A Bright Future for Housing Investors?

Solar Panels and Investors in Single Family Homes

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Abstract:

U.S. investors' single-family home transactions rose over 50% since 2014, while 1,000% more houses installed solar panels. We test two hypotheses with a Connecticut solar initiative as a quasi-natural experiment: (i) investors' transactions of homes with solar exhibit greater "bargaining effects"; (ii) investors receive a solar signaling effect. Difference-in-differences demonstrate investors pay less and sell for more, but no solar "bargaining effect" wedge. Second, investors pay less for unobserved quality, which is offset by 25% for houses with solar. This solar "demand effect" mechanism may occur with both solar and new roofs. Overall, solar offers investors strong house quality signals.

JEL Codes: R

I. Introduction and Literature Review

Investors in single family residential real estate have taken a prominent share of the market in the U.S., with approximately 24 percent of transactions involving an investor buyer and/or investor seller in 2021, compared with 14 percent in the prior decade (Henderson, 2022). This surge in investment in single-family homes naturally raises the question of whether real estate investors value homes differently from non-investors. The literature documents how institutional and individual investors differ from non-investors in terms of both tastes and bargaining ability (e.g., Cohen and Harding, 2021); all else equal, investors exhibit better bargaining ability and higher demand for unmeasured attributes. Across individual real estate markets, it is not apparent a priori whether transactions involving investors result in higher or lower property sale prices. On the one hand, an investor may have more flexibility in selecting attributes such as location or condition compared to those purchasing homes as residences, allowing them to shop around in different locations and markets; this could result in lower transaction prices. On the other hand, some investors may have deeper pockets than the average non-investor; thus, an investor may be willing to pay more for desirable qualities (Cvijanovic and Spaenjers, 2020).

One characteristic of particular interest in recent years is the installation of distributed photovoltaic cells, or solar panels. Not only do these installations represent potential savings in energy consumption for primary residents (Gillingham and Watten, 2023), but, in many cases, excess energy can be sold to the grid as supplemental income. The literature demonstrates a valuation premium for solar installations (Begley and Hoen, 2021). However, whether investors would show a greater preference for properties with solar compared to non-investors has not been explored; investors may see solar installations as a signal of higher quality properties.

Investors have several reasons for preferring properties with solar. For example, an investor could rent out a property and entice renters with lower energy bills. Other investors could have a particular interest in green investing and advocacy. In addition, having solar on a single-family home may be a signal that there have been other renovations (such as a new roof and new electrical system), which are sometimes not observable to investors. Finally, it is possible that valuation differences between investors and non-investors also affect asymmetry in bargaining ability between them.

This paper aims to address these issues. Specifically, using the bargaining power model of Harding, Rosenthal, and Sirmans (2003, henceforth HRS), we examine the relation between the value of solar installations and the demand and bargaining effects of investors. The demand effect represents the valuation differences that investors associate with unobserved attributes of properties, while the bargaining effect represents the possibility that investors can buy for less and sell for more, compared with non-investors. Solar installations could represent some part of previously unobserved attributes and affect the difference in bargaining power between investors and non-investors.

We examine transactions of single-family homes in Connecticut from 2006 to 2021 and model transaction prices with a hedonic model. We find evidence of an overall significantly negative demand effect and a significantly positive bargaining effect; in other words, investors place a lower value on unobserved qualities and investors buy for less and sell for more, compared with non-investors. Furthermore, although the bargaining effect is not significantly different in the presence of solar installations, the demand effect is weakened by a factor of approximately 25% when solar installations are present. In other words, the valuation gap between investors and non-investors that is unaccounted for by observable quality is mitigated by as much as 25%, after accounting for their difference in bargaining power. More broadly, this dampening of the demand effect for house sales with solar implies investors generally value solar installations more than non-investors. These findings are robust to a variety of alternative regression specifications and additional control variables.

We explore the mechanisms of unobserved quality in several different ways. We integrate data for days on the market and property renovations from the CoreLogic Multiple Listing Services (MLS) dataset. The results are robust to controlling for the potential simultaneity of sales prices and days on the market, as one might expect higher priced houses to take longer to sell, while houses that have been on the market for quite some time may end up selling for less.

Next, using a smaller sample from the CoreLogic MLS dataset, we find the impact of solar on the demand effect is attenuated by the presence of a new roof. This finding highlights a potential mechanism for why investors could value solar: the installation of solar signals to investors that the property is of higher quality after accounting for other property characteristics. Installer fixed effects also can go a long way to addressing whether residential solar is owned or leased, since some installers focus on power purchase agreements, while other installers almost entirely put up owned systems (that are sometimes financed). Our solar dataset provides additional information on whether the solar system is leased or owned, and we control for ownership type, because the potential benefits to a homeowner from ownership are expected to be greater on average than from a leased system. Our dataset also includes whether the installation was part of "Solarize CT", which is a program that encourages homeowners to install solar.

The literature on investor ownership in single family housing is well-developed, as is the literature on the impact of solar on residential housing. But little work has focused on a synthesis of these two strands. One aspect of valuation that could differ between investors and non-investors is the presence of solar installations. In this literature review section, we describe these separate bodies of past research, to motivate our framework of combining the two modeling approaches.

One of the classic papers on the bargaining power model is HRS (2003), who apply this model to find that repeat homebuyers have more bargaining power. Their model examines both the bargaining power that one group (investors) has over another (non-investors), as well as demonstrating evidence of differing "demand effects" of those two groups. Subsequent research builds on the Harding, Rosenthal, and Sirmans (2003) approach, by considering different geographical contexts as well as varying residential property types. For instance, Ihlanfeldt and Mayock (2012) find that outside buyers have weaker bargaining power than local buyers in Florida. Ling, Naranjo, and Petrova (2018) find weaker bargaining power for outsiders in multiple metropolitan areas and classes of real estate transactions. In contrast, our study finds evidence of differing demand effects between investors and non-investors, rather than differing bargaining effects.

An additional paper in the outside buyers strand is Cvijanovic and Spaenjers (2021), who focus on the Paris, France housing market. They find that buyers from out of the country buy at higher prices and sell at lower prices. These differences are not due to information asymmetry and search costs, rather they can be attributed to wealth-related differences in bargaining. In examining the impact of out-of-country buyers on real estate prices, they use "shift-share" instruments, which allocate purchase volumes in the aggregate to areas based on historical settlement patterns and neighborhood desirability. Their causal effect of out-of-country buyer demand shocks to house prices are positive, but relatively low in magnitude. On the other hand, out-of-country investors realize approximately 10 percent lower capital gains than other investors. Our paper finds a premium for solar that investors are willing to pay, due to higher valuation of unobserved quality, compared to non-investors.

Favilukis and Van Nieuwerburgh (2021) examine the effects of out-of-town (OOT) investors in several parts of the world, including Europe, Canada, the U.S., Asia, Australia, and Israel. They find that OOT investors' buying 10% more urban and 5% more suburban housing leads to a 0.61% decrease in "consumption-equivalent units". Given the differential effects of increased rents and increased local demand and tax revenue, the authors construct an equilibrium model to examine this issue, and calibration is tied to the average of 75 of the largest U.S. MSAs. In sum, Favilukis and Van Nieuwerburgh (2021) find OOT investors tend to harm overall welfare, which is in contrast to the observations by Cohen and Harding (2021), who note how investors tend to absorb some of the excess supply of housing during the U.S. housing crisis and Great Recession in the late-2000s. Cohen and Harding (2021) also find that professional investors tend to have more bargaining power than individual investors and that professional investors tend to buy lower-quality homes based on unobservable characteristics. Our findings are similar, but we document one quality that helps close the gap in demand between investors and non-investors: solar installations.

In addition to investors having an important role in stabilizing housing markets during the Great Recession, the period following the Great Recession was also a pivotal time frame for housing investors. Garriga, Gete, and Tsouderou (2023) find evidence of growth in small- and medium-sized real estate investors (SMREI) across U.S. cities during this period. They find an increase of one standard deviation in SMREI purchases leads to a 1.37 percentage point increase in housing price growth for the median house. They also observe a significant effect of a one-percent increase in SMREI share on building permits, of approximately 5 percent for single unit buildings. They find strong evidence of parallel pre-trends, which validates their identification strategy.

While there is an extensive body of research on investors in single family housing, and an emerging literature during the past decade on the impacts of solar on house prices, little work has synthesized these two strands of research. Solar installations represent a potential signal or avenue through which homes could exhibit their quality to investors. Therefore, our work relates closely to the literature on the effect of solar installations on property pricing. There have been numerous such studies in the past decade. For instance, Hoen et al. (2012, 2013) document a $17,000 average premium of distributed photovoltaic installations on property prices in California. Hoen et al. (2017) find an average premium of $4 per kilowatt across multiple states in the U.S. Dastrup et al. (2012) examine solar installation premiums in San Diego and Sacramento, California, and find a premium of 3.5% on average. Qiu, Colson, and Grebitus (2014) find reluctance to install photovoltaics for risk-averse homeowners and those likely to relocate, implying the benefits of solar are expected to accrue over time. Ma, Polyakov, and Pandit (2016) find that homeowners tend to recover their solar installation costs on resale for properties in Perth, Australia. Wee (2016) finds diminishing returns for solar installations in Oahu, Hawaii. Qiu, Wang, and Wang (2017) examine price premiums for both solar panels and solar water heaters in Phoenix, Arizona, and they find that the premiums are 15% of home value on average for solar panels. Walls et al. (2017) study the capitalization of energy-efficient features in homes in the Research Triangle Park (RTP), North Carolina; Portland, Oregon; and Austin, Texas. They find that the premiums offset energy savings in RTP, but not in Portland.

Lan, Gou, and Yang (2020) document the negative impact that feed-in tariffs have on solar installation premiums for property prices in Southport, Queensland. Our paper contributes by documenting that solar premiums increase when investors are involved in single-family home transactions.

In more recent research, Begley and Hoen (2021) evaluate changes in solar premiums over time in California, Connecticut, Massachusetts, and Oregon. They find that rising energy costs over time have resulted in the projected savings from solar installations exceeding their premiums. More specifically, solar panels that are owned are associated with a 1.63 percent increase in house prices in all these states, while those that are leased have no significant relationship with the value of houses on average. Begley and Hoen (2021) also find that the house price premiums are significantly higher in California than in the other states in their sample. We also find evidence of significant solar premiums for single-family homes in Connecticut over our sample period; these premiums grow when investors are involved in these transactions.

Another recent contribution to this literature is by Gillingham and Watten (2023), who note that solar installations in the U.S. have increased by approximately 1,000 percent over the last decade. They incorporate the present value of expected future benefits from solar into a repeat sales version of the hedonic model, as an approach to estimate capitalization for houses in Connecticut and Massachusetts. They also include zip-code level averages of political party affiliations as controls for area-wide openness to solar. They find evidence suggestive of solar being fully capitalized into house prices at the time of the average house sale.

Finally, Gillingham and Bollinger (2021) study a program intended to encourage adoption of residential solar in Connecticut, called Solarize CT. Solarize is a community-level campaign where municipalities choose an installer. Installers bid using a discount group price, and there are 20 weeks of community outreach through primarily “solar ambassadors”. Using a “rolling difference-in-differences” identification strategy, the authors find a causal effect of 37 additional solar installations per municipality when it is subject to the Solarize CT program. While the Solarize CT program is implemented in 53 municipalities in a difference-in-differences framework, care needs to be taken when defining the control group of municipalities. The authors use a propensity-score matching approach to address this potential concern, which strengthens the plausibility of their causal estimates. The Gillingham and Bollinger (2021) approach of using the Solarize CT program as part of their identification strategy motivates our use of this program as a treatment variable in a difference-in-differences framework. This approach is discussed further below in the Data and Methodology section.

The gaps in the prior, distinct literatures for solar impacts on house prices, and the differences in willingness to pay of investors, motivates our hypothesis that synthesizes these two strands. Specifically, we hypothesize that investors value solar properties to a greater extent than non-investors, since solar installations can be a signal of higher quality related to house characteristics that may be unobservable to the buyer.

The remainder of this paper is structured as follows. Section II details the datasets and methods used in our analysis. Section III presents the empirical results. Section IV summarizes our findings and offers some suggestions for future research.

II. Data and Methodology

One of our primary data sources is the Warren Group, which contains the full population of real estate transactions in the state of Connecticut. We merge this data with proprietary data on solar installations in Connecticut, which is from the Connecticut Green Bank (CGB). Our base sample spans 2006 to 2022 and contains approximately 540,000 total transactions, of which 5,471 had solar installations at the time of sale. Robustness analyses require use of data for days on the market from the Multiple Listing Services (MLS) by CoreLogic. The MLS dataset merged with the Warren dataset spans 2006 to 2019 and contains approximately 300,000 observations, including 1,110 with solar, due to data and merging limitations.

The base sample merges the Warren Group data with the solar installations data. Investors are determined by examining the buyer and seller fields and identifying strings associated with institutional investors (such as LLC, INC, CO, and others), as well as by individual names that are involved in three or more transactions in the entire sample period (2006 to 2021). This approach to classifying investors is similar to Cohen and Harding (2021). The data from these different sources are merged by address fields. All regression analyses include quarter fixed effects and either census tract or ZIP code fixed effects to account for temporal and spatial variation, as well as clustering standard errors at the tract level or using robust standard errors. To eliminate non-arm's length transactions, we drop observations with a transaction price less than $10,000. To reduce the effects of outliers, the sample is restricted to properties with less than 10 bedrooms, less than 30 total rooms, built after the year 1500, and interior/lot size greater than 500 square feet.

The dependent variable of interest is the log of sale price of the property. By identifying investor buyers and sellers and creating indicator variables for them, we follow Harding, Rosenthal and Sirmans (2003) and construct the bargaining effect (*investor seller - investor buyer*) and the demand effect (*investor seller + investor buyer*). The bargaining effect represents the bargaining advantage that investors have over non-investors in real estate transactions and the demand effect represents the investors' willingness-to-pay for unobserved characteristics of a property. A key assumption of the model is that buyers and sellers of the same type (investor or non-investor) have the same preferences and bargaining power.

The control variables include the number of bedrooms, the number of bathrooms, the total rooms, the size of the lot, the size of the interior, the age of the property, an indicator for whether the solar installation is part of the Solarize CT initiative, and an indicator for whether the solar installation is leased. The baseline model we estimate is as follows:

$$log(price)_i = \alpha + \beta_1 \, Solar_i + \beta_2 \, (InvestorSeller_i - InvestorBuyer_i) + \beta_3 \, (InvestorSeller_i + InvestorBuyer_i) + \beta_4 \, Solar \; x \; (InvestorSeller_i - InvestorBuyer_i) + \beta_5 \, Solar \; x \; (InvestorSeller_i + InvestorBuyer_i) + \gamma \, X_i + TractFE + QuarterFE + \varepsilon_i \quad (1)$$

Here, *Solar* is an indicator variable for whether the property had a solar installation at the time of sale. The bargaining effect is defined as the difference between the indicator variables *InvestorSeller* and *InvestorBuyer* (a higher bargaining effect indicates that investors have superior bargaining ability), while the demand effect is defined as the sum of the indicator variables, *InvestorSeller* and *InvestorBuyer* (a higher demand effect indicates that investors are willing to pay more for unobserved characteristics). The *InvestorSeller* variable is equal to one if the seller is a professional or individual investor, while the *InvestorBuyer* variable is similarly defined for the buyer. X_i represents a matrix of hedonic regression control variables. *TractFE* and *QuarterFE* are, respectively, fixed effects for the census tract of the sale's underlying property and the quarter in which it was sold.

Control variables used in each specification include the number of bedrooms, the number of bathrooms, the total number of rooms, the total lot size, the interior square footage, and an indicator for whether the solar installation is leased. We define an installation as leased if its solar incentive type is listed as “Performance Based Incentive” or PBI. In contrast, installations designated with “Expected Performance Based Buydown” or EPBB have a one-time incentive payment and are not leased. Regarding investor interest in solar leases, of the 613 transactions with solar and an investor seller, 485 are leased, while of the 321 transactions with solar and an investor buyer, 255 are leased. These numbers do not differ significantly from that of non-investors, which indicates that the incentive to sell energy back to the grid is not likely to entice investors to pay more for homes with solar compared to non-investors.

The breakdown of property transactions with solar at time of sale is shown in Table 1. Out of 5,471 transactions, 934 have an identifiable investor buyer, investor seller, or both: 541 have an investor seller only, 249 have an investor buyer only, and 72 transactions have both an investor buyer and seller. We define an institutional investor using the buyer and seller name strings in the Warren dataset while pinpointing specific substrings associated with institutional investors and an individual investor as one involved in three or more transactions as a buyer or three or more transactions as a seller, similar to the approach of Cohen and Harding (2021). We observe that solar installations are not uncommon, and investors are involved in many transactions of properties with solar installations; however, the majority of transactions involving solar properties do not have identifiable investor buyers or sellers.

Table 2 shows the summary statistics for the log price, bargaining and demand effects (as defined in the previous sections), and control variables for sales with solar and without solar. Given the number by which sales without solar outnumber sales with solar, the variation for these solar-free transactions is greater, ranging from 1.25x to 1.5x in magnitude. The mean values for these control variables do not differ significantly between sales of properties with solar and sales of properties without solar. However, the proportion of investor buyers and investor sellers are lower for sales of properties with solar, which supports the notion that homeowners who install solar panels are less likely to put their properties up for sale.

III. Empirical Findings

We provide further evidence for investor preferences for solar properties in our regression analyses. The baseline results are shown in Table 3. This specification includes robust standard errors as well as quarter and census tract fixed effects. In line with prior studies (e.g., Hayunga and Munneke, 2021), the bargaining effect is positive which implies investors exhibit more bargaining power and receive higher transaction prices, and the demand effect is negative which implies that transactions involving investors tend to be associated with lower willingness to pay for unobserved quality; these two effects in concert form the influence investors have on transaction prices. In other words, if the transaction involves both an investor buyer and an investor seller, the transaction price decreases by a factor of about 35%, as the demand effect changes from 0 to 2 without affecting the bargaining effect. The presence of solar at time of sale increases the transaction price by about 4.5%. Furthermore, the impact of solar on the bargaining effect is minimal, but it has a mitigating impact on the demand effect; about 20% to 25% of the base demand effect is attenuated when the property has solar at the time of sale. In other words, when solar installations are present, unobserved quality that other variables do not account for reduces the price by a factor of only 15% when both an investor buyer and investor seller are present. This result indicates that properties with solar are associated with a higher willingness to pay for quality of unobservable characteristics when investors are involved in the transaction, compared to properties without solar. In other words, these results provide some evidence that investors value solar installations to a greater extent than non-investors. The presence of solar is a strong signal of unobserved quality to investors.

We also test if the coefficients for the demand effect and the demand effect's interaction terms with solar offset each other. In other words, does the presence of solar offset the investors' reduced demand for unobserved characteristics? A Wald test for whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction results in an F-statistic of 84.81, or a p-value < 0.01. This result provides evidence that the presence of solar does not completely account for the discrepancy in demand and willingness to pay between investors and non-investors. We perform this test for other specifications without significant differences.

Alternative Specifications

In further analyses, we use installer fixed effects in lieu of a leased indicator to control for installation ownership (Table 4). Solar panel installers have a tendency to specialize in either leasing solar panels or not leasing them. Because installer fixed effects perfectly predict the solar indicator, the latter is excluded from the model specification in Table 4. The magnitude and significance of the demand effect and its interaction with solar installations remain close to the baseline model, with the respective reverse-log-transformed coefficients at approximately -0.1864 and 0.044, respectively. We also consider the robustness of our results to using log lot size, log interior square footage, and log of age, opposed to the linear versions, with the results in Table 5. Both the demand effect and its interaction with solar are mitigated slightly in magnitude (-0.1791 and 0.036 respectively), but they remain significant.

As an alternative to using robust standard errors, we also consider robustness of clustering by census tract and using quarter and ZIP code fixed effects, with these results in Table 6. This alternative specification results in slightly increased magnitudes for the demand effect and its interaction with solar; they increase to -0.1959 and 0.0599 respectively.

The Impact of Solarize Connecticut

We include an indicator variable for whether the installation was a part of the Solarize Connecticut programs, which are campaigns that petition an installer to provide a group discount and invite homes to install photovoltaics through peer effects. Gillingham and Bollinger (2021) document that Solarize CT programs increase the solar installation rate in municipalities; they also find that installation costs are reduced as well. The results are shown in Table 7. These programs do not directly affect the sale price of the property, but they can mitigate the demand effect by as much as 80%. In this case, the base coefficient for the demand effect remains similar to those of previous specifications, at around -0.1864. Moreover, the demand effect's interaction with solar is weakened to 0.0372, which indicates that some of the impact solar has on the willingness to pay for unobserved quality is attributed to the Solarize CT program. Thus, there exists a price premium for the presence of Solarize CT in investors' eyes, even when accounting for the base effect of a solar installation.

Robustness Tests

Some observations in our dataset are missing information in the "use code" field, which designates the category that the property falls in (e.g., single-family residence). While we exclude observations for condominiums and other non-residential properties, we do not categorically exclude these categories. Including the observations that are missing use-codes could confound the analysis. To account for the potential influence of properties that are not single-family homes, we restrict our analysis to include only use codes associated with single-family homes. These results are tabulated in Table 8. This restriction results in a loss of fewer than 1,000 property sales. Moreover, the magnitude of the demand effect and its interaction with solar are bolstered slightly (-0.1902 and 0.0472 respectively).

Time on the Market and New Roof Installations

In auxiliary analysis of days on the market, we use the days on market measure to construct the "theta" (i.e., θ) market measure from Carrillo (2013), which measures whether the market favors buyers or sellers for a given time period and location. Including the Carillo (2013) "theta" measure in the regressions in equation (1) helps to account for local real estate market conditions at a given point in time. A higher θ indicates a buyers' market, while a lower θ implies a seller's market. The θ measure ranges from 0 to 1 and is defined as:

$$\theta = [1 + \kappa^{d}(1 - \kappa^{d})^{-1} \exp[(\lambda^{q})(\kappa^{ps} - \kappa^{pm})(\kappa^{d})^{-1}] [(1 - \kappa^{d})(1 - \kappa^{d} + r\kappa^{T})^{-1}]\text{^}[1 + (1 - \kappa^{d})(r\kappa^{T})^{-1}]]^{-1} \quad (4)$$

In equation (4), $\kappa^{ps} - \kappa^{pm}$ is the difference between mean log listing prices and mean log sale prices, κ^{d} is the proportion of transactions that occurred below the listing price, κ^{T} is the mean number of days a property is on the market, r is the daily discount rate, and λ^{q} is a structural parameter for the responsiveness of buyers to shifts in listing prices. All means are taken over quarter and two-digit ZIP. Following Carrillo (2013), we set r equal to .0001 and λ^{q} equal to 1.

The results that control for this θ measure and other renovations to the property (remodels, new electrical installations, and a new heat pump) are shown in Table 9. In this more limited sample, we observe that the magnitude of the demand effect remains significant and mostly unchanged from the prior analyses at -0.2034. However, the mitigating effect of the presence of solar has increased significantly to 0.1552, or around 60 to 65% of the demand effect's magnitude. We repeat the analysis from Table 7 using participation in the Solarize CT programs for this dataset in Table 10. We see here that the demand effect and its interaction with the solar indicator are largely unchanged in magnitude from the prior analysis (-0.2034 and 0.1547 respectively), but the effect of the Solarize CT program on the demand effect has disappeared entirely. This change is likely due to the low population of participants in the matched MLS dataset.

Furthermore, the MLS dataset also contains information regarding changes made to the property, including updates, remodeling, new electrical installations, heat pumps, and new roofing. The analysis including this additional information is in Table 11. We find that the demand effect has increased in magnitude compared to the baseline without the additional MLS data, to approximately -0.2098, or 10 - 15% higher in magnitude than the baseline coefficient in Table 3. However, the interaction of the new roof indicator with the demand effect, as well as the interaction of solar with the demand effect, are positive and significant. This implies that part of the demand effect in the larger sample without the roofing update information could include this information as part of its unobserved characteristics. This is one possible mechanism for explaining the demand effect. In other words, non-investors are less willing to pay for houses with unobserved differences in quality, but investors are more likely to be aware of roofing replacements at the time of solar installation. Furthermore, these roofing replacements could indicate to investors that the property is high-quality irrespective of other known characteristics, implying a strong signal of the property's overall quality.

Symmetry

A key aspect of identifying the bargaining power and demand effect for investors is the assumption that buyers and sellers of this type are the same in these aspects; this is the symmetry assumption in HRS. Next, we explore the robustness of the interaction between solar and the bargaining and demand effects to changes in the balance. We shift the bargaining power and demand of investor sellers compared to investor buyers. To change the bargaining symmetry assumption, we change the measure of the bargaining effect to (*m * investorseller – investorbuyer)*, where *m* is a varying multiplier that affects whether buyers or sellers have increased bargaining power. Likewise, the demand effect changes to (*m * investorseller + investorbuyer)*.

We present the coefficients and t-statistics for the interactions with solar in the tables in Appendix Table A1 and A2. The coefficient of the solar interaction with the bargaining effect is reduced in magnitude as the bargaining power multiplier shifts from 1x, but the t-statistic remains constant. However, the coefficient of the solar interaction with the demand effect becomes less significant as the bargaining power multiplier increases; the coefficient becomes insignificant at the 5% level after the multiplier exceeds 3x (meaning investor sellers have more than triple the bargaining power than investor buyers). Shifting the demand multiplier does not change the significance of the coefficient of the solar interaction with the demand effect, but it reduces the magnitude of the coefficient as the multiplier moves away from 1x. The coefficient of the solar interaction with the bargaining effect remains insignificant.

One key control variable for real estate transaction pricing hedonic regressions is the days on the market between the “for sale” listing date and the sale closing date of the property. For most properties, the longer the property is listed, the lower the final selling price. However, one reason a property can be listed for many days is that the listing price is too high (Taylor, 1999). We address this simultaneous determination problem using an instrumental variables approach pioneered by Turnbull and Dombrow (2007). The two instrumental variables we use are measures of *competitiveness* and *listing density*, as proposed by Turnbull and Dombrow (2007). In theory, *competitiveness* accounts for the number of competing properties for sale within the same time frame and location. Empirically, the competitiveness measure for a house is an average of how long each competing house overlaps with the given house, inversely weighted by the distance between the two houses:

$$COMP_i = \Sigma_j [(1 - D(i,j))^2 O(i,j)]$$

Here, the summation is taken over all competing houses j within 1 mile of the given house i. $D(i,j)$ is the distance in miles between houses i and j. $O(i,j)$ is their overlap in days on the market:

$$O(i,j) = max[min[s(i), s(j)] - max[l(i), l(j)] + 1 , 0]$$

The sold date and listing date for i are $s(i)$ and $l(i)$ respectively.

The listing density measure is the competitiveness measure scaled by the days on market of the subject property:

$$LDensity_i = COMP_i [s(i) - l(i) + 1]^{-1}$$

The Warren Group dataset is based on assessor data that does not contain information on days on the market data for sales, therefore we merge in the Multiple Listing Services (MLS) data from CoreLogic, leading to a smaller sample size of just under 300,000 observations. Moreover, it is possible that realtors do not add full details to the listings in this data, which leads to the potential for missing data.

We compute the above measures by municipality and run a three-stage-least-squares regression, with results in Appendix Table A3 and A4. The first-stage equation, for the days on market, is given as:

$$log(DaysOnMarket)_i = \alpha + \beta_1 Solar_i + \beta_2 (InvestorSeller_i - InvestorBuyer_i) + \beta_3 (InvestorSeller_i + InvestorBuyer_i) + \beta_4 Solar\ x\ (InvestorSeller_i - InvestorBuyer_i) + \beta_5 Solar\ x\ (InvestorSeller_i + InvestorBuyer_i) + \beta_6 LDensity_i + \gamma X_i + TractFE + QuarterFE + InstallerFE + \varepsilon_i \quad (2)$$

The results for the days on the market regression are shown in Appendix Table A3. We observe that the days on market are positively impacted by more competition, which validates competitiveness as a relevant instrument. The specification for sale price is shown in equation (3):

$$log(price)_i = \alpha + \beta_1 Solar_i + \beta_2 (InvestorSeller_i - InvestorBuyer_i) + \beta_3 (InvestorSeller_i + InvestorBuyer_i) + \beta_4 Solar\ x\ (InvestorSeller_i - InvestorBuyer_i) + \beta_5 Solar\ x\ (InvestorSeller_i + InvestorBuyer_i) + \beta_6 COMP_i + \gamma X_i + TractFE + QuarterFE + InstallerFE + \varepsilon_i \quad (3)$$

The transaction price results are given in Table A4. As anticipated, the days on the market negatively impacts the selling price: a 1% increase in days on the market decreases the selling price by a factor of .012%, on average. However, the demand effect and its interaction with solar installations remains similar in magnitude and significance to our results shown in Table 11. That is, both solar installations and a new roof increase investor willingness to pay for unobserved quality.

IV. Conclusion

Residential solar can offer investors additional return by capitalization of future net benefits. Investors may also have experience in transacting houses with solar, compared with individuals who are owner-occupiers. In this paper, we test the hypothesis that investors' willingness to pay for houses with solar is different than for houses without solar. We also test the hypothesis that solar is a signal for higher unobserved quality, based on investors' willingness to pay for characteristics that are not always easy to visualize (such as a new roof or new electrical systems). A quasi-experiment, using data on a solar program called Solarize CT, enables us to explore the relationships between residential solar locations and investor ownership of single-family housing in Connecticut during the period of 2006-2021.

In summary, though investors value unobserved qualities less than non-investors, the presence of rooftop solar installations brings the valuations of these two groups closer together. In this respect, investors generally place more value on solar installations than non-investors. Though investors generally buy for less and sell for more compared to non-investors, the presence of solar installations does not significantly impact this gap. Moreover, the presence of a new roof attenuates the demand effect mitigation attributed to solar, which provides evidence of the mechanism of how solar installations can be a signal to investors of quality.

Additional research is needed in this area, to consider how Solarize campaigns in other parts of the country might have a differential impact on single family housing investors. There could be parallels to other real estate classes as well, such as industrial, apartments, and office buildings. For instance, depending on the differences in the holding periods for houses versus commercial properties, the willingness to pay for unobserved quality might be different. Also, quality might be much more difficult to observe in a skyscraper than a ranch house, for instance, so perhaps the marginal benefits of solar for illuminating the extent of unobserved quality are different for these two types of properties. The Solarize data could allow for such analyses in future work.

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Table 1: Sample of Solar Properties with Investor Buyers and/or Sellers

	Non-Inv. Seller	Inv. Seller	Total
Non-Inv. Buyer	4,609	541	5,150
Inv. Buyer	249	72	321
Total	4,858	613	5,471

This table divides all property transactions with solar installations at time of sale into whether they have an investor buyer or an investor seller. Investors are identified using the name string or if an individual is involved in three or more transactions as a buyer or three or more transactions as a seller.

Table 2: Summary Statistics for Properties with and without Solar at Time of Sale

	Properties With Solar			**Properties Without Solar**		
Variable	**Obs**	**Mean**	**SD**	**Obs**	**Mean**	**SD**
Log Price	5,471	12.6540	0.5600	535,964	12.5207	0.7856
Bedrooms	5,471	3.3045	0.7827	535,964	3.3051	0.9303
Bathrooms	5,471	2.2036	0.9224	535,964	2.1049	0.9985
Total Rooms	5,471	6.9505	1.7327	535,964	7.0096	2.0106
Lot Size (tsf)	5,471	44.6987	93.2468	535,964	43.0791	133.3028
Interior (tsf)	5,471	1.9085	0.9034	535,964	1.9219	1.2721
Investor Buyer	5,471	0.0587	0.2350	535,964	0.1179	0.3225
Investor Seller	5,471	0.1120	0.3155	535,964	0.2468	0.4312
Bargaining Effect (IS - IB)	5,471	0.0534	0.3763	535,964	0.1289	0.5023
Demand Effect (IS + IB)	5,471	0.1707	0.4098	535,964	0.3647	0.5723
Solar Lease	5,471	0.7724	0.4193			
Solarize CT	5,471	0.0451	0.2076			

This table shows summary statistics for log price and key covariates for all property transactions with solar at time of sale. Lot size and interior are given in thousands of square feet. *Investor Buyer* and *Investor Seller* are indicator variables for whether the transaction included an investor buyer and an investor seller respectively. *Bargaining Effect* is defined as the difference between the *Investor Seller* and *Investor Buyer* variables. *Demand Effect* is defined as the sum of the *Investor Seller and Investor Buyer* variables. *Solarize CT* is an indicator for whether the solar installation was part of one of the Solarize Connecticut programs. *Leased* is an indicator for whether the solar installation was leased, as opposed to purchased.

Table 3: Quarter and Census Tract Fixed Effects and Robust Standard Errors

Log Price	**Coefficient**	**SE**
Bargaining Effect	0.0520***	0.0015
Solar	0.0449***	0.0126
BE x Solar	-0.0054	0.0167
Demand Effect	-0.1864***	0.0014
DE x Solar	0.0433**	0.0178

This table looks at the impact of solar installations on the demand and bargaining effects and property transaction prices. The number of transactions is 541,409 and covers all arm's-length transactions in Connecticut from 2006 to 2023. The *adjusted R-squared* is .719. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, and an indicator variable for whether the solar installation is leased, rather than owned. This specification includes quarter and census tract fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 84.81 and a p-value below .0001, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 4: Quarter, Census Tract, and Installer Fixed Effects, and Robust Standard Errors

Log Price	**Coefficient**	**SE**
Bargaining Effect	0.0520***	0.0015
BE x Solar	-0.0110	0.0169
Demand Effect	-0.1864***	0.0014
DE x Solar	0.0442**	0.0170

This table looks at the impact of solar installations on the demand and bargaining effects and property transaction prices. The number of transactions is 541,389 and covers all arm's-length transactions in Connecticut from 2006 to 2023. The *adjusted R-squared* is .719. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, and the age of the property. The base solar indicator is excluded due to collinearity with the installer fixed effects. This specification includes quarter, census tract, and installer fixed effects and robust standard errors. Because installer fixed effects are included, the base effect of solar is excluded. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 92.70 and a p-value below .0001, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 5: Log Controls, Quarter and Census Tract Fixed Effects, and Robust SE

Log Price	Coefficient	SE
Bargaining Effect	0.0467***	0.0014
Solar	0.0220*	0.0122
BE x Solar	-0.0010	0.0165
Demand Effect	-0.1791***	0.0013
DE x Solar	0.0362**	0.0177

This table looks at the impact of solar installations on the demand and bargaining effects and property transaction prices. The number of transactions is 540,570 and covers all arm's-length transactions in Connecticut from 2006 to 2023. The *adjusted R-squared* is .7387. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the log lot size and log interior in thousands of square feet, the log age of the property, and an indicator variable for whether the solar installation is leased, rather than owned. This specification includes quarter and census tract fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 83.91 and a p-value below .0001, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 6: Quarter and ZIP Fixed Effects and Census Tract Clustered Errors

Log Price	Coefficient	SE
Bargaining Effect	0.0525***	0.0025
Solar	0.0461***	0.0145
BE x Solar	-0.0007	0.0171
Demand Effect	-0.1959***	0.0036
DE x Solar	0.0599***	0.0175

This table looks at the impact of solar installations on the demand and bargaining effects and property transaction prices. The number of transactions is 541,393 and covers all arm's-length transactions in Connecticut from 2006 to 2023. The *adjusted R-squared* is .704. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, and an indicator variable for whether the solar installation is leased, rather than owned. This specification includes quarter and ZIP code fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 85.69 and a p-value below .0001, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 7: Including Solarize Indicator, Quarter and Census Tract FE, and Robust SE

Log Price	**Coefficient**	**SE**
Bargaining Effect	0.0520***	0.0015
Solar	0.0470***	0.0135
BE x Solar	-0.0046	0.0172
Demand Effect	-0.1864***	0.0014
DE x Solar	0.0372**	0.0183
Solarize CT	-0.0292	0.0278
BE x Solarize CT	-0.0043	0.0732
DE x Solarize CT	0.1538*	0.0761

This table looks at the impact of solar installations on the demand and bargaining effects and property transaction prices. The number of transactions is 541,409 and covers all arm's-length transactions in Connecticut from 2006 to 2023. The *adjusted R-squared* is .719. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. *Solarize CT* is an indicator for whether the solar installation was part of a Solarize Connecticut program. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, and an indicator variable for whether the solar installation is leased, rather than owned. This specification includes quarter and census tract fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 86.48 and a p-value below .0001, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 8: Excluding Condo Use Codes, Quarter and Census Tract FE, and Robust SE

Log Price	Coefficient	SE
Bargaining Effect	0.0543***	0.0015
Solar	0.0402***	0.0127
BE x Solar	-0.0075	0.0167
Demand Effect	-0.1902***	0.0013
DE x Solar	0.0472**	0.0178

This table looks at the impact of solar installations on the demand and bargaining effects and property transaction prices. The number of transactions is 535,427 and covers all arm's-length transactions in Connecticut from 2006 to 2023. The *adjusted R-squared* is .7248. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, and an indicator variable for whether the solar installation is leased, rather than owned. This specification includes quarter and census tract fixed effects and robust standard errors and explicitly excludes sales with use codes specifying condominiums and non-residential properties. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 85.84 and a p-value below .0001, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 9: Using MLS Data, Including Theta Measure and Additional Controls, Quarter and Census Tract Fixed Effects, and Robust Standard Errors

Log Price	Coefficient	SE
Theta	-0.0844*	0.0500
Bargaining Effect	0.0347***	0.0018
Solar	0.0458***	0.0091
BE x Solar	-0.0462*	0.0284
Demand Effect	-0.2034***	0.0017
DE x Solar	0.1552***	0.0245

This table looks at the impact of solar installations and the Solarize CT programs on the demand and bargaining effects and property transaction prices while controlling for local real estate market conditions and additions to the subject property. The number of transactions is 299,832, because of the loss in transactions when merging with the MLS dataset, and covers arm's-length transactions in the state of Connecticut from 2006 to 2019. The *adjusted R-squared* is .7823. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Theta* is a measure of housing market heat spanning 0 to 1, aggregated at the 2-digit-ZIP and quarter level: a value closer to 1 indicates a market where buyers have more relative bargaining power over sellers, while a value closer to 0 indicates the reverse (Carrillo, 2013). *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, an indicator variable for whether the solar installation is leased, and if the property has had updates, remodeling, a new roof, new electrical installations, or a new heat pump. This specification includes quarter and census tract fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 11.57 and a p-value of .0007, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 10: Using MLS Data, Including Solarize CT Indicator and Additional Controls, Quarter and Census Tract Fixed Effects, and Robust Standard Errors

Log Price	**Coefficient**	**SE**
Bargaining Effect	0.0347***	0.0018
Solar	0.0467***	0.0092
BE x Solar	-0.0461	0.0288
Demand Effect	-0.2034***	0.0017
DE x Solar	0.1547***	0.0248
Solarize	-0.0117	0.0431
BE x Solarize	-0.0019	0.1340
DE x Solarize	-0.0003	0.1400

This table looks at the impact of solar installations and the Solarize CT programs on the demand and bargaining effects and property transaction prices while controlling for local real estate market conditions and additions to the subject property. The number of transactions is 299,832, because of the loss in transactions when merging with the MLS dataset, and covers arm's-length transactions in the state of Connecticut from 2006 to 2019. The *adjusted R-squared* is .7823. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. *Solarize CT* is an indicator for whether the solar installation was part of a Solarize Connecticut program. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, an indicator variable for whether the solar installation is leased, the theta measure of market heat, and if the property has had updates, remodeling, a new roof, new electrical installations, or a new heat pump. This specification includes quarter and census tract fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 11.40 and a p-value of .0007, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Table 11: Using MLS Data, Including New Roof Indicator, Quarter and Census Tract Fixed Effects, and Robust Standard Errors

Log Price	Coefficient	SE
Bargaining Effect	0.0271***	0.0019
Solar	0.0763***	0.0197
BE x Solar	-0.0472*	0.0284
Demand Effect	-0.2098***	0.0019
DE x Solar	0.1552***	.0242
New Roof	-0.0138***	0.0034
BE x New Roof	0.0636***	0.0059
DE x New Roof	0.1055***	0.0059

This table looks at the impact of solar installations and a new roof on the demand and bargaining effects and property transaction prices. The number of transactions is 299,832, because of the loss in transactions when merging with the MLS dataset, and covers arm's-length transactions in the state of Connecticut from 2006 to 2019. The *adjusted R-squared* is .7831. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. *New Roof* is an indicator for whether the property had a new roof at the time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, an indicator variable for whether the solar installation is leased, the theta measure of housing market heat, and if the property has had updates, remodeling, new electrical installations, or a new heat pump. This specification includes quarter and census tract fixed effects and robust standard errors. A Wald test of whether the demand effect coefficient is equal to the negative of the demand effect-solar interaction coefficient has an F-statistic of 14.29 and a p-value of .0002, indicating that the presence of solar does not completely account for the unobserved characteristics that reduce investor willingness to pay.

Appendix

Table A1: Relaxing the Bargaining Power Symmetry Assumption

Seller Bargaining Power Multiplier	Solar x Bargaining Coef.	Solar x Demand Coef.
0.125	-0.0012	0.0378**
0.25	-0.0022	0.0388**
0.5	-0.0036	0.0402**
1	-0.0054	0.0420**
2	-0.0036	0.0439**
3	-0.0027	0.0448*
4	-0.0022	0.0453*
5	-0.0018	0.0457*
6	-0.0016	0.0459*
7	-0.0014	0.0461*
8	-0.0012	0.0463*

This table presents the coefficients and T-stats for the solar interaction with the bargaining and demand effects depending on the multiplier applied to the seller's bargaining power compared to the buyer's. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. All specifications include control variables for the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, and an indicator for whether the solar installation is leased, rather than owned. All specifications include quarter and census tract fixed effects and robust standard errors.

Table A2: Relaxing the Demand Symmetry Assumption

Seller Demand Multiplier	Solar x Bargaining Coef.	Solar x Demand Coef.
0.125	0.0273*	0.0093**
0.25	0.0198	0.0168**
0.5	0.0086	0.0280**
1	-0.0054	0.0420**
2	-0.0194	0.0280**
3	-0.0264	0.0210**
4	-0.0307	0.0168**
5	-0.0335	0.0140**
6	-0.0355	0.0120**
7	-0.0370	0.0105**
8	-0.0381	0.0093**

This table presents the coefficients and T-stats for the solar interaction with the bargaining and demand effects depending on the multiplier applied to the seller's demand compared to the buyer's. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. All specifications include control variables for the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, and an indicator for whether the solar installation is leased, rather than owned. All specifications include quarter and census tract fixed effects and robust standard errors.

Table A3: Days on Market with Competitiveness and Listing Density (3SLS)

Log Days on Market	Coefficient	SE
Log Price	0.138	0.367
Competitiveness	0.372*	0.183
Solar	0.114	6.91
Bargaining Effect	-0.0407	0.522
BE x Solar	0.0656	12.00
Demand Effect	-0.0659	0.472
DE x Solar	0.0539	10.60
New Roof	-0.0217	0.856
BE x New Roof	-0.0506	1.818
DE x New Roof	0.0682	1.709

This table looks at the impact of solar installations and a new roof on the demand and bargaining effects and days on the market. These are the results of a 3SLS regression to simultaneously determine days on the market and sale price. The number of transactions is 300,491, because of the loss in transactions when merging with the MLS dataset, and covers arm's-length transactions in the state of Connecticut from 2006 to 2019. The *R-squared* is .766. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log days on market is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *COMP* is the competitiveness measure defined in Appendix II that measures the intensity of local housing market competition for each property. *LDensity* is the listing density measure obtained by dividing the competitiveness measure by the days on the market. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. *New Roof* is an indicator for whether the property had a new roof at the time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, an indicator variable for whether the solar installation is leased, the theta measure of housing market heat, and if the property has had updates, remodeling, new electrical installations, or a new heat pump. This specification includes quarter and ZIP fixed effects; census tract fixed effects are not used due to the large size of the model in the 3SLS framework.

Table A4: Log Transaction Price with Competitiveness and Listing Density; Quarter and ZIP Fixed Effects (3SLS)

Log Price	Coefficient	SE
Log Days on Market	-0.0121***	0.000784
Listing Density	-0.0202***	0.000884
Solar	0.079***	0.02
Leased x Solar	-0.0495*	0.0235
Bargaining Effect	0.0273***	0.00151
BE x Solar	-0.0473	0.0348
Demand Effect	-0.253***	0.00135
DE x Solar	0.170***	0.0308
New Roof	-0.0155***	0.00249
BE x New Roof	0.0615***	0.00528
DE x New Roof	0.108***	0.00496

This table looks at the impact of solar installations, days on the market, and a new roof on the demand and bargaining effects and property transaction prices. These are the results of a 3SLS regression to simultaneously determine days on the market and sale price. The number of transactions is 300,491, because of the loss in transactions when merging with the MLS dataset, and covers arm's-length transactions in the state of Connecticut from 2006 to 2019. The *R-squared* is .766. Three, two, and one asterisks respectively denote p-values of less than .01, .05, and .1. Log price is the dependent variable. The coefficients shown here have been transformed to reflect a marginal percentage change in the transaction price, rather than the log price. *Fitted DoM* is the fitted values for log days on market obtained from the first stage regression in Table A3. *Bargaining Effect* is the difference between an investor seller and investor buyer indicator variable. *Demand Effect* is the sum of an investor seller and investor buyer indicator variable. *Solar* is an indicator variable for whether solar installations were present at time of sale. *New Roof* is an indicator for whether the property had a new roof at the time of sale. Control variables include the number of bedrooms, the number of bathrooms, the total number of rooms, the lot size and interior in thousands of square feet, the age of the property, an indicator variable for whether the solar installation is leased, the theta measure of housing market heat, and if the property has had updates, remodeling, new electrical installations, or a new heat pump. This specification includes quarter and census tract fixed effects and robust standard errors. This specification includes quarter and ZIP fixed effects; census tract fixed effects are not used due to the large size of the model in the 3SLS framework.