Evidence of a Homeowner-Renter Gap for Electric Appliances

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ABSTRACT

This paper provides the first empirical analysis of the homeowner-renter gap for electric appliances. Using U.S. nationally representative data, the analysis shows that renters are significantly more likely than homeowners to have electric heat, electric hot water heating, an electric stove, and an electric dryer. The gap is highly statistically significant, prevalent across regions, and holds after controlling for the type, size, and age of the home, as well as for climate and household characteristics. The paper argues that this gap arises from the same split incentives that lead to the "landlord-tenant problem" and discusses the implications of the gap for an emerging set of policies aimed at reducing carbon dioxide emissions through building electrification.

Keywords: Electrification mandates, Natural gas bans, Electric-preferred building codes, Landlord-tenant problem, Principal-agent problem, Split incentives

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1. INTRODUCTION

There is a growing consensus that building electrification will play a crucial role in reducing carbon dioxide emissions. Several recent large-scale studies of the United States, for example, conclude that virtually all feasible pathways to decarbonization include widespread residential electrification (Larson et al., 2020; National Academies of Sciences, Engineering, and Medicine, 2021; Williams et al., 2021). Already many U.S. cities have banned natural gas for new homes in what the Wall Street Journal aptly describes as "a growing fight unfolding across America."[1]

While most of the academic literature and policy discussion surrounding building electrification emphasizes owner-occupied housing, this paper focuses on rental housing. In the United States, over one-third of homes are rented and these homes consume almost one trillion cubic feet of natural gas annually.[2] Moreover, the incentive issues which arise between landlords and tenants mean that the economics of rental housing is different from owner-occupied, and of considerable independent interest.

This paper provides the first empirical analysis of the homeowner-renter gap for electric appliances. Using U.S. nationally representative data, the analysis shows that renters are significantly more likely than homeowners to have electric heat, electric hot water heating, an electric stove, and an electric dryer. The gap is statistically significant at the 1% level for all four appliance

1. Blunt, Katherine, "Battle Brews Over Banning Natural Gas to Homes," *Wall Street Journal*, May 31, 2021.

2. U.S. DOE/EIA Residential Energy Consumption Survey, Energy Consumption and Expenditure Tables. Accessed online May 31, 2021.

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categories, prevalent across regions, and persists after controlling for the type, size, and age of the home, as well as for climate and household characteristics.

This gap likely arises from the same split incentives that lead to underinvestment in energy-efficiency. Researchers have long bemoaned the "landlord-tenant problem," pointing out that landlords have too little incentive to invest in energy-efficiency when their tenants pay the energy bills (Blumstein et al., 1980; Jaffe and Stavins, 1994; Gillingham et al., 2009; Allcott and Greenstone, 2012; Gillingham and Palmer, 2014; Gerarden et al., 2017).[3]

By the same argument, landlords tend to prefer electric appliances because they are less capital-intensive. Electric resistance heating is cheaper to install than a natural gas furnace, and electric dryers and electric hot water heaters are cheaper to install than natural gas.[4] Although in theory, the higher capital cost of natural gas appliances could be passed on in the form of higher rents, it can be difficult for landlords to effectively convey this type of information (Myers, 2020).

These findings are relevant for an emerging set of policies aimed at reducing carbon dioxide through building electrification. In California, more than 40 cities have passed measures prohibiting or restricting natural gas in new homes, and policymakers are retooling state building codes to favor all-electric homes.[5] In addition, the Biden administration announced in May 2021 its support for building performance standards and other initiatives aimed at building electrification.[6]

This paper is related to an existing literature on split incentives and energy-efficiency (Levinson and Niemann, 2004; Maruejols and Young, 2011; Davis, 2012; Gillingham et al., 2012; Krishnamurthy and Kriström, 2015; Aydin et al., 2019). These studies have tended to find that homeowners are more likely than renters to have energy-efficient technologies. For example, Gillingham et al. (2012) shows that California homeowners are 20 percent more likely than renters to have attic and ceiling insulation and Krishnamurthy and Kriström (2015) show that homeowners are more likely than renters to have energy-efficient appliances and other energy-efficient technologies using data from 11 OECD countries.[7]

This paper also contributes to a broader literature on energy consumption in rental housing. Best et al. (2021) shows that U.S. rental homes use 35% less electricity than owner-occupied homes, but that this negative unconditional effect turns into a positive 9% conditional effect after controlling for location, household, and appliance quantity characteristics. They attribute this positive conditional effect to lower energy-efficiency, behavioral factors like more television watching, differences in bill payment responsibilities, and increased reliance on electric space and water heating.

3. Blumstein et al. (1980) explains, "The economic benefits of energy conservation do not always accrue to the person who is trying to conserve. For example, if an apartment tenant pays the utility bill, the landlord has little incentive to make energy conserving improvements."

4. U.S. Department of Energy, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies," June 2018, reports equipment cost estimates for a variety of residential appliances. Across categories, there is a considerable cost premium for natural gas. For example, installed equipment costs for natural gas and electric furnaces are $2,240 and $1,200, respectively. Installed equipment costs for natural gas and electric dryers are $660, and $540, respectively. Finally, installed equipment costs for natural gas and electric hot water heaters are $2,450 and $1,100, respectively. These values reflect the typical models for 2020, but the cost premium for natural gas is similar in other years.

5. Mulkern, Anne C. "California is Closing the Door to Gas in New Homes," *Scientific American*, January 4, 2021.

6. Renshaw, Jarrett and Nichola Groom, "White House Announces Efforts to Curb Emissions in Buildings" *Reuters*, May 17, 2021.

7. More recently, this pattern has been documented in several additional datasets. Melvin (2018) uses data from the 2009 Residential Energy Consumption Survey to show that homeowners are more likely than renters to have wall insulation, multi-paned windows, weatherstripping, and other energy-efficient technologies. Souza (2018) uses data from a supplemental module of the 2011 American Housing Survey to show that homeowners are more likely than renters to have energy-efficient air conditioners, dishwashers, clothes washers, and other appliances.

The paper proceeds as follows. Section 2 describes the data and presents baseline evidence on electric appliances for homeowners and renters. Section 3 discusses alternative explanations and performs regression analyses with a large number of controls. Section 4 performs additional analyses distinguishing between tenant-pay and landlord-pay housing units, estimating models separately by housing type, and corroborating the main results with evidence from an alternative dataset. Section 5 concludes with a discussion of economic and policy implications.

2. BASELINE EVIDENCE

2.1 Data

The primary dataset for these analyses is household-level microdata from the 2015 Residential Energy Consumption Survey (RECS) from the U.S. Department of Energy.[8] These data are nationally representative of the United States' 83 million owner-occupied housing units and 43 million renter-occupied housing units. RECS provides rich household-level information about household appliances, as well as about household income and other characteristics. The RECS sample is selected using stratified sampling, so RECS sampling weights are used in all results.

The 2015 RECS has a total sample size of 5,686 households, with 3,928 homeowners and 1,758 renters. The analyses throughout exclude households if they do not have a particular category of appliance. Among homeowners, 97%, 100%, 99%, and 95% have heat, hot water, stove, and dryer, respectively. Among renters, the saturation rates are 93%, 100%, 98%, and 56%. Thus, in the regressions which follow the sample sizes for the four appliance categories are 5,428, 5,686, 5,622, and 4,750. In practice, excluding households without a particular category of appliance only substantively impacts the results for dryers.

2.2 Comparing Means

Figure 1 plots the percentage of U.S. homeowners and renters with four different categories of electric appliances. Across categories, renters are significantly more likely than homeowners to have electric appliances. The biggest gap is for electric heating. Whereas 49% of U.S. renters heat their homes primarily with electricity, only 29% of U.S. homeowners do the same. There is a considerable homeowner-renter gap for all four categories, with renters between 9 and 20 percentage points more likely to have electric appliances.

2.3 Results by U.S. Region

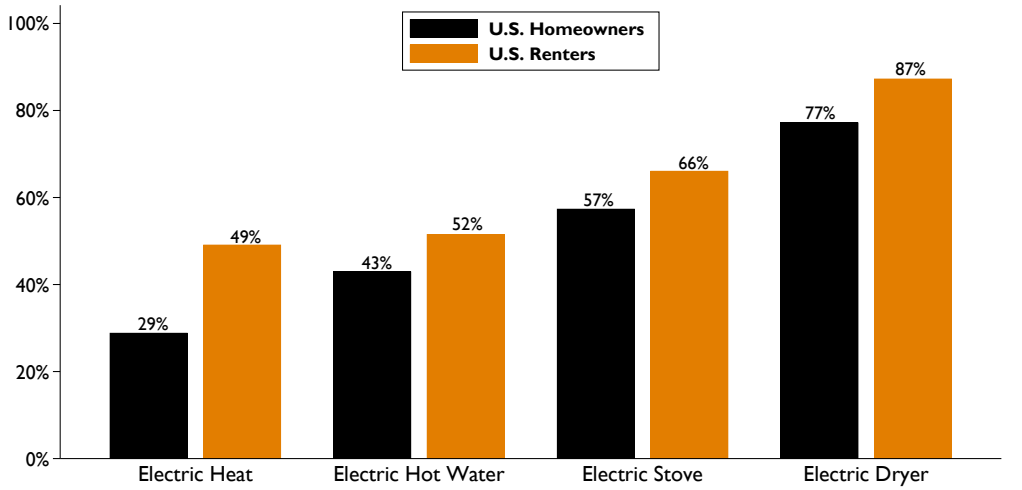
Table 1 presents estimates of the homeowner-renter gap for the entire U.S. and for the four Census regions. Estimates and standard errors are reported from twenty separate least squares regressions of the following form,

$$1(\text{Electric Appliance})_i = \alpha_0 + \alpha_1 1(\text{Renter})_i + \varepsilon_i. \quad (1)$$

In all regressions, the dependent variable 1(Electric Appliance) is an indicator variable equal to one if the household has an electric appliance of the category indicated in the panel head-

8. Data collection has been completed for the 2020 wave of the Residential Energy Consumption Survey but microdata from this wave have not yet been released. For details see https://www.eia.gov/consumption/residential/.

Figure 1: Evidence of a Homeowner-Renter Gap for Electric Appliances



Note: This figure was constructed using data from the 2015 Residential Energy Consumption Survey. Observations are weighted using RECS sampling weights.

Table 1: Evidence of a Homeowner-Renter Gap for Electric Appliances

	Entire United States (1)	Northeast Region (2)	Midwest Region (3)	South Region (4)	West Region (5)
			A. Electric Heating		
1(Renter)	0.20**	0.12**	0.22**	0.23**	0.22**
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
			B. Electric Hot Water Heater		
1(Renter)	0.09**	0.01	0.14**	0.14**	0.04
	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
			C. Electric Stove		
1(Renter)	0.09**	–0.05	0.17**	0.13**	0.09**
	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
			D. Electric Dryer		
1(Renter)	0.10**	–0.02	0.19**	0.06**	0.09**
	(0.01)	(0.06)	(0.03)	(0.01)	(0.03)

Note: This table reports estimates from twenty separate least squares regressions. The dependent variable is an indicator variable equal to one if the household has the electric appliance indicated in the panel heading. All regressions are estimated using data from the 2015 Residential Energy Consumption Survey (RECS). Observations are weighted using RECS sampling weights. In the full national sample in column (1) the number of observations in the four panels is 5,428, 5,686, 5,622, and 4,750, respectively. Robust standard errors are reported in parentheses. Single and double asterisks indicate estimates that are statistically significant at the 5% and 1% level, respectively.

ing. The table reports the coefficient α_1 corresponding to 1(Renter), an indicator variable for renters. This coefficient is the difference in electric appliance saturation between renters and homeowners, with a positive coefficient indicating that renters are more likely to have an electric appliance. For these results no additional control variables are included, so this is equivalent to a two-sample t-test.

The estimates reveal a pronounced homeowner-renter gap across appliances and regions. The national estimates are equivalent to the gaps presented in Figure 1. Point estimates range from 9 percentage points for electric hot water heaters and electric stoves, to 20 percentage points for elec-

tric space heating. Electric heating has the largest point estimate across all regions, ranging from 12 percentage points in the Northeast to 23 percentage points in the South. Across appliance categories point estimates tend to be smaller in the Northeast, and larger in the Midwest. Of the 20 estimates, 16 are positive and statistically significant at the 1% level.

3. ALTERNATIVE EXPLANATIONS

These results demonstrate a consistent pattern of renters being more likely to have electric appliances. This homeowner-renter gap likely arises from the same split incentives that lead to the landlord-tenant problem. As discussed in the introduction, landlords have too little incentive to make capital-intensive investments when their tenants pay the energy bills. Natural gas appliances are more expensive to purchase and install, so are eschewed by landlords much the same way as landlords are less likely to invest in energy-efficiency.

Before continuing, however, it is important to consider alternative potential explanations. For example, completely apart from the landlord-tenant problem, there is an economies-of-scale argument. Electric appliances tend to have lower capital costs but also higher operating costs, so they make the most sense for smaller homes, and for homes with fewer occupants where they get less use.[9] More generally, the homeowner-renter gap might reflect other compositional difference between homeowners and renters.

This section expands the regression analysis to include controls, X_i, aimed at distinguishing the landlord-tenant problem from these other potential explanations,

$$1(\text{Electric Appliance})_i = \beta_0 + \beta_1 1(\text{Renter})_i + \beta_2 X_i + \omega_i. \quad (2)$$

Table 2 reports estimates of β_1 from five difference specifications. Column (1) recreates the baseline estimates without controls, identical to the estimates in the first column of Table 1 and corresponding to the percentage gaps plotted in Figure 1. Column (2) controls for the type of home, number of bedrooms, number of bathrooms, and square footage. Column (3) adds controls for the age of the home.[10] Column (4) adds Census division fixed effects, heating degree days, and cooling degree days. Finally, column (5) adds household characteristics including the number of household members, household income, and race.

Flexible specifications are used for all controls. Type of home includes indicator variables for mobile home, single family detached, single family attached, apartment building 2–4 units, and apartment building 5+ units. Number of bedrooms and bathrooms include indicator variables for 1, 2, 3, 4, and 5+ bedrooms, and for 1, 2, and 3+ bathrooms. Square footage includes a cubic polynomial in estimated square footage. Age of home includes indicator variables for eight categories.

9. This tradeoff between capital costs and operating costs is a long-standing theme in economic models of energy demand (Hausman, 1979; Dubin and McFadden, 1984). Electric appliances tend to have significantly higher operating costs than natural gas. For example, according to the U.S. Department of Energy, "Energy Cost Calculator for Electric and Gas Water Heaters," a typical electric hot water heater costs $661 per year to operate compared to $263 per year for natural gas. This assumes 64 gallons per day average daily usage, energy factors of 0.93 for electricity and 0.62 for natural gas, and residential prices of $.13 per kilowatt hour for electricity and $1.04 per therm for natural gas.

10. Age of the home is potentially consequential because the percentage of U.S. homes heated with electricity has increased dramatically over time. Davis (2021) documents that that percentage of U.S. homes heated with electricity has increased steadily from 1% in 1950, to 8% in 1970, to 26% in 1990, and 39% in 2018. The paper finds that several factors contribute to this increased adoption of electric heating but that changing energy prices is by far the single most important factor, explaining two-thirds of the increase since 1950.

Table 2: National-Level Estimates After Adding Controls

	(1)	(2)	(3)	(4)	(5)
			A. Electric Heating		
1(Renter)	0.20**	0.13**	0.12**	0.09**	0.08**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
			B. Electric Hot Water Heating		
1(Renter)	0.09**	0.08**	0.07**	0.06**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
			C. Electric Stove		
1(Renter)	0.09**	0.07**	0.07**	0.06**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
			D. Electric Dryer		
1(Renter)	0.10**	0.08**	0.08**	0.07**	0.06**
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Type of Home	No	Yes	Yes	Yes	Yes
Num. of Bedrooms	No	Yes	Yes	Yes	Yes
Num. of Bathrooms	No	Yes	Yes	Yes	Yes
Square Footage	No	Yes	Yes	Yes	Yes
Age of Home	No	No	Yes	Yes	Yes
Census Division	No	No	No	Yes	Yes
HDDs and CDDs	No	No	No	Yes	Yes
HH Characteristics	No	No	No	No	Yes

Note: This table reports estimates from twenty separate least squares regressions. The dependent variable is an indicator variable equal to one if the household has the electric appliance indicated in the panel heading. All regressions are estimated using data from the 2015 Residential Energy Consumption Survey (RECS). Column (1) is identical to the national estimates reported in the first column of Table 1. The subsequent columns progressively add housing characteristics and additional controls, as described in more detail in the text. The number of observations in the four panels is 5,428, 5,686, 5,622, and 4,750, respectively. Observations are weighted using RECS sampling weights. Robust standard errors are reported in parentheses. Single and double asterisks indicate estimates that are statistically significant at the 5% and 1% level, respectively.

Census division includes indicator variables for the 10 categories. Heating degree days (HDDs) and cooling degree days (CDDs) include cubic polynomials in the 30-year average values. Household characteristics include indicator variables for households with 1, 2, 3, 4, and 5+ members, indicator variables for eight categories for household income, and indicator variables for six categories for race.

The homeowner-renter gap persists after adding these additional controls. Point estimates tend to get smaller as more controls are added, consistent with economies-of-scale and other explanations providing part of the explanation for why renters are more likely to have electric appliances. But the homeowner-renter gap remains large and statistically significant at the 1% level for all four appliances even with the full set of controls in column (5). Indeed, across the twenty point estimates in Table 2, all twenty are positive and statistically significant at the 1% level.

4. CORROBORATING EVIDENCE

4.1 Tenant Pay vs Landlord Pays Utilities

In these data, 88% of renters pay their own electricity bills, while 12% of renters live in homes where the electricity bill is included in the rent. When landlords pay utility bills there is no longer a split incentive problem for capital investments and one would expect landlords to be more

motivated to invest in equipment with low operating costs. Thus, comparisons between these two regimes can shed additional light on the behavioral mechanisms.

Table 3 presents estimates that distinguish between tenant-pay and landlord-pay. The underlying estimating equation is identical to equation (2), but replaces 1(Renter) with two separate indicators for rental homes that are tenant-pay and landlord-pay,

$$1(\text{Electric Appliance})_i = \delta_0 + \delta_1 1(\text{Tenant Pays Utilities})_i + \delta_2 1(\text{Landlord Pays Utilities})_i + \delta_3 X_i + \zeta_i. \quad (3)$$

The excluded category continues to be owner-occupied homes. Thus, the coefficient on 1(Tenant Pays Utilities) is the homeowner-renter gap for tenant-pay rental units, and the coefficient on 1(Landlord Pays Utilities) is the homeowner-renter gap for landlord-pay rental units. The table also reports p-values for a test of the null hypothesis that the two coefficients are equal.

The results are interesting. The twenty coefficients corresponding to 1(Tenant Pays Utilities) are very similar to the estimates in Table 2. This makes sense because the large majority of U.S.

Table 3: Tenant Pay vs Landlord Pay

	(1)	(2)	(3)	(4)	(5)
			A. Electric Heating		
1(Tenant Pays Utilities)	0.21**	0.12**	0.11**	0.08**	0.07**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
1(Landlord Pays Utilities)	0.10**	–0.01	0.03	0.03	0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
p-value for equal coefficients	.01	.00	.03	.20	.18
			B. Electric Hot Water Heating		
1(Tenant Pays Utilities)	0.10**	0.08**	0.07**	0.06**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
1(Landlord Pays Utilities)	–0.04	–0.05	–0.02	–0.01	–0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
p-value for equal coefficients	.00	.00	.03	.07	.09
			C. Electric Stove		
1(Tenant Pays Utilities)	0.10**	0.07**	0.07**	0.06**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
1(Landlord Pays Utilities)	–0.03	–0.06	–0.03	–0.03	–0.02
	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)
p-value for equal coefficients	.00	.00	.02	.04	.06
			D. Electric Dryer		
1(Tenant Pays Utilities)	0.10**	0.08**	0.07**	0.07**	0.06**
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
1(Landlord Pays Utilities)	0.14**	0.11**	0.12**	0.11**	0.11**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
p-value for equal coefficients	.29	.43	.23	.26	.17
Type of Home	No	Yes	Yes	Yes	Yes
Num. of Bedrooms	No	Yes	Yes	Yes	Yes
Num. of Bathrooms	No	Yes	Yes	Yes	Yes
Square Footage	No	Yes	Yes	Yes	Yes
Age of Home	No	No	Yes	Yes	Yes
Census Division	No	No	No	Yes	Yes
HDDs and CDDs	No	No	No	Yes	Yes
HH Characteristics	No	No	No	No	Yes

This table is identical to Table 2 except the estimating equation replaces 1(Renter) with 1(Tenant Pays Utilities) and 1(Landlord Pays Utilities). The former is an indicator variable for rental units in which the tenant pays utilities. The latter is an indicator variable for rental units in which the landlord pays utilities. The table reports p-values for a test of the null hypothesis that the two coefficients equal.

rental housing units are tenant-pay. All twenty estimates are positive and statistically significant at the 1% level.

In contrast, the coefficients on 1(Landlord Pays Utilities) have a less consistent pattern. For heating, hot water heating, and stove, the coefficients tend to be much smaller than the coefficients on 1(Tenant Pays Utilities), with many estimates close to zero. One would expect to see less of a split incentives problem with these landlord-pay units, and this appears to be the case.

For dryers the pattern is different, with larger point estimates for landlord-pay. This is not what was expected based on the split incentives problem, though it is worth pointing out that there are relatively few landlord-pay rental housing units with dryers, and the standard errors corresponding to 1(Landlord Pays Utilities) tend to be large relative to the point estimates.

4.2 Results By Building Type

In this section regressions are estimated separately by housing type, i.e., single-family detached, single-family attached, and multi-unit. Whereas the previous tables control for housing type, these regressions assess whether a homeowner-renter gap is present among each of these individual housing types. The RECS data has an additional category for mobile homes, but there were too few observations in that category to support a separate analysis.

Table 4 compares single-family detached owner-occupied homes with single-family detached renter-occupied homes. The point estimates in this table tend to be a bit smaller, perhaps because many single-family detached renter-occupied homes were initially built as owner-occupied homes. But of the 20 point estimates, all 20 are positive and 11 are positive and statistically significant at the 1% level, providing strong evidence of a homeowner-renter gap within detached single-family homes.

Table 4: Single-Family Detached Homes

	(1)	(2)	(3)	(4)	(5)
			A. Electric Heating		
1(Renter)	0.13**	0.10**	0.10**	0.07**	0.06*
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
			B. Electric Hot Water Heating		
1(Renter)	0.11**	0.07**	0.07**	0.06*	0.05*
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
			C. Electric Stove		
1(Renter)	0.05	0.04	0.04	0.03	0.03
	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)
			D. Electric Dryer		
1(Renter)	0.08**	0.06**	0.06**	0.05**	0.05*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Num. of Bedrooms	No	Yes	Yes	Yes	Yes
Num. of Bathrooms	No	Yes	Yes	Yes	Yes
Square Footage	No	Yes	Yes	Yes	Yes
Age of Home	No	No	Yes	Yes	Yes
Census Division	No	No	No	Yes	Yes
HDDs and CDDs	No	No	No	Yes	Yes
HH Characteristics	No	No	No	No	Yes

This table is identical to Table 2 except estimated using only single-family detached homes. The number of observations in the four panels is 3,658, 3,752, 3,725, and 3,601, respectively.

Table 5 compares single-family attached owner-occupied homes with single-family attached renter-occupied homes. This category includes duplexes and townhouses, and/or any single-family home which shares one or two exterior walls. This is a less common housing type and the sample sizes (reported in the table notes) are smaller. Nonetheless, with the exception of stoves,

Table 5: Single-Family Attached Homes

	(1)	(2)	(3)	(4)	(5)
			A. Electric Heating		
1(Renter)	0.18**	0.15**	0.17**	0.15**	0.15**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
			B. Electric Hot Water Heating		
1(Renter)	0.12*	0.12*	0.13*	0.12*	0.11*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
			C. Electric Stove		
1(Renter)	0.01	–0.02	–0.02	–0.03	–0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
			D. Electric Dryer		
1(Renter)	0.12*	0.13*	0.12*	0.10*	0.10
	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Num. of Bedrooms	No	Yes	Yes	Yes	Yes
Num. of Bathrooms	No	Yes	Yes	Yes	Yes
Square Footage	No	Yes	Yes	Yes	Yes
Age of Home	No	No	Yes	Yes	Yes
Census Division	No	No	No	Yes	Yes
HDDs and CDDs	No	No	No	Yes	Yes
HH Characteristics	No	No	No	No	Yes

This table is identical to Table 2 except estimated using only single-family attached homes, i.e. duplexes, townhouses and/or any single-family home which shares one or two exterior walls. The number of observations in the four panels is 457, 479, 476, and 429, respectively.

Table 6: Homes in Multi-Unit Buildings

	(1)	(2)	(3)	(4)	(5)
			A. Electric Heating		
1(Renter)	0.21**	0.23**	0.14**	0.09*	0.08
	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)
			B. Electric Hot Water Heating		
1(Renter)	0.05	0.11*	0.03	0.06	0.09
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
			C. Electric Stove		
1(Renter)	0.21**	0.24**	0.19**	0.17**	0.18**
	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)
			D. Electric Dryer		
1(Renter)	0.18**	0.21**	0.20**	0.20**	0.20**
	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
Num. of Bedrooms	No	Yes	Yes	Yes	Yes
Num. of Bathrooms	No	Yes	Yes	Yes	Yes
Square Footage	No	Yes	Yes	Yes	Yes
Age of Home	No	No	Yes	Yes	Yes
Census Division	No	No	No	Yes	Yes
HDDs and CDDs	No	No	No	Yes	Yes
HH Characteristics	No	No	No	No	Yes

This table is identical to Table 2 except estimated using only homes in multi-unit buildings i.e. condominiums and apartments. The number of observations in the four panels is 1,040, 1,169, 1,147, and 476, respectively.

the table provides strong evidence of a homeowner-renter gap, with 14 out of the 20 point estimates positive and statistically significant at the 5% level.

Finally, Table 6 compares multi-unit owner-occupied homes (i.e. condominiums) with multi-unit renter-occupied homes (i.e. apartments). This is a particularly interesting housing type because shared walls and vertical construction mean that the overall level of heating demand tends to be lower in these homes. Again, the results point to a considerable homeowner-renter gap. Of the 20 point estimates, all 20 are positive and 13 are positive and statistically significant at the 1% level.

4.3 Earlier Wave of Same Survey

A limitation of the 2015 RECS is the low response rate. This latest available wave of RECS had a response rate of 51%, compared to 79% in the previous wave in 2009. Survey documentation attributes this lower response rate to an increased reliance on self-administered surveys. The sampling weights provided by the survey designers attempt to correct for non-response by balancing observable household characteristics, but it is impossible to rule out concerns about unobserved differences between responders and non-responders.

This section corroborates the evidence on the homeowner-renter gap by estimating the same specifications using data from the 2009 RECS. In addition to providing reassurance that the results are not driven by non-response bias, the 2009 RECS is notable because it had a sample size more than twice as large as other waves. Replicating the results with data from the earlier wave also rules out potential lingering concerns about there being something idiosyncratic about that particular survey wave.

Table 7 presents regression evidence from specifications identical to Table 2, but estimated using the 2009 RECS. The point estimates tend to be a bit smaller. For example, the estimates for

Table 7: National-Level Estimates, 2009 RECS

	(1)	(2)	(3)	(4)	(5)
			A. Electric Heating		
1(Renter)	0.14**	0.06**	0.07**	0.05**	0.04**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
			B. Electric Hot Water Heating		
1(Renter)	0.04**	0.03	0.03	0.02	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
			C. Electric Stove		
1(Renter)	0.03**	0.05**	0.05**	0.05**	0.06**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
			D. Electric Dryer		
1(Renter)	0.10**	0.08**	0.08**	0.07**	0.07**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Type of Home	No	Yes	Yes	Yes	Yes
Num. of Bedrooms	No	Yes	Yes	Yes	Yes
Num. of Bathrooms	No	Yes	Yes	Yes	Yes
Square Footage	No	Yes	Yes	Yes	Yes
Age of Home	No	No	Yes	Yes	Yes
Census Division	No	No	No	Yes	Yes
HDDs and CDDs	No	No	No	Yes	Yes
HH Characteristics	No	No	No	No	Yes

Note: This table is identical to Table 2 except it is constructed using data from the previous wave of the Residential Energy Consumption Survey (RECS) conducted in 2009 rather than the most recent wave in 2015. The number of observations in the four panels is 11,637, 12,083, 11,991, and 9,724, respectively.

electric hot water heating are not as large or statistically significant. However, the general pattern is quite similar to the previous results from the 2015 RECS. Of the twenty estimates, 16 are positive and statistically significant at the 1% level, providing robust evidence of a homeowner-renter gap, and corroborating the evidence from the 2015 RECS.

5. CONCLUSION

Thus, the evidence shows that U.S. renters are significantly more likely than homeowners to have electric heat, electric hot water heating, an electric stove, and an electric dryer. This homeowner-renter gap is highly statistically significant, prevalent across regions, and persists after including a large set of controls, separately for different housing types, and for an earlier wave of the same nationally-representative survey.

This homeowner-renter gap has important economic and policy implications. First, this pattern suggests that renters pay higher appliance operating costs than homeowners. Although in theory these higher operating costs might be partially compensated via lower rents, evidence from Myers (2020) suggests that rents are relatively unresponsive to energy costs. Higher operating costs could have significant distributional consequences as renters have lower average income and lower average net worth (Bhutta et al., 2020).

Second, the homeowner-renter gap implies that rental homes have lower on-site consumption of natural gas, propane, and heating oil. In addition to the carbon dioxide impacts, this is significant because it means less local emissions of criteria pollutants. This also likely means less indoor air pollution, for example, from natural gas stoves (Lebel et al., 2022).

Third, the results imply that the U.S. rental housing stock is getting greener. Holland et al. (2020) find that emissions from U.S. power plants have decreased 45% since 2010. The rental housing stock relies relatively more on electricity, so its environmental impact has fallen over time relative to owner-occupied homes. Moreover, as U.S. electricity generation continues to move away from coal and towards renewables, this inclination toward electricity gives rental housing a significant environmental advantage.

Finally, the homeowner-renter gap implies that, from a political economy perspective, the pushback to electrification policies is more likely to come from homeowners than landlords or renters. Rental homes are already more likely to have electric appliances, so landlords and renters have less at stake when it comes to natural gas bans and other pro-electrification policies, and could even emerge as an ally when it comes to forming political coalitions to support building electrification.

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REFERENCES

Allcott, H. and M. Greenstone (2012). "Is There an Energy Efficiency Gap?" *Journal of Economic Perspectives* 26(1): 3–28. https://doi.org/10.1257/jep.26.1.3.

Aydin, E., P. Eicholtz, and R. Holtermans (2019). "Split Incentives and Energy Efficiency: Evidence from the Dutch Housing Market" *Working Paper*. https://doi.org/10.1016/j.jue.2020.103243.

Best, R., P. J. Burke, and S. Nishitateno (2021). "Factors Affecting Renters' Electricity Use: More Than Split Incentives." *The Energy Journal* 42(5). https://doi.org/10.5547/01956574.42.5.rbes.

Bhutta, N., J. Bricker, A.C. Chang, L.J. Dettling, S.F. Goodman, A.H. Volz, J.W. Hsu, K.B. Moore, S. Reber, R. Windle, et al. (2020). "Changes in U.S. Family Finances from 2016 to 2019: Evidence from the Survey of Consumer Finances." *Federal Reserve Bulletin* 106(5): 1–42. https://doi.org/10.17016/bulletin.2020.106.

Blumstein, C., B. Krieg, L. Schipper, and C. York (1980). "Overcoming Social and Institutional Barriers to Energy Conservation." *Energy* 5(4): 355–371. https://doi.org/10.1016/0360-5442(80)90036-5.

Davis, L.W. (2012). "Evaluating the Slow Adoption of Energy Efficient Investments: Are Renters Less Likely to Have Energy Efficient Appliances?" In *The Design and Implementation of U.S. Climate Policy*, University of Chicago Press 301–316. https://doi.org/10.7208/chicago/9780226921983.003.0020.

Davis, L.W. (2021). "What Matters for Electrification? Evidence from 70 Years of U.S. Home Heating Choices." *NBER Working Paper*. https://doi.org/10.3386/w28324.

Dubin, J.A. and D.L. McFadden (1984). "An Econometric Analysis of Residential Electric Appliance Holdings and Consumption" *Econometrica* 52(2): 345–362. https://doi.org/10.2307/1911493.

Gerarden, T.D., R.G. Newell, and R.N. Stavins (2017). "Assessing the Energy-Efficiency Gap" *Journal of Economic Literature* 55(4): 1486–1525. https://doi.org/10.1257/jel.20161360.

Gillingham, K., M. Harding, and D. Rapson (2012). "Split Incentives in Residential Energy Consumption." *The Energy Journal* 33(2): 37–62. https://doi.org/10.5547/01956574.33.2.3.

Gillingham, K., R.G. Newell, and K. Palmer (2009). "Energy Efficiency Economics and Policy." *Annual Review of Resource Economics* 1(1): 597–620. https://doi.org/10.1146/annurev.resource.102308.124234.

Gillingham, K. and K. Palmer (2014). "Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence." *Review of Environmental Economics and Policy* 8(1): 18–38. https://doi.org/10.1093/reep/ret021.

Hausman, J.A. (1979). "Individual Discount Rates and the Purchase and Utilization of Energy-using Durables." *Bell Journal of Economics* 10(1): 33–54. https://doi.org/10.2307/3003318.

Holland, S.P., E.T. Mansur, N.Z. Muller, and A.J. Yates (2020). "Decompositions and Policy Consequences of an Extraordinary Decline in Air Pollution from Electricity Generation." *American Economic Journal: Economic Policy* 12(4): 244–274. https://doi.org/10.1257/pol.20190390.

Jaffe, A.B. and R.N. Stavins (1994). "The Energy-Efficiency Gap What Does it Mean?" *Energy Policy* 22(10): 804–810. https://doi.org/10.1016/0301-4215(94)90138-4.

Krishnamurthy, C.K.B. and B. Kriström (2015). "How Large is the Owner-Renter Divide in Energy Efficient Technology? Evidence from an OECD Cross-Section" *The Energy Journal* 36(4): 85–104. https://doi.org/10.5547/01956574.36.4.ckri.

Larson, E., C. Greig, J. Jesse, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, et al. (2020). *Net-Zero America: Potential Pathways, Infrastructure and Impacts*. Princeton, New Jersey: Princeton University.

Lebel, E.D., C.J. Finnegan, Z. Ouyang, and R.B. Jackson (2022). "Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes." *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.1c04707.

Levinson, A. and S. Niemann (2004). "Energy Use by Apartment Tenants when Landlords Pay for Utilities." *Resource and Energy Economics* 26(1): 51–75. https://doi.org/10.1016/S0928-7655(03)00047-2.

Maruejols, L. and D. Young (2011). "Split Incentives and Energy Efficiency in Canadian Multi-Family Dwellings." *Energy Policy* 39(6): 3655–3668. https://doi.org/10.1016/j.enpol.2011.03.072.

Melvin, J. (2018). "The Split Incentives Energy Efficiency Problem: Evidence of Underinvestment by Landlords." *Energy Policy* 115: 342–352. https://doi.org/10.1016/j.enpol.2017.11.069.

Myers, E. (2020). "Asymmetric Information in Residential Rental Markets: Implications for the Energy Efficiency Gap." *Journal of Public Economics* 190: 104251. https://doi.org/10.1016/j.jpubeco.2020.104251.

National Academies of Sciences, Engineering, and Medicine (2021). *Accelerating Decarbonization of the U.S. Energy System*. The National Academies Press: Washington, DC, USA .

Souza, M. (2018). "Why are Rented Dwellings Less Energy-Efficient? Evidence from a Representative Sample of the U.S. Housing Stock." *Energy Policy* 118: 149–159. https://doi.org/10.1016/j.enpol.2018.03.013.

Williams, J.H., R.A. Jones, B. Haley, G. Kwok, J. Hargreaves, J. Farbes, and M.S. Torn (2021). "Carbon-Neutral Pathways for the United States." *AGU Advances* 2(1). https://doi.org/10.1029/2020AV000284.