building code. From January 2006 until the end of 2011, homes were qualified under Energy Star Version 2. This version was developed in response to increased mandatory requirements in the national building codes and local regulations, as well as technological progress in construction practices. The updated guidelines included a visual inspection of the insulation installation, a requirement for appropriately sized HVAC systems, and a stronger promotion of incorporating efficient lighting and appliances into qualified homes. An additional "thermal bypass checklist" (TBC) became mandatory in 2007. As of 2012, Energy Star Version 3 has been in place, including further requirements for energy efficiency measures and strict enforcement of checklist completion.

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obtained for proximity to public transport, and for awareness and education.[3]

Whereas LEED ratings for commercial (office) space have diffused quite rapidly over the past ten years (see Kok et al., 2011, for a discussion), the LEED for Homes rating started in pilot form in 2005 only, and it was fully balloted as a rating system in January 2008.

It is claimed that LEED-certified dwellings reduce expenses on energy and water, have increased asset values, and that they provide healthier and safer environments for occupants. It is also noted that the award of a LEED designation "demonstrate[s] an owner's commitment to environmental stewardship and social responsibility."

In addition to these national programs intended for designating exemplary performance in the energy efficiency and sustainability of (single-family) homes, labeling initiatives have also emerged at the city or state level. In California, the most widely adopted of these initiatives is GreenPoint Rated, developed by Build It Green, a non-profit organization whose mission is to promote healthy, energy- and resource-efficient homes in California.

The GreenPoint Rated scheme is comparable to LEED for Homes, including multiple components of "sustainability" in the rating process, with minimum rating requirements for energy, water, indoor air quality, and resource conservation. Importantly, the GreenPoint Rated scheme is not just available for newly constructed homes, but it is applicable to homes of all vintages. The label is marketed as "a recognizable, independent seal of approval that verifies a home has been built or remodeled according to proven green standards." Comparable to other green rating schemes, proponents claim that a GreenPoint rating can improve property values at the time of sale.

### 2.2. Explaining home price variation

Consider the determinants of the value of a single-family dwelling at a point in time as a bundle of residential services consumed by the household (Kain and Quigley, 1970). It is well-documented in the urban economics literature that the services available in the neighborhood, such as schools, public transport and other amenities, will explain a large fraction of the variation in price (see, for example, Joseph Gyourko et al., 1999). But of course, the dwelling's square footage, architecture and other structural attributes will also influence its value.

In addition to attributes included in standard asset pricing models explaining home prices, the thermal characteristics and other "sustainability" features of the dwelling may have an impact on the transaction price. These characteristics provide input, which combined with energy inputs, provide comfort (Quigley and Rubinfield, 1989). However, the energy efficiency of homes (and their equipment) is often hard to observe, leading to information asymmetry between the seller and the buyer. Homeowners typically have limited information on the efficiency of their own home — it has been documented that the "energy literacy" of resident households is quite low (Brounen et al., 2013). Indeed, recent evidence shows that providing feedback to private consumers with respect to their energy consumption is a simple, but effective "nudge" to reduce energy consumption (Allcott, 2011).

To resolve the information asymmetry in energy efficiency and general "green" attributes, energy labels and green certificates have been introduced in commercial and residential real estate markets. These labels can be viewed as an additional step to enhance the transparency of resource consumption in the real estate sector. Such information provision may enable private investors to take sustainability into account when making housing decisions, reducing costly economic search (Gilmer, 1989). From an economic perspective, the labels should have financial utility for prospective homeowners, as the savings resulting from purchasing a more efficient home may result in lower operating costs during the economic life, or less exposure to utility cost escalation over time.[4] In addition, similar to a high quality "view," various attributes of homes, such as durability or thermal comfort, may not provide a direct cash flow benefit, but may still be capitalized in sales transactions.

To empirically test this hypothesis, we regress the logarithm of the transaction price on the hedonic characteristics of single-family homes by estimating:

$$\ln\left(P_{ijt}\right) = \alpha green_i + \beta X_t + \gamma_{jt} + \varepsilon_{ijt}. \qquad (1)$$

In this formulation, $P_{ijt}$ is the home's sales price commanded by dwelling $i$ in cluster $j$ in quarter $t$; $X_i$ is the set of hedonic characteristics of building $i$, and $\varepsilon_{ijt}$ is an error term. To control more precisely for locational effects, we include a set of dummy variables, $\gamma_{jt}$, one for each combination $j$ of street and zip code. These zip-code–street-fixed effects account for cross-area differences in local public goods such as weather, crime, neighborhood demographics and school quality. To capture the time-variation in home prices we include year/quarter fixed effects.

In Eq. (1), $green_i$ is a dummy variable with a value of one if dwelling $i$ is rated by the EPA, USGBC or Build It Green, and zero otherwise. $\alpha$, $\beta$, $\gamma_{jt}$ are estimated coefficients. $\alpha$ is thus the average premium, in percent, estimated for a labeled building relative to those observationally similar buildings in its geographic cluster — the zip code–street. Standard errors are clustered at the zip code level to control for spatial autocorrelation in prices within zip codes.

Below, we will report estimates of Eq. (1) for the entire state of California and in addition, we report results where we stratify by local markets (urban versus rural) and by vintage. We also contrast our results based on this fixed-effects approach, with results based on a sample that focuses on a subset of control homes with similar observable attributes as homes that tend to have a green label. In these comparisons, green and nongreen buildings are matched by propensity scores (Rosenbaum and Rubin, 1983), based conservatively on the identification of "nearest neighbors" (see Black and Smith, 2004).

In a second set of estimates, we include additional interaction terms in Eq. (1), interacting "green" with a vector (Z) of locational attributes:

$$\ln\left(P_{ijt}\right) = \alpha_o green_i + \alpha_1 Z green_i + \beta X_t + \gamma_{jt} + \varepsilon_{ijt}. \qquad (2)$$

We estimate Eq. (2) to study whether the "green label" premium varies with key observables such as climatic conditions and local electricity prices.[5] We posit that green homes will be more valuable in areas that experience more hot days and areas where electricity prices are high. Presumably, the present value of future energy savings is highest in those regions, which should be reflected in the value attributed to the "green" indicator.

A second interaction effect addressed in this study is whether the capitalization effect of green labels is larger in communities that reveal a preference for "green products." A desire to appear environmentally

[3] For more information on the rating procedures and measurements for LEED for Homes, see: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147.

[4] For the commercial real estate market, a series of papers that study investor and tenant demand for "green" office space in the U.S. show that buildings with an Energy Star label – indicating that a building belongs to the top 25% of the most energy-efficient buildings – or a LEED label have rents that are two to three percent higher as compared to regular office buildings. Transaction prices for energy-efficient office buildings are higher by 13–16%. Further analyses show that the cross-sectional variation in these premiums has a strong relation to real energy consumption, indicating that tenants and investors in the commercial property sector capitalize energy savings in their investment decisions (Eichholtz et al., 2010).

[5] In model (2), we replace the zip-code-fixed effects with county-fixed effects, as data on Prius registrations, electricity prices and the clustering of green homes is measured at the zip code level. To further control for the quality of the neighborhood and the availability of local public goods, we include a set of demographic variables from the Census bureau, plus distance to the central business district (CBD) and distance to the closest public transportation hub.

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conscious may increase the value of "green" homes, because it is a visible signal of environmental virtue — like private investors' preference for socially responsible investments (Derwall et al., 2011). Of course, this assumes that green-labeled homes have visibility in the marketplace, either through public display of actual plaques (often present in LEED buildings) or in advertisements of developers and brokers. Our proxy for environmental idealism and the social returns to demonstrating environmental awareness is the Toyota Prius share of registered vehicles in the zip code (these data are from the year 2007).[6] Last, we test for whether the green home premium differs over the business cycle. The recent sharp recession offers significant variation in demand for real assets, which may affect the willingness to pay for energy efficiency and other green attributes.

Anecdotally, we know that the green homes in our sample are mostly "production homes" and not high-end custom homes — many large residential developers, such as KB Home, are now constructing Energy Star and GreenPoint Rated homes. But, it is important to note that we do not have further information on the characteristics of the developers of "green" homes and conventional homes. Therefore, we cannot control for the possibility that some developers choose to systematically bundle green attributes with other amenities, such more valuable appliances or a higher-quality finishing. We assume that such unobservables are not systematically correlated with green labels. Otherwise, we would overestimate the effects of green labels on housing prices.

## 3. Data

### 3.1. Data sources

We obtain information on LEED-rated homes and GreenPoint Rated homes using internal documentation provided by the USGBC and Build It Green, respectively. Energy-Star-rated homes are identified by street address in files available from local Energy Star rating agencies. We focus our analysis on the economically most important state of California, covering the 2007–2012 time period.

The number of homes rated by the "green" schemes is still rather limited — 4921 single-family homes rated with GreenPoint Rated and 489 homes rated with LEED for homes (as of January 2012). The number of homes that obtained an Energy Star label is claimed to be substantially larger, but we note that data on Energy Star Version 1 has not been documented, and information on homes certified under Energy Star Version 2 is not stored in a central database at the federal level. Therefore, we have to rely upon information provided by consultants who conduct Energy Star inspections. We obtained details on 4938 single-family dwellings that have been labeled under the Energy Star Version 2 program.

We matched the addresses of the buildings rated in these three programs as of January 2012 to the single-family residential dwellings identified in the archives maintained by DataQuick. The DataQuick service and the data files maintained by DataQuick are advertised as a "robust national property database and analytic expertise to deliver innovative solutions for any company participating in the real estate market."[7] Our initial match yielded 8243 certified single-family dwellings for which an assessed value or transaction price, and dwelling characteristics could be identified in the DataQuick files — of those homes, 4231 transacted during the sample period.[8]

Fig. 1 shows the geographic distribution of the certified homes in our sample. There is a clustering of "green" rated homes in certain areas, such as the Los Angeles region and the San Francisco region. The geographic distribution is correlated with higher incomes (e.g., in the San Francisco Bay Area), but also with higher levels of construction activity in recent years (e.g., in the Central Valley). As shown by the maps, in the case of Los Angeles, many of the "green label" homes are built in the hotter eastern part of the metropolitan area. It is important to note that there is little new construction in older, liberal cities such as Berkeley and Santa Monica (Kahn, 2011). This means that it is likely to be the case that there will be few single-family "green homes" built in such areas.

To investigate the effect of energy efficiency and sustainability on values of dwellings as observed in the market, we also collect information on all non-certified single-family dwellings that transacted during the same time period, in the same geography. In total, there are nearly 1.6 million observations with hedonic and financial data in our sample of green dwellings and control dwellings.

Besides basic hedonic characteristics, such as vintage, size and presence of amenities, we also have information on the time of sale. Clearly, during the time period that we study, many homes in our geography were sold due to financial distress (i.e., foreclosure or mortgage delinquency). This, of course, has implications for the transaction value of homes (Campbell et al., 2011). We therefore create an indicator for a "distressed" sale, based on information provided by DataQuick.

We also collect data on environmental ideology, proxied by the registration share of Prius vehicles in each zip code.[9] Local climatic conditions are assessed by the total annual cooling degree days at the nearest weather station (measured by the longitude and latitude of each dwelling and each weather station) during the year of sale.[10] Information on electricity prices is collected at the zip code level.[11]

### 3.2. Descriptive statistics

Table 1 summarizes the information available on the samples of certified and non-certified dwellings. The table reports the means and standard deviations for a number of hedonic characteristics of green buildings and control buildings, including their size, quality, and number of bedrooms, as well as indexes for building renovation, the presence of on-site amenities (such as a garage or carport, swimming pool, or presence of cooling equipment), and the presence of a "good" view.[12]

Non-parametric comparisons between the samples of certified and non-certified homes show that transaction prices of "green" homes are higher by about $45,000, but of course, this ignores any observable differences between the two samples. Indeed, green homes are much younger — the average age is 1.68 years, as compared to 32.23 years for the control sample (some 70% of the dwellings in the green sample have been constructed during the last five years).

The sample of certified homes consists for more than two thirds of dwellings certified by Energy Star, but there is substantial overlap between the green certifications — about 20% of the green homes have multiple labels.

## 4. Results

Table 2 presents the results of a basic regression model (see Eq. (1)) relating transaction prices of single-family dwellings to their observable

[6] See Kahn (2007) for a discussion of Prius registrations as proxy for environmentalism.

[7] DataQuick maintains an extensive micro database of approximately 120 million properties and 250 million property transactions. The data has been extensively used in previous academic studies. See, for example, Bostic and Ok Lee (2008) and Ferreira et al. (2010).

[8] We were not able to match the remaining 2105 certified properties to the DataQuick files. Reasons for the missing observations include, for example, properties that were still under construction, and incomplete information on certified properties.

[9] We calculate the Toyota Prius share of registered vehicles from zip code totals of year 2007 automobile registration data.

[10] Data retrieved from http://www.ncdc.noaa.gov/cdo-web/.

[11] Data retrieved from http://www.energy.ca.gov/maps/serviceareas/electric_service_areas.html. We thank the California Energy Commission for providing a list containing each zip code in California and the corresponding local electric utility provider.

[12] DataQuick classifies the presence and type of view from the property. A "good" view includes the presence of a: canyon, water, park, bluff, river, lake or creek.

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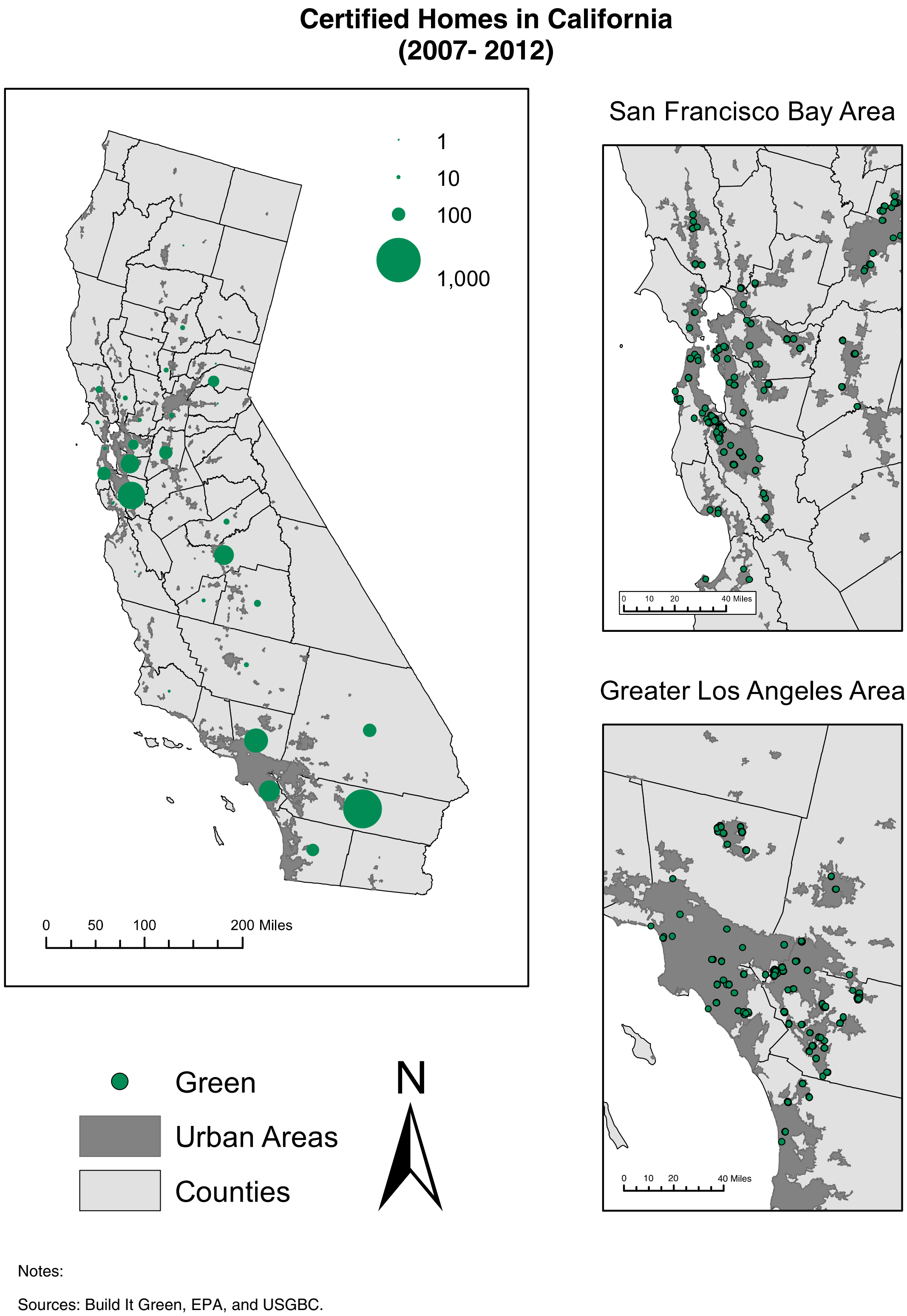


**Fig. 1.** Certified homes in California (2007–2012).

characteristics and a "green" rating. Zip-code/street-fixed effects account for cross-area differences in local public goods, such as weather, crime, neighborhood demographics and school quality. The analysis is based upon more than 1.6 million observations on rated and unrated dwellings. Results are presented for ordinary least squares regression models, with errors clustered at the zip code level. Coefficients for the individual location clusters and the time-fixed effects are not presented. Column (1) reports a model that includes some basic hedonic features: dwelling size in thousands of square feet, the number of bed and bathrooms, and the presence of a garage or carport. The model explains about 90% of the variation in the natural logarithm of home prices.

Larger homes command higher prices — a thousand square feet increase in total dwelling size (corresponding to an increase of about 50% in the size of typical home) leads to a 24% higher transaction

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**Table 1**
Comparison of green-labeled dwellings and other homes (standard deviations in parentheses).

| | Rated buildings | | Control buildings | |
|---|---|---|---|---|
| Sample size | 4321 | | 1,600,558 | |
| Dwelling characteristics | | | | |
| Sales price (thousands of dollars) | 445.29 | (416.58) | 400.51 | (380.47) |
| Dwelling size (thousands of sq ft) | 2.06 | (0.69) | 1.80 | (0.86) |
| Age (years) | 1.68 | (9.49) | 32.23 | (24.39) |
| Renovated dwelling (percent) | 0.04 | (0.19) | 0.12 | (0.33) |
| Garage (number) | 0.15 | (0.55) | 0.61 | (0.94) |
| Number of bedrooms (number) | 2.64 | (1.63) | 2.96 | (1.18) |
| Number of bathrooms (number) | 2.03 | (1.26) | 2.11 | (0.94) |
| Distressed sale (1 = yes) | 0.08 | (0.26) | 0.49 | (0.50) |
| Cooling equipment (1 = yes) | 0.45 | (0.50) | 0.39 | (0.49) |
| Swimming pool (1 = yes) | 0.01 | (0.09) | 0.11 | (0.31) |
| View (1 = yes) | 0.00 | (0.02) | 0.02 | (0.15) |
| Locational characteristics | | | | |
| Prius registration share (percent × 100) | 0.45 | (0.38) | 0.42 | (0.41) |
| Cooling degree days per year (thousands) | 6.86 | (3.86) | 6.37 | (4.34) |
| Electricity price (cents/kWh) | 15.06 | (0.84) | 14.94 | (1.37) |
| Green features | | | | |
| Green label | | | | |
| Energy Star (percent) | 0.68 | (0.47) | – | |
| GreenPoint (percent) | 0.47 | (0.50) | – | |
| LEED (percent) | 0.03 | (0.16) | – | |
| Multiple certifications (percent) | 0.17 | (0.38) | – | |
| Distance to closest rail station (in kilometers) | 63.90 | (71.52) | 82.35 | (104.65) |
| Distance to CBD (in kilometers) | 27.37 | (18.84) | 28.61 | (26.56) |

price. Controlling for dwelling size, an additional bathroom adds about 6% to the value of a home, and a garage yields about 5%, on average.

In column (2), we add a vector of vintage indicators to the model. Relative to homes constructed more than fifty years ago (the omitted variable), recently developed homes fetch significantly higher prices. The relation between vintage and price is negative, but homes constructed during the 1960–1980 period seem to transact at prices similar to very old ("historic") homes. Renovation of dwellings is capitalized in the selling prices, although the effect is small — prices of renovated homes are just 1% higher.[13]

Column (3) includes a selection of dwelling amenities in the model. The results show that homes that were sold as "distressed," for example following mortgage default, transact at a discount of 12%, on average. The presence of a swimming pool, cooling system or a "view" contributes significantly to home prices.

Importantly, holding all hedonic characteristics of the dwellings constant, column (4) shows that a single-family dwelling with a LEED, GreenPoint Rated or Energy Star certificate transacts at a premium of 5%, on average. This result holds while controlling specifically for all the observable characteristics of dwellings in our sample.[14] The "green" premium is quite close to what has been documented for properties certified as efficient under the European energy labeling scheme: Brounen and Kok (2011) report for a sample of 32,000 homes that those with "green" energy labels transact for about 4% more as compared to standard homes. The capitalization effect is also quite similar to the effect reported in Singapore by Yongheng Deng et al. (2012). In the commercial property market, "green" premiums have been documented to be significantly higher — about 16% (Eichholtz et al., 2010).

### 4.1. Robustness checks

Relative to just 4321 "treated," green homes, our sample includes a (very) large number of "non-treated," control homes. This allows for stratification of the sample such that differences in geography and vintage are minimized. Indeed, as noted in Table 1, most homes certified by one of three rating schemes have been constructed quite recently — some 70% of the green homes were constructed less than six years ago. To create a comparable control group of non-certified

**Table 2**
Regression results dwelling characteristics, amenities, and sales prices (California, 2007–2012).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Green rating | | | | 0.053*** |
| (1 = yes) | | | | [0.016] |
| Dwellings size | 0.240*** | 0.226*** | 0.220*** | 0.220*** |
| (thousands of sq ft) | [0.008] | [0.008] | [0.008] | [0.008] |
| Number of bathrooms | 0.057*** | 0.045*** | 0.043*** | 0.043*** |
| | [0.004] | [0.003] | [0.003] | [0.003] |
| Number of bedrooms | 0.027*** | 0.028*** | 0.029*** | 0.029*** |
| | [0.002] | [0.002] | [0.002] | [0.002] |
| Number of garages | 0.049*** | 0.049*** | 0.047*** | 0.047*** |
| | [0.003] | [0.003] | [0.003] | [0.003] |
| Age[a] | | | | |
| New construction (1 = yes) | | 0.232*** | 0.196*** | 0.195*** |
| | | [0.017] | [0.016] | [0.016] |
| 1–2 years (1 = yes) | | 0.270*** | 0.235*** | 0.235*** |
| | | [0.016] | [0.015] | [0.015] |
| 2–3 years (1 = yes) | | 0.259*** | 0.242*** | 0.242*** |
| | | [0.014] | [0.014] | [0.014] |
| 3–4 years (1 = yes) | | 0.218*** | 0.218*** | 0.218*** |
| | | [0.014] | [0.013] | [0.013] |
| 4–5 years (1 = yes) | | 0.198*** | 0.200*** | 0.200*** |
| | | [0.014] | [0.013] | [0.013] |
| 5–6 years (1 = yes) | | 0.187*** | 0.189*** | 0.189*** |
| | | [0.013] | [0.013] | [0.013] |
| 6–10 years (1 = yes) | | 0.173*** | 0.170*** | 0.170*** |
| | | [0.012] | [0.012] | [0.012] |
| 10–20 years (1 = yes) | | 0.126*** | 0.120*** | 0.120*** |
| | | [0.011] | [0.010] | [0.010] |
| 20–30 years (1 = yes) | | 0.058*** | 0.053*** | 0.053*** |
| | | [0.010] | [0.009] | [0.009] |
| 30–40 years (1 = yes) | | 0.002 | −0.002 | −0.002 |
| | | [0.008] | [0.007] | [0.007] |
| 40–50 years (1 = yes) | | −0.005 | −0.007 | −0.007 |
| | | [0.005] | [0.005] | [0.005] |
| Renovated | | 0.006** | 0.004 | 0.004 |
| (1 = yes) | | [0.003] | [0.003] | [0.003] |
| Distressed sale | | | −0.118*** | −0.118*** |
| (1 = yes) | | | [0.002] | [0.002] |
| View | | | 0.038*** | 0.038*** |
| (1 = yes) | | | [0.006] | [0.006] |
| Swimming pool (1 = yes) | | | 0.057*** | 0.057*** |
| | | | [0.002] | [0.002] |
| Cooling systems | | | 0.044*** | 0.044*** |
| (1 = yes) | | | [0.005] | [0.005] |
| Constant | 12.053*** | 11.960*** | 12.022*** | 11.971*** |
| | [0.189] | [0.149] | [0.152] | [0.151] |
| *N* | 1,609,879 | 1,609,879 | 1,609,879 | 1,609,879 |
| $R^2$ | 0.913 | 0.915 | 0.919 | 0.919 |
| Adj $R^2$ | 0.897 | 0.899 | 0.904 | 0.904 |

Notes:
Regressions include: fixed effects by quarter year, 2007I–2012I, as well as fixed effects by zip code–street. (Coefficients are not reported.)
Standard errors, clustered at the zip code level, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.
[a] Omitted variable: vintage > 50 years.

[13] We replace the original "birth year" of a home with the renovation date in the analysis, so that vintage better reflects the "true" state of the home. This may explain the low economic significance of the renovation indicator.

[14] Quite clearly, this paper mostly deals with labeled developer homes rather than existing homes that went through the labeling process. As noted in Section 2, this raises the possibility of a "developer effect" in explaining the price variation between "green" and conventional homes. More information on the identity of developers of labeled and non-labeled homes would allow us to further disentangle this effect, but we have information on the developers of green homes only. About one third of the homes in the labeled sample have been constructed by KB Home. Regression that exclude homes constructed by KB Home lead to quite similar results, with the green premium decreasing to 4.5%.

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**Table 3**
Regression results robustness checks.

| | | | Propensity-score matched sample | |
|---|---|---|---|---|
| | (1)[a] | (2)[a] | (3)[b] | (4)[b] |
| Green rating | 0.039*** | 0.036** | 0.025** | 0.021** |
| (1 = yes) | [0.015] | [0.015] | [0.010] | [0.010] |
| Dwellings size | 0.225*** | 0.227*** | 0.284*** | 0.272*** |
| (thousands of sq ft) | [0.008] | [0.009] | [0.013] | [0.012] |
| Number of bathrooms | 0.010** | 0.009* | 0.073*** | 0.063*** |
| | [0.005] | [0.005] | [0.012] | [0.012] |
| Number of bedrooms | 0.013*** | 0.013*** | −0.021*** | −0.021*** |
| | [0.003] | [0.003] | [0.007] | [0.008] |
| Distance to closest rail station | | | | −0.007*** |
| (in kilometers) | | | | [0.001] |
| Distance to CBD | | | | 0.001** |
| (in kilometers) | | | | [0.001] |
| Constant | 12.247*** | 12.517*** | 11.947*** | 12.204*** |
| | [0.429] | [0.567] | [0.392] | [0.348] |
| MSA restricted?[c] | No | Yes | No | No |
| *N* | 314,759 | 260,925 | 5396 | 5372 |
| $R^2$ | 0.929 | 0.925 | 0.779 | 0.796 |
| Adj $R^2$ | 0.914 | 0.908 | 0.776 | 0.793 |

Notes:
Standard errors, clustered at the zip code level (columns 1 and 2), are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.
[a] Regressions in columns (1) and (2) include: fixed effects by quarter year, 2007I–2012I, and fixed effects by zip code–street, as well as vintage (ranging from 1–5 years), amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)
[b] Regressions in columns (3) and (4) include: fixed effects by quarter year, 2007I–2012I, fixed effects by county; we also include the following Census variables, measured at the zip code level: percentage of the population with at least some college education, percentage blacks, and percentage Hispanics, percentage in age categories 18–64, >64; as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)
[c] MSA restricted refers to a sample that is restricted to transactions in the following MSAs: Los Angeles, San Diego, and San Francisco.

single-family transactions, we therefore restrict the analysis to the subset of homes dwellings that are five years old or younger. Also, a large fraction of the treated sample is located in one of California's major metropolitan areas. We further restrict the analysis to the subset of dwellings that are located in the Metropolitan Statistical Area (MSA) of Los Angeles, San Diego, and San Francisco.

Of course, these stratifications leave non-labeled homes in the sample that are observationally different from labeled homes with regards to size, composition of the homes, and amenities. In the literature on "green" commercial buildings, these differences have been minimized through propensity-scoring models (see, for example, Eichholtz et al., 2013). Following this literature, we estimate a logit model, explaining the presence of a green label by the vintage, size, and county-fixed effects. The resulting propensity score is then used for a nearest-neighbor match on location and housing characteristics, with each green home matched to its closest non-green peer, measured by the propensity score.

Table 3 presents the results of these robustness checks. Control variables, location-fixed effects and time-fixed-effects are omitted from the table. The results presented in Table 3 are not consistently different from the results in Table 2, but the green premium is slightly lower: on average, green-rated homes that were constructed and sold during the last five years transact at a premium of almost 4%, one percentage point lower than estimations in Table 2, Column (4). In column (2), the sample is restricted to the large urban areas in the sample. The coefficient on "Green Rating" is compressed further, to 3.3%. Comparisons between green homes and non-green homes while controlling for vintage and geography significantly reduces the premium.

Columns (3) and (4) present the results of the regressions based on a propensity-matched sample. Importantly, in these regressions, we replace the zip-code-fixed effects with county-fixed effects. To further control for the quality of the neighborhood and the availability of local public goods, we include a set of demographic variables from the Census bureau, plus distance to the central business district (CBD) and distance to the closest public transportation hub.

Column (3) shows that some of the control variables change slightly. Most importantly, the coefficient of interest ("Green Rating") remains positive, but the economic significance decreases to 2.5%. In column (4), we add distance to the central business district (CBD) and distance to the closest public transportation hub to the model. This compresses the marginal effect of green building certification to 2.1% — the propensity match clearly reduces some of the observable differences between green and non-green homes.

**Table 4**
Regression results variation in label type and year of sale.[a]

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Energy Star | 0.047*** | | | |
| (1 = yes) | [0.016] | | | |
| GreenPoint | | −0.020 | | |
| (1 = yes) | | [0.023] | | |
| LEED | | | 0.041 | |
| (1 = yes) | | | [0.066] | |
| Green * Year 2008 | | | | −0.071*** |
| (1 = yes) | | | | [0.027] |
| Green * Year 2009 | | | | 0.017 |
| (1 = yes) | | | | [0.022] |
| Green * Year 2010 | | | | 0.050*** |
| (1 = yes) | | | | [0.017] |
| Green * Year 2011 | | | | 0.066** |
| (1 = yes) | | | | [0.032] |
| Constant | 12.270*** | 12.299*** | 12.286*** | 12.154*** |
| | [0.436] | [0.431] | [0.429] | [0.426] |
| *N* | 314,759 | 314,759 | 314,759 | 314,759 |
| $R^2$ | 0.929 | 0.929 | 0.929 | 0.929 |
| Adj $R^2$ | 0.914 | 0.914 | 0.914 | 0.914 |

Notes:
Regressions include: fixed effects by quarter year, 2007I–2012I, fixed effects by zip code–street, as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.)
Standard errors, clustered at the zip code level, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.
[a] Sample restricted to dwellings constructed during the 2007I–2012I period.

### 4.2. Testing for heterogeneity in "green label" capitalization

In Table 4, the green rating is disaggregated into three components: an Energy Star label, a LEED certification, and a GreenPoint Rated label. We again restrict the sample to those dwellings constructed and sold in Los Angeles, San Diego and San Francisco during the 2007–2012 time period. The (unreported) coefficients of the other variables are unaffected when the green rating is disaggregated into the component categories. The estimated coefficient for the Energy Star rating indicates a premium of 4.7%. The GreenPoint Rated and LEED rating are associated with insignificantly higher transaction prices. Energy efficiency is an important underlying determinant of the increased values for "green" certified dwellings.[15] An alternative explanation for the insignificant results for the GreenPoint Rated and LEED schemes is the limited recognition of those "brands" in the marketplace, leading to consumers

[15] The fundamental energy efficiency requirement is identical across the three different labeling schemes, and the mechanisms for verification are almost entirely similar. The three labels require design for fifteen percent energy savings beyond building code requirements and all schemes require various on-site verifications to confirm the delivered home was built to that standard. GreenPoint Rated and LEED offer the highest number of credits for exceeding that minimum requirement. Energy Star rated homes are thus not necessarily better energy performers as compared to the other rating schemes.

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**Table 5**
Regression results green labels, climatic conditions, electricity costs, and sales prices.[a]

| | (1)[b] | (2)[c] | (2)[c] | (3)[c] |
|---|---|---|---|---|
| Green rating (1 = yes) | −0.007 [0.025] | 0.098* [0.054] | −0.057 [0.039] | 0.082** [0.033] |
| Green rating ∗ Cooling degree days | 0.006* [0.003] | 0.006 [0.075] | | |
| Green rating ∗ Cooling degree days ∗ Electricity price | | −0.001 [0.005] | | |
| Green rating ∗ Prius registration | | | 21.957*** [5.355] | |
| Green rating ∗ Green density | | | | −0.002 [0.001] |
| Distance to closest rail station (in kilometers) | | −0.004*** [0.001] | −0.004*** [0.001] | −0.004*** [0.001] |
| Distance to CBD (in kilometers) | | −0.001 [0.001] | −0.001 [0.001] | −0.001 [0.001] |
| Time–ZIP-fixed effects | Y | N | N | N |
| Time–FIPS-fixed effects | N | Y | Y | Y |
| Control variables | Y | Y | Y | Y |
| Constant | 11.906*** [0.027] | 12.494*** [0.067] | 12.378*** [0.161] | 12.759*** [0.240] |
| *N* | 323,840 | 238,939 | 242,678 | 286,325 |
| $R^2$ | 0.925 | 0.760 | 0.761 | 0.749 |
| Adj $R^2$ | 0.910 | 0.758 | 0.758 | 0.747 |

Notes:
Standard errors, clustered at the zip code level in all regressions, are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.
[a] Sample restricted to dwellings constructed during the 2007I–2012I period.
[b] Regression in column (1) includes: fixed effects by quarter year, 2007I–2012I, fixed effects by zip code–street, as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.).
[c] Regressions in columns (2)–(4) include fixed effects by quarter year, 2007I–2012I, fixed effects by county; we also include the following Census variables, measured at the zip code level: percentage of the population with at least some college education, percentage blacks, and percentage Hispanics, percentage in age categories 18–64, >64; as well as vintage, amenities and other measures reported in Table 2 (column 4). (Coefficients are not reported.).

attributing less value to these labels.[16] We note that, even though the LEED variable is statistically insignificant, the size of the coefficient is almost similar to the coefficient for Energy Star, whereas the coefficient on the GreenPoint variable is actually negative. But of course, sample sizes for homes certified under the alternative rating schemes are quite limited, and just a small fraction of those homes transacted over the past years.

The downturn in housing markets and the subsequent decrease in transaction prices may also have an impact on the willingness to pay for more efficient, green homes. It has been documented that prices are more procyclical for durables and luxuries as compared to prices of necessities and nondurables (see Bils and Klenow, 1998). To control for the time-variation in the value attributed to "green," we include interaction terms of year-fixed effects and the green indicator in column (4). When interaction terms of year-fixed effects are included in the model (the years 2007 and 2012 are omitted due to the lack of a sufficient number of observations in those years), we document substantial variation in the premium for green dwellings over the sample period. In the first year of the sample, labeled homes sold for a discount (which may be related to the lack of demand for newly constructed homes during that time period), whereas the premium is large and significant in later years. The parallel with the business cycle suggests that, among private homeowners, demand for "green" is lower in recessions, but increases as the economy accelerates. This is contrasting evidence for the commercial market: it has been documented that green-certified office buildings experienced rental decreases similar to conventional office buildings during the most recent downturn in the economy (Eichholtz et al., 2013).

As demonstrated in the statistical models reported in Tables 2–4, there is a statistically significant and rather large premium in the market value for green-certified homes. The statistical analysis does not identify the source of this premium, or the extent to which the signal about energy efficiency is important relative to the other potential signals provided by a building of sufficient quality to earn a label. The estimates provide a common percentage premium in value for all rated dwellings. But the value of green certification may be influenced by factors related to the location of homes: Fig. 1 suggests that the spatial distribution of green-rated dwellings is not random within urban areas in California, and this may affect the geographic variation in the value increment estimated for green-certified homes. For example, non-financial utility attributed to "green" certification may be higher for environmentally conscious households (comparable to the choice for solar panels, see Dastrup et al., 2012, for a discussion) or in areas where such homes are clustered (this peer-effect is referred to as "conspicuous conservation" by Sexton and Sexton, 2011).

But, the financial utility of green homes may also be affected by other factors related to the location of a dwelling. The financial benefits of a more efficient home should increase with the temperature of a given location, ceteris paribus. (Presumably, more energy is needed for the heating of dwellings in areas with more heating degree days, and more energy is needed for the cooling of buildings in areas with more cooling degree days.) To test this hypothesis, we interact the green indicator with information on cooling degree days for each dwelling in the transaction year, based on the nearest weather station in the database of the National Oceanic and Atmospheric Administration (NOAA). Similarly, in areas with higher electricity costs, the return to energy efficiency should be higher. We therefore interact the climate variable with information on the retail price of electricity in the electric utility service area.

Table 5 presents a set of models that include a proxy for ideology, green home density, climatic conditions and local electricity prices. In this part of the analysis, we seek to (at least partially) distinguish the effects of the energy-saving aspect of the rating from other, intangible effects of the label itself. We restrict the sample to those homes that are five years or younger, but do not impose geographic restrictions, to allow for sufficient within-sample variation. The results in column (1) show that more efficient homes located in hotter climates (e.g., the Central Valley) are more valuable as compared to labeled homes constructed in more moderate climates (e.g., the coastal region). At the mean temperature level (6680 cooling degree days), the green premium equals about 10%. But for every one-thousand cooling degree day increase, the premium for certified homes increases by 0.6%, ceteris paribus. This result suggests that private homeowners living in areas where cooling loads are higher are willing to pay more for the energy efficiency of their dwellings.[17]

In column (2), we add an interaction term of climatic conditions with local electricity prices. (In models 2–4, we control for location using county-fixed effects.) Presumably, energy savings are more valuable if the price of electricity per kWh is higher. However, our results do not show a difference in the capitalization of energy savings between consumers paying high rates (the maximum rate in our sample equals 0.27 cents/kWh) and those paying lower rates (the minimum rate in our sample equals 0.07 cents/kWh).

[16] The Energy Star label is recognized by more than 80% of U.S. households, and 44% of households report they knowingly purchased an Energy Star labeled product in the past 12 months (see http://www.cee1.org/eval/00-new-eval-es.php3). Energy Star is one of the most widely recognized brands in the U.S. While similar data is not available for GreenPoint Rated or LEED, both were introduced as building labels much more recently, and do not benefit from the near ubiquitous cobranding in consumer products.

[17] While we do not have household level data on electricity consumption in more efficient homes, the "rebound effect" would predict that such homeowners might respond to the relatively lower price of achieving "cooling" by lowering their thermostat. This effect has been documented for commercial real estate (Kahn et al., 2013). In such a case, the actual energy performance of the buildings would not necessarily be lower, because of the behavioral response.

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In column (3), we include the share of Prius registrations for each zip code in the sample, interacted with the indicator for green certification. Quite clearly, the capitalization of "green" varies substantially by heterogeneity in the Prius measure of local environmentalism. In areas with higher concentrations of hybrid vehicle registrations, the value attributed to the green certification is higher. These results on the larger capitalization effect of green homes in more environmentally-conscious communities are consistent with empirical work on solar panels (Dastrup et al., 2012) and theoretical work on the higher likelihood for the private provision of public goods by environmentalists (Kotchen, 2006).

In column (4), we include a variable for the "density" of green homes in a given street and zip code, and built by the same developer. One could argue that in areas with a larger fraction of green homes, there is a higher value attributed to such amenity by the local residents. Households who purchase a home on this street know that their neighbors also will be living in a "green" home and this will create a type of Tiebout sorting as those who want to live near other environmentalists will be willing to pay more to live there. In this sense, the "green label" density acts as a co-ordination device. However, competition in the share of green homes in a given neighborhood may also negatively affect the willingness to pay for "green," as such feature is becoming a commodity (see Chegut et al., in press, for a discussion).

When including the density indicator, the point estimate for green certification does not change significantly, but the coefficient on green home density is indicating a negative relation between the intensity of local green development and the transaction increment paid for green homes. This finding is not significant, but the sign of the coefficient is in line with evidence on green building competition in the UK. As more labeled homes are constructed, the *marginal* effect relative to other green homes becomes smaller, even though the *average* effect, relative to non-green homes, remains positive.

## 5. Discussion and conclusions

### *5.1. The costs and benefits of green homes*

The economic significance of the "green" premium documented for labeled homes is quite substantial. Considering that the average transaction price of a non-labeled home equals $400,000 (see Table 1), the incremental value of 2.1% for a certified dwelling (the most conservative estimate, see Table 3, column 4) translates into some $8400 more than the value of a comparable dwelling nearby.

Of course, this raises the issue of relative input costs. The increment in construction costs of more efficient, "green" homes is open to popular debate, and there is a lack of consistent and systematic evidence. Anecdotally, a recent industry report shows that estimated cost to reach a *modeled* efficiency level of 15% above California's 2008 energy code, is between $1600 and $2400 for a typical 2000 sq ft dwelling, depending on the climate zone. To reach a *modeled* energy efficiency level of some 35% above the 2008 code, estimated costs range from $4100 to $10,000 for a typical 2000 square foot dwelling, again depending on the climate zone.[18] (Some of these costs are offset by incentives: it is estimated that about one third of the costs could be compensated for by rebates.) These admittedly rough estimates suggest that the capitalization of energy efficiency features in the transaction price (about $8400) would, on average, exceed the input cost for the developer (about $4100 to $10,000).

From the perspective of a homeowner, the benefits from purchasing a labeled home, or from "greening" an existing dwelling, include direct cost savings during tenure in the home. Indeed, we document some consumer rationality in pricing the benefits of more efficient homes, as reflected in the positive relation between cooling degree days in a given geography and the premium rewarded to a certified home. Presumably, the capitalization of the label should at least reflect the present value of future energy savings. Considering that the utility bill for a typical single-family home in California equals approximately $200 per month, and savings in a more efficient home are expected to yield a 30% reduction in energy costs, the annual dollar value of savings for an average consumer is some $720. Compared to the increment for green-labeled homes documented in this paper, that implies a simple payback period of some 12 years. Of course, this assumes that there is no "rebound effect" for consumers in more efficient homes, which may offset all or part of the energy savings (Greening et al., 2000).

Of course, there are other (unobservable) features of green homes that add value for consumers. This may include savings on resources other than energy, such as water, but the financial materiality of these savings is relatively small. However, there are also other, intangible benefits of more efficient homes, such as better insulation, reducing draft, and more advanced ventilation systems, enhancing indoor air quality. These ancillary benefits may be appealing to consumers through the comfort they provide.

The results documented in this paper also show that the premium in transaction price associated with a green label varies considerably across geographies. The premium is positively related to the environmental ideology of the neighborhood. In line with previous evidence on the private value of green product attributes, some homeowners seem to attribute non-financial utility to a green label (and its underlying features), explaining part of the premium paid for green homes.

### *5.2. Conclusion*

The durable building stock is among the largest consumers of natural resources, and increasing the stock's energy efficiency can thus play a significant role towards achieving cost savings for private consumers and corporate organizations, and it can be an important step in realizing global carbon reduction goals. With these objectives in mind, an ongoing effort has sought to certify buildings that have been constructed more efficiently. Considering the lack of "energy literacy" among private consumers, if homebuyers are unaware of a building's steady state (modeled) energy consumption, then they will most likely not appropriately capitalize energy savings in more efficient dwellings.

Credible energy labels provide a relatively low cost strategy for differentiating the residential building stock. If such homes sell for a price premium, then this encourages home owners who may expect that they could move to a new home in the medium term to consider investing in increased energy efficiency. This paper has used detailed data on a large sample of California homes to study whether there is credible evidence of a price premium for energy efficient homes. California is an important test case because the state enacted AB32 in 2006. This policy commits California to sharply reduce its greenhouse gas emissions by the year 2020 and achieve even deeper reductions by the year 2050. For the residential sector to play an important role in achieving AB32's goals, new "green homes" must be a growing share of the stock and these homes must achieve the efficiency gains that their proponents have claimed.

Comparable to evidence documented for the commercial sector in the U.S., and to the residential sector in Europe, the results in this paper provide the first evidence on the importance of publicly providing information about the energy efficiency and "sustainability" of structures in affecting consumer choice. Green homes transact for significantly higher prices as compared to other recently constructed homes that lack sustainability attributes. This is important information for residential developers and for private homeowners: energy efficiency and other green features are capitalized in the selling price of homes.

[18] Source: Gabel (2008). "Codes and Standards: Title 24 Energy-Efficient Local Ordinances."

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We note that the green homes in our sample are not high-end, custom homes, but are rather "production homes" built by large developers. From the developer's perspective, there are likely to be economies of scale from producing more efficient homes in the same geographic area. If green communities command a price premium and developers enjoy cost savings from producing multiple homes featuring similar attributes, then for-profit developers will be increasingly likely to build such complexes. This has implications for the green premium, as the marginal effect relative to other green homes becomes smaller — an effect that has been documented for green-certified office buildings in the UK.

The findings in this paper also have some implication for policy makers. Information on the energy efficiency of homes in the U.S. residential market is currently provided just for exemplary dwellings. The mandatory disclosure of such information for the full distribution of the residential building stock could further the understanding of private consumers on the energy efficiency of their (prospective) residence, thereby reducing the information asymmetry that is presumably an important explanation for the energy-efficiency gap (Allcott and Greenstone, 2012). An effective and cheap market signal may trigger investments in the efficiency of the building stock, with positive externality effects as a result.

Of course, we cannot disentangle the energy savings required to obtain a label from the unobserved effects of the label itself, which could serve as a signaling measure of environmental ideology and other non-financial benefits from occupying a green home. Future research should incorporate the *realized* energy consumption in green homes and conventional homes to further disentangle these effects. Reselling of green-labeled homes will also offer an opportunity to further study the value persistence of certified homes, unraveling the effect of developer quality on the green premium documented in this paper.

This study has focused on the market for owner-occupied single-family dwellings. While this represents an important fraction of the housing market, the market for rental housing has been growing considerably over the course of the housing crisis, and represents the majority of the housing stock in large U.S. metropolitan areas such as New York and San Francisco. Addressing the signaling effect of green labels for tenants in multi-family buildings should thus be part of a future research agenda.

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