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The Race Gap in Residential Energy Expenditures

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Abstract

Black households have higher residential energy expenditures than white households in the US. This residential energy expenditure gap persists after controlling for income, household size, homeowner status, and city of residence. It decreased but did not disappear between 2010 and 2017, and it is fairly stable in levels across the income distribution, except at the top. Controlling for home type or vintage does not eliminate the gap, but survey evidence on housing characteristics and available appliances is consistent with the gap being driven at least in part by differences in housing stock and related energy efficiency investments.

This paper provides estimates of the Black-white residential energy expenditure gap in the US. I use publicly available data from the American Community Survey (ACS) from 2010 to 2017 to show that annual residential energy expenditures – defined as the sum of expenditures on electricity, natural gas, and other home heating fuels – are both statistically and economically significantly higher for Black households than for white households.[1]

Unconditional differences in residential energy expenditures could be driven by many factors including regional variation in climates, prices, and public support for energy efficient investments; household variation in income, wealth, credit access, and home ownership; and local variation in housing stock. After controlling for year, income, household size, and city of residence, Black renters pay $273 more a year than white renters (16% of the sample average of $1,705), and Black homeowners pay $408 more a year than white homeowners (15% of the sample average of $2,649). Energy expenditures for both groups are decreasing between 2010-2017, and the conditional gap in annual expenditures decreases by about $150 for the average household, but continues to be economically significant at about $200 for renters and $310 for homeowners in 2017. The gap is fairly stable in levels across most income deciles, except it closes at the very top of the income distribution. Therefore, as a percent of income (and baseline residential energy expenditures), the gap is largest for low income households.

Given the long history of discriminatory housing policy, lending practices, and racial segregation in the United States, differences in housing stock and accumulated wealth are possible explanations for the remaining residential energy expenditure gap. Controlling for home type or vintage does not eliminate, or even significantly reduce, the gap. This may be because neither variable is a complete measure of housing quality. Evidence from the 2015 Residential Energy Consumption Survey (RECS) is consistent

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[1] Residential energy expenditures are distinct from transportation energy expenditures such as gasoline purchases. In 2019, residential energy use made up about 20% of energy consumption in the US, and transportation energy use made up about 30%. These two sectors are the largest sources of emissions from individual energy consumption, and understanding the energy expenditure gap in both sectors is crucial for assessing the impacts of possible climate policies. I leave the analysis of transportation energy expenditure gaps to future research.

with this interpretation: Conditional on income, Black households are more likely to report that their home is drafty. They also report fewer Energy Star qualified appliances and home features, and are less likely to have received a rebate or tax credit for having upgraded an appliance. These differences exist despite the fact that Black households in the RECS sample are just as (if not slightly more) likely to have gotten an energy audit.

This paper contributes to a growing body of work on energy burden. For example, Reames (2016), Bednar et al. (2017), and Kontokosta et al. (2020), find that energy burden is higher in high minority share neighborhoods than low minority share neighborhoods in a few cities across the US, and Hernández et al. (2014) study differences in energy insecurity by family characteristics, including race, in the 2011 ACS. Carley and Konisky (2020) review implications of these differences for a clean energy transition. The energy economics literature has to date focused on energy expenditure differences along other dimensions, especially income (e.g. Kolstad and Grainger (2010); Goulder et al. (2019)), and increasingly, geography (e.g. Cronin et al. (2016)). In terms of racial differences in burden from the current energy system, the focus has mostly been on differential exposure to resulting pollution. Research shows that Black people are much more likely to live near pollution point sources and be exposed to neighborhoods with higher particulate matter (e.g. US GAO, 1983; Tessum et al, 2019). Rothstein (2017) argues that disproportionate exposure to pollution is due to discriminatory siting of sources, and Christensen et al (2020) show evidence from an experiment that discrimination, which restricts housing choice sets, causes disproportionate sorting of Black families into neighborhoods near polluting point sources. Hausman and Stolper (2020) argue that hidden information about pollution, even when constant across all households, also leads to disproportionate sorting across neighborhoods because pollution is correlated with other disamenities.

More broadly, this paper builds on insights from a large body of work on the persistent effects of systemic racism on other outcomes. Black people have less wealth and are less likely to own homes (e.g. Rothstein, 2017), they are more likely to face high cost loans, even when controlling for credit score and other risk factors (e.g. Bayer et al, 2018), and they pay higher property taxes for the same home values (Avenancio-Leon and Howard, 2020). Aaronson et al. (2019) provide evidence that many of the above outcomes were meaningfully affected by the Home Owners' Loan Corporation (HOLC) redlining maps in the 1930s, which restricted credit access in Black neighborhoods. Beyond facing discrepancies in home prices, Hardey et al. (2018) show that Black Americans face higher year-to-year income volatility, and Ganong et al. (2020), show that as a result of wealth differentials, Black consumption is more sensitive to income shocks. These differences in wealth, home ownership, income volatility, and credit access all serve as potential barriers to living in higher quality, more energy efficient homes or to making necessary energy efficiency upgrades.

Tying these literatures together, this paper contributes to a broad set of evidence that Black Americans bear a disproportionate burden of the current energy system, both through disproportionate pollution exposure, and as I highlight, through disproportionate costs, likely at least in part as a result of persistent disparities in wealth and housing. In the remainder of this paper, I outline the data and methodology, present descriptive results, and discuss conclusions and next steps.

Data and Methodology

I use the American Community Survey (ACS) Public Use Microdata Sample from 2010 to 2017. The ACS is a nationally representative survey of about 1% of the US population every year. I restrict the sample to households that are either entirely Black or entirely white. I drop households with missing or negative income. I calculate residential energy expenditures as the sum of self-reported electricity expenditures, natural gas expenditures, and other home heating fuel expenditures, and I drop households whose residential energy bills are included in their rent payments or condo fees.[2] I deflate all dollar amounts to 2012 dollars using the consumer price index (CPI) from the Bureau of Economic Analysis (BEA), and express income in thousands of dollars. ACS household incomes and energy expenditures are censored at the 99.5th percentile by state-year, and I additionally censor household size at 10 people. After all restrictions, the pooled sample consists of 7,906,852 people. All estimates are weighted by the ACS's household weight. Black households make up 12.9% of the weighted sample.[3]

I compute unconditional and conditional annual residential energy expenditure gaps by regressing household residential energy expenditures on an indicator for household race, year fixed effects, and an increasing set of household controls:

$$y_{it} = \mathbb{1}[Black_i] + \tau_t + X_{it} + \epsilon_{it}$$

where y_{it} is annual household (i) energy expenditures, τ_t are year fixed effects, and X_{it} includes characteristics such as household income, size, and geographic characteristics. Residential energy expenditures do not actually increase linearly in either household income or household size, so I have also run these specifications controlling for household income deciles and household size dummies on the right hand side, as well as in log-log form. In both versions, level estimates and implied percentage gaps are very similar to those in my main specification, so I report the linear specifications for simplicity. I estimate specifications separately for renters and homeowners, as renters may face principal-agent problems that prevent them from making optimal energy efficiency investments. For estimates that include Metropolitan Statistical Area (MSA) fixed effects, I use a state fixed effect for observations where MSA is not identified. My preferred specification includes city fixed effects, which are the most granular geographic control I can add using the publicly available microdata sample. Since these are meant to be narrow geographies, I only include observations with an identified city. This decrease the sample size and changes the sample composition significantly: The city sample is 901,580 households (about 13% of the weighted full sample), and the weighted share of Black households in this sample is 27%. Errors are clustered at the state level in all specifications.

To understand residential energy expenditure patterns in more depth, I expand on my preferred specification to look at how annual expenditures have changed over time. I also compute income deciles for the full sample population each year, and look at how the gap differs across income deciles, and how that distribution has evolved between 2010 and 2017.

Lastly, I explore possible mechanisms. Continuing to use the ACS sample, I add flexible controls for home type (single-family detached, single-family attached, van or mobile home, 2-4 plex, 5+ unit apartment building) and home vintage (decade fixed effects) to test whether either of these variables reduces the gap. I also supplement my analysis with the 2015 Residential Energy Consumption Survey (RECS). RECS is administered by the Energy Information Administration every 4-6 years to a small, nationally representative set of housing units. RECS asks a detailed set of questions about energy use and investments through a combination of surveys and in-person interviews. I restrict the RECS sample to mirror sample restrictions in the ACS.[4] The final sample consists of 4,805 respondents, with Black respondents making up 12% of the weighted sample. I use RECS to test differences by race, conditional on income, in receipt of energy assistance and audits, self-assessed home quality, and availability of Energy

[2] This is 6% of white households and 9% of Black households after all other sample restrictions.

[3] This percentage is slightly increasing over the course of the sample, from 12.7% in 2010 to 13.2% in 2017.

[4] In RECS, I only know the race of the respondent, not everyone in the household. I keep only Black or white respondents. RECS reports incomes in 8 categories (in thousands: < 20, [20,40) [40,60), [60-80), [80-100), [100-120), [120-140), $\geq$140) and only reports Census Divisions for geography. I drop households whose residential energy bills are included in their rent (9% of white respondents and 14% of Black respondents in the weighted sample). Lastly, many of the questions asked by RECS allow respondents to answer "I don't know" or refuse to answer. I treat these answers as missing. I treat "N/A"s as "No"s, except for when estimating the share of Energy Star -rated appliances/features, in which case I treat "N/A"s as missing.

Star appliances and other energy-efficient home features. I also test differences in energy burden, as measured by whether a household reported reducing or forgoing on basic necessities to pay an energy bill, whether a household reported keeping the home at an unhealthy temperature in order to pay an energy bill, or whether a household received a disconnect notice due to inability to pay a bill. All estimates are weighted by RECS sample weights, and errors are clustered at the census division level.

Results

Evidence on Expenditures

Table 1 shows evidence from the ACS that there is a statistically and economically significant residential energy expenditure gap across Black and white households in the years 2010-2017.[5] Column (1) shows the unconditional mean difference: on average, Black households in my sample pay about $54 more a year in energy bills than white households do, although this unconditional difference is not significantly different from 0. The gap becomes statistically significant and economically meaningful after controlling for income (column 2): Black households pay about $193 more a year than white households do. This is 8% of the sample average annual expenditures. The gap persists with controls for household size (column 3), and is driven by both renters and homeowners (columns 4 and 5). The gap for homeowners is bigger in levels ($381 relative to $258), but as a percent of sample averages the gaps are comparable (14% for renters and 15% for homeowners). Accounting for sorting across climates by controlling for MSA (columns 6 and 7) decreases the gap somewhat for both renters and homeowners but it is still economically and statistically significant at 10% and 11% of average expenditures, respectively.[6]. Columns 8 and 9 add city fixed effects. This is my preferred specification because it most precisely controls for location-specific characteristics. Within the same cities, Black renters spend $273 more a year than white renters (16% relative to average), and Black homeowners spend $408 a year more than white homeowners (15% relative to average).[7] In Appendix Table A1, I report estimates for all specifications using just the city sample; they are significantly bigger than those in the full sample. This suggests that the large gap when I include city fixed effects is driven by the restriction of the sample to people living in cities, likely as a result of the fact that wealthy suburbs that use a lot of energy tend to be white.

Figure 1 shows that average energy expenditures conditional on income, household size, and city have decreased between 2010 and 2017 for both Black and white households. The conditional energy expenditure gap has also decreased in this period, by about $150 for the average household, although I cannot reject a constant gap over time.[8] In 2017 the gap remains significantly different from zero, at close to $200 a year for renters and $310 a year for homeowners.

Figure 2 shows that the gap is fairly stable in levels across income deciles, for both renters and homeowners, in 2010 and 2017, except at the very top of the income distribution where it closes. Given that energy expenditures are a larger share of lower-income households' consumption, this means energy burden is especially heightened for low income Black households.

[5] I have also analyzed the Black-white energy expenditure gap with the Consumer Expenditure Survey (CEX) and Residential Energy Consumption Survey (RECS). The patterns and orders of magnitude are broadly consistent. Both those surveys do not have as much geographic detail and so I exclude those results and focus on the ACS for brevity.

[6] Controlling more flexibly for weather by interacting MSA FEs with year FEs does not change these estimates

[7] Individual regressions of electricity costs, natural gas costs, and other home heating fuel costs suggest that the gap is driven by electricity and natural gas. If anything, Black households spend less on home heating fuel than white households do, but this difference goes to 0 within cities.

[8] A useful avenue for future work is to explore what has driven this decrease. Of particular interest could be the role of the American Recovery and Reinvestment Act of 2009, which directed significant funds into energy efficiency investments.

Possible Mechanisms

I first test whether the residential energy expenditure gap can be explained by differences in home type. Columns (1) and (2) of Table 2 show results. As expected, single-family detached homes have the highest energy expenditures, and apartments in large buildings have the lowest expenditures. However, controlling for home type does not decrease the gap for renters, and it only decreases the gap for home-owners by about $50 relative to the main specification. I next test whether the residential energy expenditure gap can be explained by home vintage by controlling for home vintage with decade fixed effects. Columns (3) and (4) of Table 2 show results. Despite the fact that newer homes are broadly speaking associated with lower residential energy expenditures, controlling for home vintage does not change the residential energy expenditure gap. Controlling for home type and vintage may not have an effect on the residential energy expenditure gap because both variables are imperfect proxies for energy efficiency, since they do not capture renovations or investments into energy efficient appliances.

To explore these mechanisms, I turn to the 2015 RECS. I compare survey responses about home quality, appliance quality, and energy burden across race, conditioning on income categories. A few key patterns emerge in Table 3. First, Black respondents are about 13 percentage points more likely to report that their home was at least somewhat drafty. Out of a set of several appliances and home features[9], Black respondents have a 7 percentage point lower share that were Energy Star rated, and they are 3 percentage points less likely to report having received a rebate or tax credit for upgrading an appliance. If anything, Black respondents are slightly more likely to have gotten an energy audit, suggesting that this isn't a matter of differential information, though this result is not statistically different from 0. Moreover, Black respondents were about 50% more likely to report having reduced or forgone basic necessities at least one month in the last year in order to afford their energy bill, were about 40% more likely to report having kept the home at an unhealthy temperature at least one month in the last year in order to afford their energy bill, and were about twice as likely to have received a disconnect notice due to inability to pay a bill at least one month in the last year. These estimates suggest that energy costs are highly salient, and are evidence of a striking disparity in energy burden.

Discussion and Conclusions

This paper provides estimates of the Black-white residential energy expenditure gap in the US. These estimates suggest that Black households face a higher energy burden than white households at almost every position in the income distribution. Understanding the differential energy burden is critical when designing policies that will affect energy prices, such as much-needed policy to reduce greenhouse gas emissions. This is especially true given that this gap may be another of many outcomes that has been affected by the persistent effects of systemic racism in the United States, mediated in particular by differences in housing stock and wealth.

This paper has some important limitations. The results are suggestive but not causal, and energy expenditures are self reported on an annual basis. In future versions of this paper, I will use residential billing data in the state of California for this analysis. This will eliminate any recall error, and will also allow me to observe differences in prices, payment of late fees, and participation in low-income assistance programs. Billing data also make it possible to control for weather more directly, and provide more spatial granularity, which I will use to estimate the long-term impacts of residential segregation policies such as redlining.

[9]RECS asks about 8 appliances/features: clothes washer, clothes dryer, dishwasher, fridge, freezer, water heater, light bulbs, and windows.

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Table 1: Gap in Annual Residential Energy Costs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Black	53.5	192.7***	163.8***	258.1***	380.5***	179.1***	289.9***	272.6***	408.0***
	(37.00)	(33.64)	(35.47)	(46.94)	(40.60)	(25.84)	(29.87)	(53.95)	(46.34)
HH income		4.783***	3.855***	1.413***	3.263***	2.019***	3.008***	1.387***	2.131***
		(0.219)	(0.176)	(0.169)	(0.192)	(0.273)	(0.128)	(0.293)	(0.435)
HH size			240.7***	271.2***	224.9***	277.4***	224.0***	268.6***	248.6***
			(13.22)	(18.52)	(12.67)	(15.90)	(10.13)	(17.57)	(20.07)
Constant	2592.9***	2226.1***	1702.6***	1203.0***	1976.5***	1176.9***	2004.9***	1055.2***	1989.4***
	(83.11)	(69.99)	(54.87)	(50.99)	(60.70)	(23.06)	(27.55)	(44.95)	(32.13)
Sample Mean Energy Expenditures	2373.5	2373.5	2373.5	1811.2	2615.5	1811.2	2615.5	1705.1	2648.9
Year FE	X	X	X	X	X	X	X	X	X
Renters only				X		X		X	
Homeowners only					X		X		X
MSA FE						X	X		
city FE								X	X
R-squared	0.00871	0.0697	0.117	0.114	0.103	0.165	0.167	0.180	0.198
N	7,906,852	7,906,852	7,906,852	1,936,533	5,970,319	1,936,533	5,970,319	363,715	537,865

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table reports annual residential energy expenditure gaps in the ACS, pooled across 2010-2017. All values are reported in 2012 dollars, and household income is reported in \$1000s. Standard errors are clustered on state.

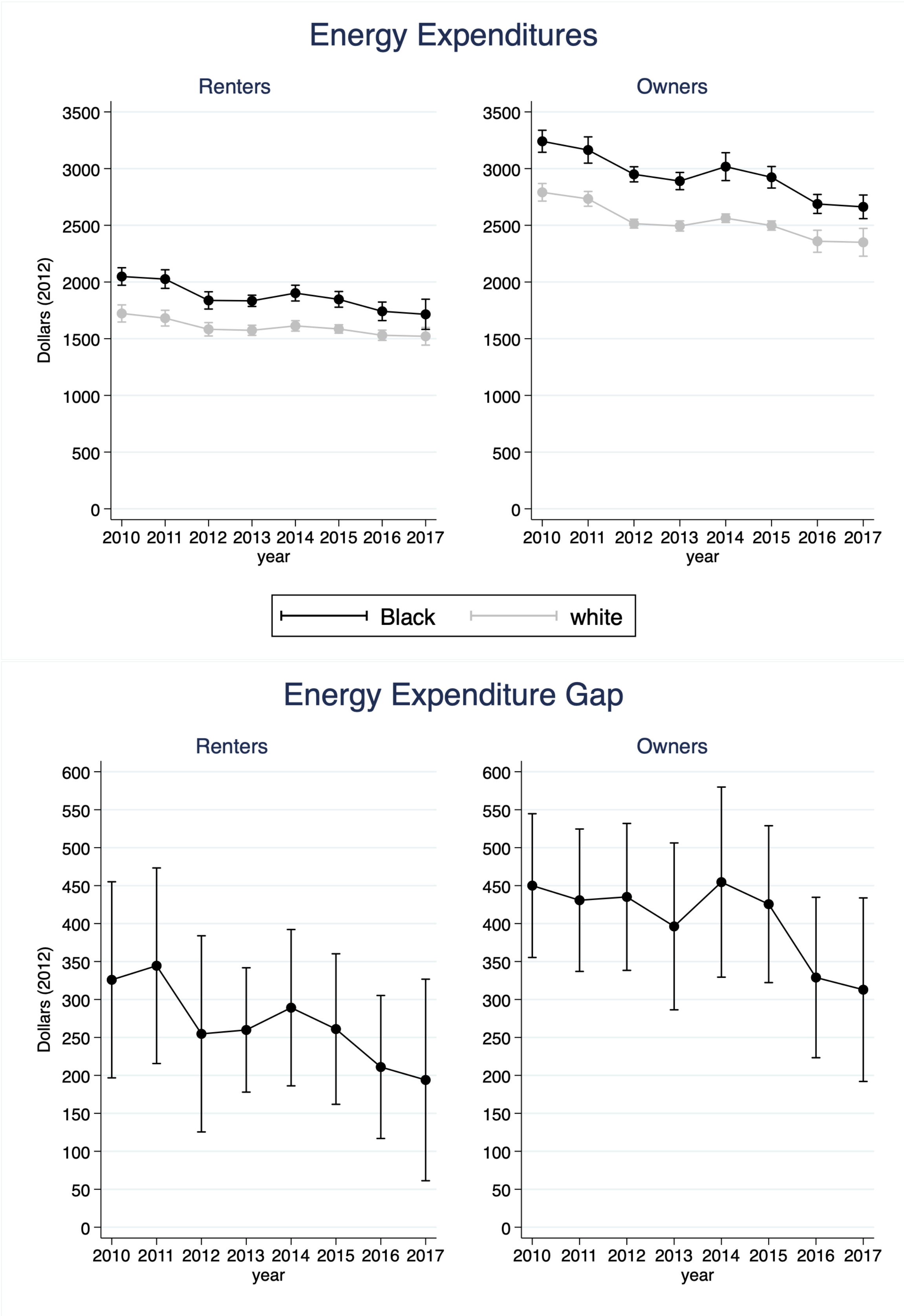

Figure 1: The top panel of this figure shows the evolution over time of mean annual energy expenditures in the ACS conditional on income, household size, and city FE. The bottom panel of this figure shows the evolution over time of the conditional gap between Black and white expenditures. All values are reported in 2012 dollars. Standard errors are clustered on state. Bars are 95% confidence intervals.

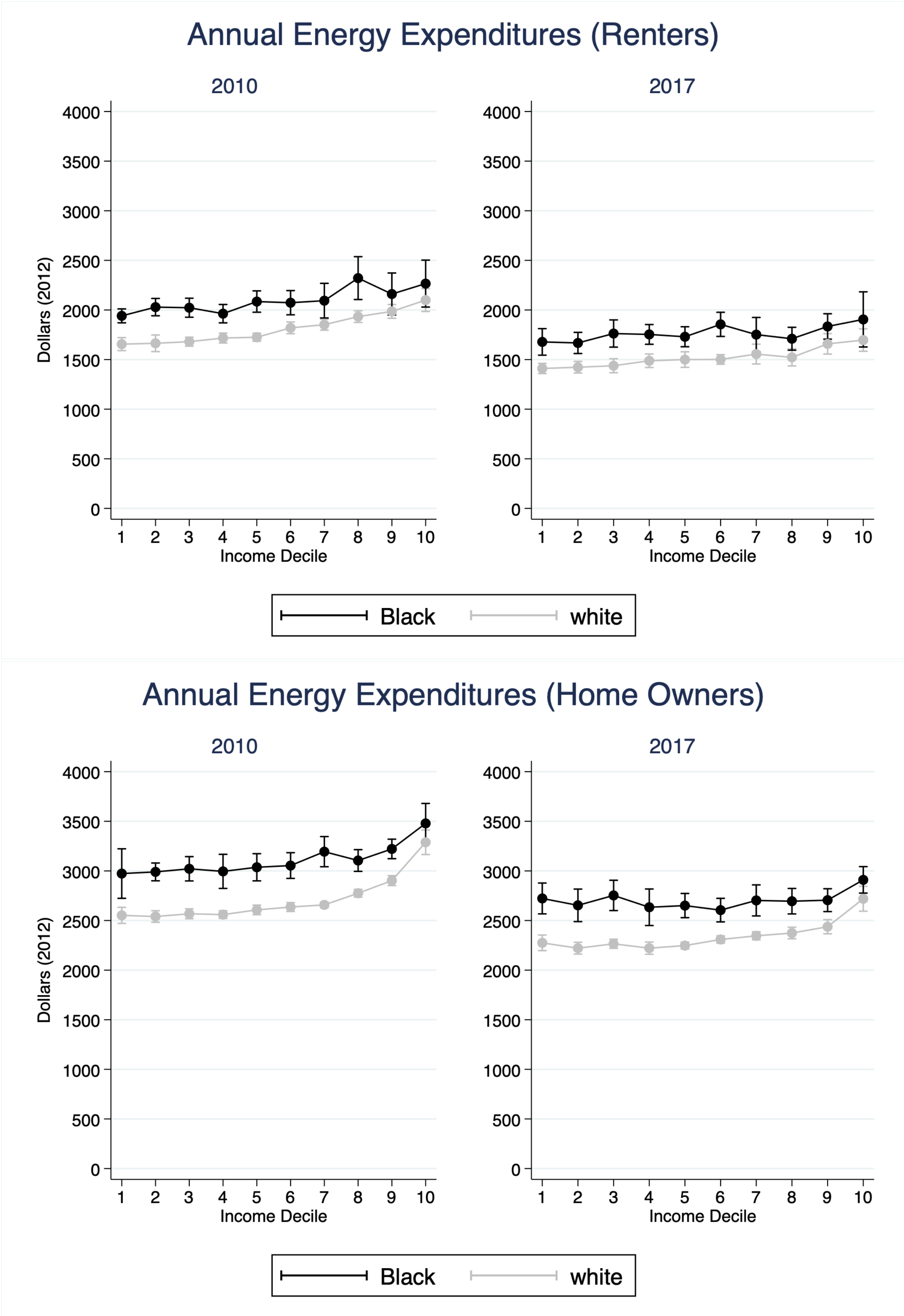

Figure 2: This figure shows mean annual energy expenditures in the ACS, conditional on household size and city, by income decile for Black and white households. The top panel shows expenditures for renters, in 2010 on the left and 2017 on the right, and the panel row shows expenditures for home owners. All values are reported in 2012 values. Standard errors are clustered on state. Bars are 95% confidence intervals.

Table 2: Gap in Annual Residential Energy Costs, Controlling for Home Vintage

	(1)	(2)	(3)	(4)
Black	275.2***	353.0***	276.9***	409.7***
	(50.44)	(36.61)	(55.21)	(44.88)
HH income	1.127***	2.221***	1.490***	2.217***
	(0.155)	(0.279)	(0.315)	(0.439)
HH size	186.1***	208.8***	265.4***	248.6***
	(12.98)	(12.36)	(16.91)	(20.35)
Single-Family Attached Home	-373.1***	-462.3***		
	(55.10)	(32.35)		
Van or Mobile Home	-385.0***	-375.5***		
	(59.32)	(70.10)		
2 - 4 plex	-638.2***	-186.3*		
	(28.77)	(86.47)		
5+ Unit Apt. Building	-1151.1***	-1451.7***		
	(51.31)	(204.4)		
Vintage: 1970 - 1979			-204.8***	-152.1***
			(35.56)	(24.37)
Vintage: 1980 - 1989			-206.1***	-246.6***
			(49.28)	(28.94)
Vintage: 1990 - 1999			-188.3**	-98.06**
			(54.53)	(31.01)
Vintage: 2000 - 2009			-194.4**	-242.4***
			(68.78)	(40.73)
Vintage: 2010 - 2017			-370.5***	-448.9***
			(71.12)	(41.17)
Constant	1995.2***	2253.5***	1140.0***	2053.0***
	(42.75)	(38.46)	(27.94)	(29.92)
Sample Mean Energy Expenditures	1705.1	2648.9	1705.1	2648.9
Year FE	X	X	X	X
Renters only	X		X	
Home-owners only		X		X
City FE	X	X	X	X
R-squared	0.275	0.236	0.185	0.201
N	363,715	537,865	363,715	537,865

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table reports annual energy-expenditure gaps in the ACS, pooled across 2010-2017, controlling for home type and vintage. Columns 1 and 2 control for home types. The omitted category is single-family detached homes. Columns 3 and 4 control for home vintage. The omitted category is homes built before 1970. All specifications include city fixed effects (and are comparable to columns 8 and 9 in Table 1). Standard errors are clustered on state.

Table 3: Conditional Differences in Housing Stock and Energy Burden

	White	Black	Diff
Received energy assistance in 2015	0.031	0.042	0.011
			(0.015)
Got an energy audit	0.086	0.099	0.013
			(0.014)
Said home was well insulated	0.320	0.329	0.009
			(0.027)
Said home was drafty	0.506	0.640	0.134***
			(0.023)
Share of appliances or features in home that are Energy Star qualified	0.443	0.370	-0.073***
			(0.008)
Received a rebate or tax credit for upgrading an appliance	0.105	0.070	-0.034*
			(0.015)
Has solar PV	0.013	0.013	-0.000
			(0.003)
Has smart meter	0.332	0.297	-0.035
			(0.037)
Has smart thermostat	0.033	0.047	0.014
			(0.011)
Has had to reduce/forgo basic necessities bc of energy bill	0.202	0.312	0.111*
			(0.037)
Has kept home at unhealthy temperature	0.103	0.144	0.041*
			(0.015)
Has received disconnect notice due to inability to pay bill	0.137	0.277	0.141***
			(0.013)
N	4,282	523	

mean coefficients; standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table tests differences across race in self-reported responses about home quality, appliance quality, and energy burden, conditioning on income categories. Data is from the 2015 RECS. Standard errors are clustered on census division.

Appendix

Table A1: Gap in Annual Residential Energy Costs
City Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Black	312.8***	451.5***	414.7***	434.6***	646.0***	289.2***	432.9***	272.6***	408.0***
	(52.55)	(54.31)	(62.25)	(82.12)	(52.63)	(55.13)	(47.72)	(53.95)	(46.34)
HH income		3.851***	3.089***	0.826***	2.312***	1.340***	2.207***	1.387***	2.131***
		(0.167)	(0.211)	(0.183)	(0.265)	(0.294)	(0.463)	(0.293)	(0.435)
HH size			269.1***	266.7***	256.8***	267.4***	245.6***	268.6***	248.6***
			(23.81)	(20.63)	(30.99)	(19.17)	(21.44)	(17.57)	(20.07)
Constant	2323.1***	2015.8***	1427.1***	1037.9***	1866.6***	1045.6***	1963.3***	1055.2***	1989.4***
	(102.0)	(104.6)	(76.68)	(77.22)	(75.22)	(42.34)	(43.12)	(44.95)	(32.13)
Sample Mean Energy Expenditures	2209.8	2209.8	2209.8	1705.1	2648.9	1705.1	2648.9	1705.1	2648.9
Year FE	X	X	X	X	X	X	X	X	X
Renters only				X		X		X	
Home-owners only					X		X		X
MSA FE						X	X		
City FE								X	X
R-squared	0.0140	0.0551	0.116	0.122	0.107	0.174	0.185	0.180	0.198
N	901,580	901,580	901,580	363,715	537,865	363,715	537,865	363,715	537,865

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table reports annual energy-expenditure gaps in the ACS, pooled across 2010-2017, restricting the sample in each specification to only households in a city identified by the ACS. All values are reported in 2012 dollars, and household income is reported in \$1000s. Standard errors are clustered on state.