Energy Insecurity in Redlined America

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Most recent web-based slides here

Energy Insecurity

> The disproportionate share of household income allocated to energy expenses with those that exceed a 10% threshold categorized as experiencing "energy insecurity." (Hernández 2015)

- Drehobl and Ross (2016) find 75th percentile energy burdens above 26%.
- Lyubich (2020) finds minority households spend more on energy
- Doremus et al (2021) finds low-income households use more energy during weather extremes

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Energy Inequity

- Reames (2016): Minority-dominated census block-groups tend to have lower (worse) energy efficiency and spend a greater total amount **for the same level of energy services relative to non-minority households**.

- Drehobl and Ross (2016) using ACS data: Black and Hispanic households face higher median energy burdens, even conditional on income.

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> **Energy Inequity**: "The disproportionate incidence of energy insecurity in heavily-minority areas relative to non-minority areas of similar income."

Why?

- Preferences & Sorting?
  - Lower-efficiency homes are less expensive, income constraints $\longrightarrow$ "coming to the nuisance" (Banzhaf, 2011)
  - But conditional on income, do minority households prefer lower efficiency?
  - Lower utility of heating? Lower utility of non-energy consumption?

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- Current housing discrimination or heterogeneous information?
  - Christensen et al (2020): Rental agents steer minority households away from low-toxic exposure properties
  - Missing information disproportionately affects those sorting to the lower quality homes (Bakkensen and Ma, 2020; Hausman and Stolper, 2020)

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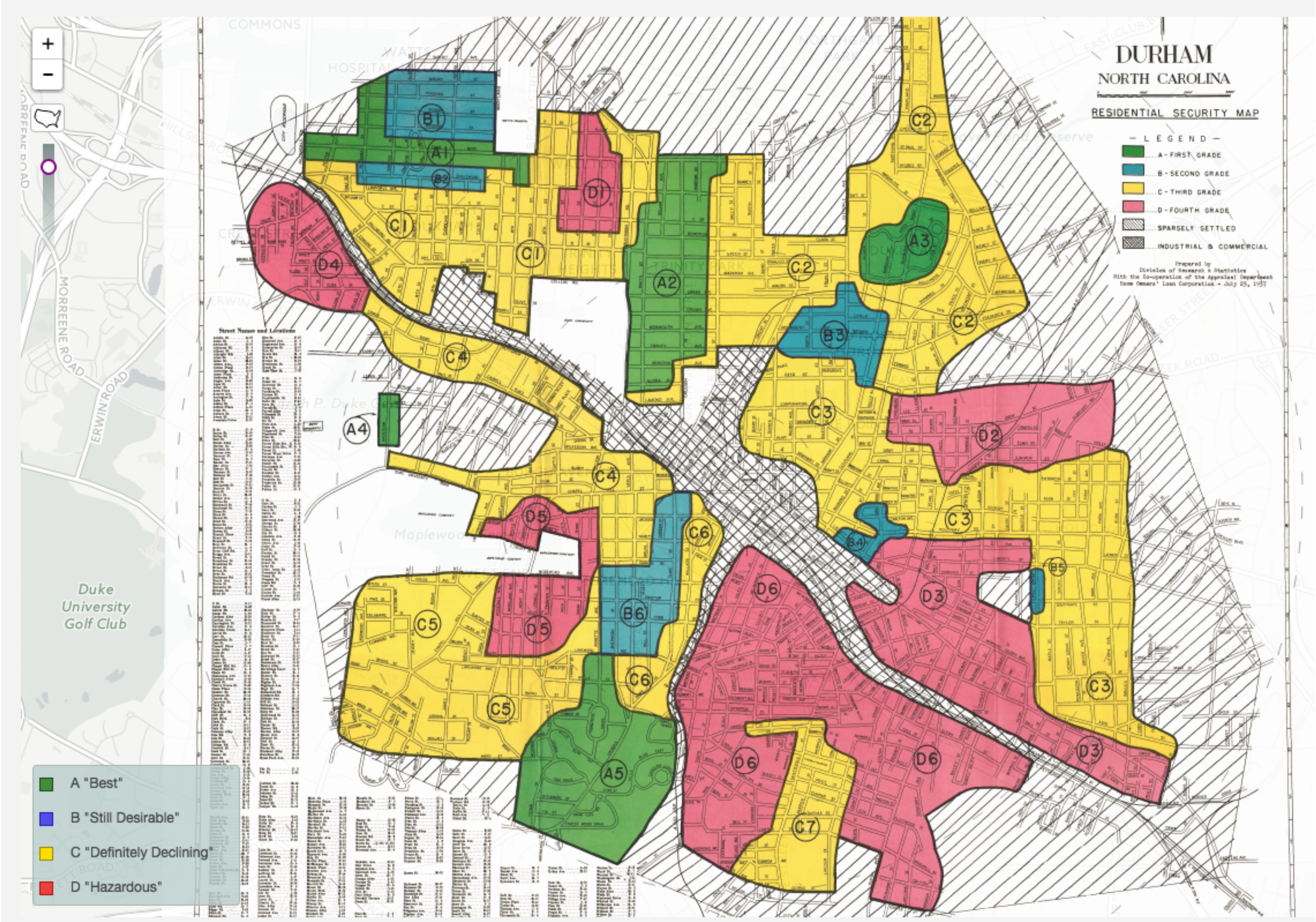
- State dependence / hysteresis
  - Historic forms of discrimination
  - Frictions in moving costs

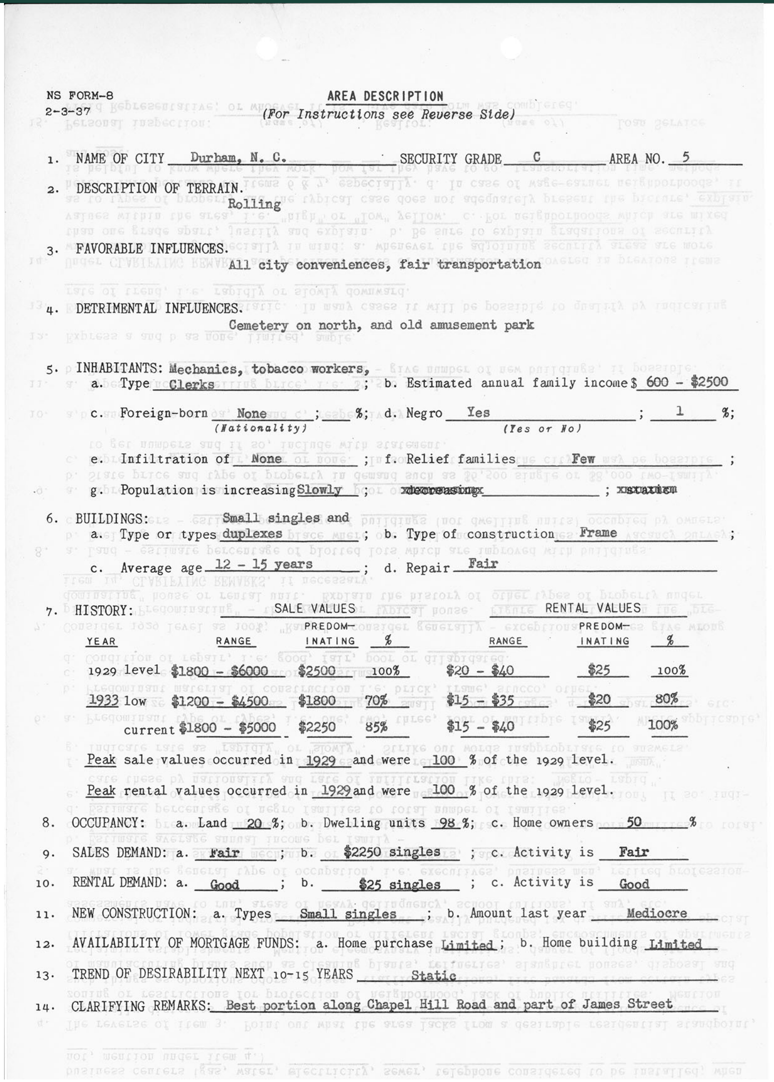
Enegy Insecurity



Durham, NC Redlining Map (source: URichmond Mapping Inequality)

Homeowners Loan Corporation (HOLC)

- New Deal agency tasked with assessing mortgage risk for federal refinancing efforts
- Neighborhoods risk-graded by local agents 1933-1939
- Largely considered "subversive minorities" to be harbinger of decline and risk.
- *De facto* discrimination in housing was widespread



NS FORM-8
2-3-37

AREA DESCRIPTION
(For Instructions see Reverse Side)

1. NAME OF CITY Durham, N. C. SECURITY GRADE C AREA NO. 5
2. DESCRIPTION OF TERRAIN. Rolling
3. FAVORABLE INFLUENCES. All city conveniences, fair transportation
4. DETRIMENTAL INFLUENCES. Cemetery on north, and old amusement park
5. INHABITANTS: Mechanics, tobacco workers,
   a. Type Clerks ; b. Estimated annual family income $ 600 - $2500
   c. Foreign-born None (Nationality) ; %; d. Negro Yes (Yes or No) ; 1 %;
   e. Infiltration of None ; f. Relief families Few ;
   g. Population is increasing Slowly ; ~~decreasing~~ ; ~~static~~
6. BUILDINGS:
   a. Type or types Small singles and duplexes ; b. Type of construction Frame ;
   c. Average age 12 - 15 years ; d. Repair Fair
7. HISTORY:

	SALE VALUES			RENTAL VALUES		
YEAR	RANGE	PREDOM-INATING	%	RANGE	PREDOM-INATING	%
1929 level	$1800 - $6000	$2500	100%	$20 - $40	$25	100%
1933 low	$1200 - $4500	$1800	70%	$15 - $35	$20	80%
current	$1800 - $5000	$2250	85%	$15 - $40	$25	100%

Peak sale values occurred in 1929 and were 100 % of the 1929 level.

Peak rental values occurred in 1929 and were 100 % of the 1929 level.

8. OCCUPANCY: a. Land 20 %; b. Dwelling units 98 %; c. Home owners 50 %
9. SALES DEMAND: a. Fair ; b. $2250 singles ; c. Activity is Fair
10. RENTAL DEMAND: a. Good ; b. $25 singles ; c. Activity is Good
11. NEW CONSTRUCTION: a. Types Small singles ; b. Amount last year Mediocre
12. AVAILABILITY OF MORTGAGE FUNDS: a. Home purchase Limited ; b. Home building Limited
13. TREND OF DESIRABILITY NEXT 10-15 YEARS Static
14. CLARIFYING REMARKS: Best portion along Chapel Hill Road and part of James Street

Example survey. (URichmond Mapping Inequality)

Energy Inequity is in part the result of a *hysteresis* effect rooted in historic housing discrimination.

Redlining was a "critical juncture" that separated otherwise similar housing stock.

- Test by examining differences in home energy services quality between redlined and observably similar households, measured as the
  - (1) *presence of sufficient heating technology* and
  - (2) *energy consumption responses to cold weather shocks*
  - Controlling for historic and current small neighborhood characteristics

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Not addressed here

- Lending discrimination debatably ended with CRA in 1977. Households able to migrate, re-sort. Why does Energy Inequity persist?
- Test for "stickiness" of neighborhood.
  - High non-market moving costs.
  - Neighborhood support, family proximity, etc.

Historic data $\rightarrow$ many assumptions

Prior literature

- Hoffman et al (2020) urban heat islands and redlined areas
- Nardone et al (2019) asthma and redlined areas
- Aaronson et al (2020) examined credit availability in redlined areas over 1930-1980 with RD-based analysis

Enlightening and incredibly inconvenient:

Fishback, La Voice, Shertzer, and Walsh (2020) on **endogeneity of redlining designation.**

- Used linked 1930 census address data and HOLC maps to show that redlined areas captured pre-existing economic and racial discontinuities in space.
- Border discontinuities not smooth in unobserveds. Even large moves in boundaries would still capture pre-existing segregations.
- Hillier (2003) no widespread proof that HOLC maps were distributed and used.

Empirical strategy

Acknowledging Fishback et al (2020), I control for selection on observables:

- Rent and income (historic and current)
- Presence of minorities in 193X
- Repair and quality of housing in 193X

Assume: conditional on observables that determined selection, Grade D (red) is as good as randomly assigned

- Unobserved neighborhood characteristics in 1930's not captured by observables are no longer relevant today.

Identification of effect of redlining using observably similar HOLC neighborhoods

- Multiple surveyors result in nearly arbitrary designation of Grade D (red) and Grade C (yellow) when "subversive minorities" were present.
- Many Grade C (yellow) areas had larger Black populations or worse home repair than nearby Grade D (red).

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Identification of effect of redlining using observably similar HOLC neighborhoods

- Multiple surveyors result in nearly arbitrary designation of Grade D (red) and Grade C (yellow) when "subversive minorities" were present.
- Many Grade C (yellow) areas had larger Black populations or worse home repair than nearby Grade D (red).
- Drawback: leaning on linear controls.
  - Solution: very flexible with linear controls.

(1) Presence of sufficient heating technology

- Ask "are there differences in heating sources between redlined and near-redlined homes, controlling for selection on observables?"
- Substandard heating technology = Coal or "None"
- Requires spatially explicit heating fuel use

(2) Energy consumption responses to cold weather shocks

- Ask "are there differences in energy consumption responses to weather shocks between redlined and near-redlined homes, controlling for selection on observables?"
- Data on monthly consumption and heating degree days for households in Grade D / Grade C areas
- Requires spatially explicit household electricity consumption with income

Data - Heating technology

HOLC from URichmond "Mapping Inequality"

- 196 cities, 8,877 neighborhoods
- Survey data processed
  - Grade A-B-C-D
  - Repair class
  - Median Income 1936
  - Mean rent 1936
  - Presence of Blacks 1936

2018 ACS at block-group

- 44,357 BGs intersect HOLC
  - Heating fuel
  - Coal + "None" $\longrightarrow$ substandard
  - Racial distribution
  - Median income 2018

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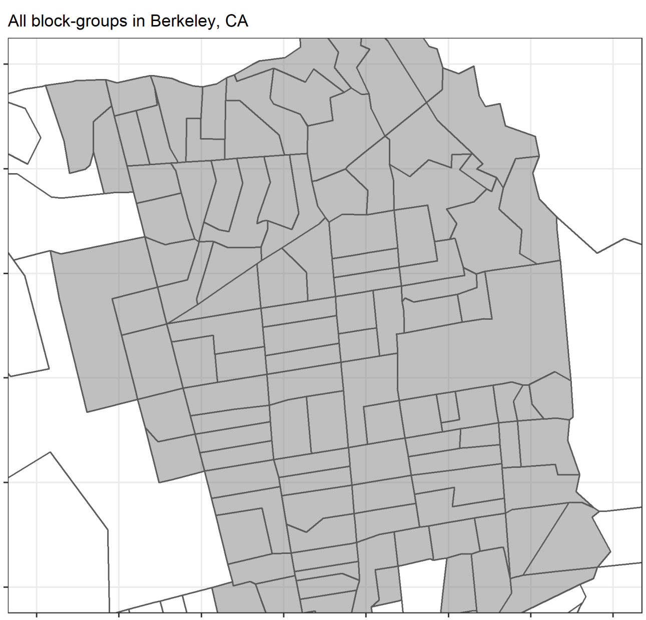
Overlay BG with HOLC, keeping those BG that have >80% within one grade

- Take areal average when BG covers multiple HOLC neigbhorhoods of same grade
- 6,715 have most HOLC information



Measuring Hh response to temperature shocks

California RASS (Residential Appliance Saturation Survey)

- Confidential dataset with 24,216 homes surveyed in CA in 2009
  - Monthly consumption (from utility) for electricity, gas (if used)
  - Monthly HDD and CDD
  - Primary heating fuel
  - Income
  - Nighttime thermostat setpoint
  - Daytime thermostat setpoint
  - **Zip code**
- 138 households in 37 zip codes with >80% coverage for electric
- 1,018 households in 83 zip codes with >80% coverage for gas

Flexible fixed effect specification

$$PercentSubstandard_b = \beta_0 + \underset{g\in\{A,B,\ \}}{} \beta_g^{Grade} + \beta \mathbf{x}_b + \Gamma_{c(b)} + \gamma_{c(b)}\mathbf{w_b} + \epsilon_b$$

- $PercentSubstandard$ is share of 2018 homes with coal or no heating fuel in block-group b
- β_g is coefficient of interest
- $\mathbf{x_b}$ is repair class, presence of Blacks in 1936
- $\Gamma_{c(b)}$ are county FEs for county c
- $\gamma_{c(b)}$ are county-specific slope shifters
- $\mathbf{w_b}$
  - Median income in 1936, 2018
  - Mean rent 1935
  - Presence of Blacks in 1936

Table 1: Share of Households with Substandard Fuel (Coal and None) by HOLC Grade

	Dependent Variable: Share of Households in Block Group with Substandard Heating			
	Model 1	Model 2	Model 3	Model 4
Grade D (Red)	0.00335*	0.00279+	0.00285*	0.00416**
	(0.00160)	(0.00155)	(0.00143)	(0.00135)
Grade B (Blue)	-0.00071	-0.00050	-0.00078	0.00006
	(0.00158)	(0.00161)	(0.00126)	(0.00140)
Grade A (Green)	0.00005	0.00045	0.00042	0.00180
	(0.00280)	(0.00289)	(0.00239)	(0.00322)
Predom. Black 2018			-0.00331**	-0.00223
			(0.00103)	(0.00144)
Predom. Asian 2018			-0.00408+	-0.00172
			(0.00244)	(0.00185)
Predom. other race 2018			-0.00059	0.00211
			(0.00396)	(0.00454)
Num.Obs.	6715	6715	3998	3998
R2 Adj.	0.126	0.121	0.070	0.070
FE: STCO	X	X	X	X
Control for home repair status 1935	X	X	X	X
County-specific slope on Med. Income 2018, 1936	X	X	X	X
County-specific slope on Mean Rent 1935	X	X	X	X
County-specific binary on Presence of Blacks 1935		X	X	X
Intx Predom. race 2018 and HOLC Grade				X

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Robust SE clustered by FIPS county
Omitted Grade: C (Yellow)
Omitted Race: White

Response to temperature shocks

Home may have insufficient energy service quality if energy consumption responses to weather shocks are very large.

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Response to temperature shocks

Home may have insufficient energy service quality if energy consumption responses to weather shocks are very large.

- Response is endogenous: both homes with efficient heating **and** inefficient homes who meet budget constraints with conservative thermostat settings have low consumption responses to weather shocks.
  - Observationally equivalent without observing thermostat setpoint.

$$consumption_{ht} = \beta_0 + \beta_1 \quad {}_{ht} + \underset{g \in \{A, B, \quad\}}{\quad} \beta_g \cdot \quad {}_{ht} \cdot 1(g = g(h))$$

$$+ \overset{3}{\underset{l=1}{\quad}} \overset{5}{\underset{s=1}{\quad}} \beta_{ls} \quad {}_{ht} \cdot 1(\quad IG \quad TSET_h = s) \cdot 1(ClimateZone_h = l) +$$

$$+ \beta_{inc} \cdot \quad {}_{ht} \cdot avgincome_h + \Gamma_h + \varepsilon_{ht}$$

- $consumption_{ht}$ is energy (kWh, therms) consumption for household h month t
- $g(h)$ is HOLC Grade g for h
- $\quad {}_{ht}$ is the heating-degree day for h in month t
- $\quad IG \quad TSET_h$ is the thermostat setting for h
- $ClimateZone_h$ is the climate type for h
- $income_h$ is reported income for h
- Γ_h is household h fixed effect

Table 1: Regression of electricity consumption on heating degree days, interacted with HOLC grade and income, conditional on thermostat setpoint

	Dependent Variable: Energy consumption (kWh)		
	Model 1	Model 2	Model 3
hdd	3.398***	2.598***	
	(0.806)	(0.184)	
hdd x Grade D (Red)	3.737***	2.809***	3.057***
	(0.573)	(0.727)	(0.673)
hdd x Avg rent 37-39	-0.050**		-0.011
	(0.018)		(0.013)
Num.Obs.	593	1150	593
R2 Adj.	0.804	0.826	0.802
FE: CZT24			X
FE: IDENT	X	X	X
Climate zone FE		X	X
Avg Inc x hdd	X	X	X
hdd x Thermostat setting		X	X
Thermostat setting x Climate Zone x hdd		X	X
Controls for 1937 incl. rent, presence of Blacks	X		X

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Using only households with elec. as primary heating fuel
Omitted grade is "C"

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Table 1: Regression of natural gas consumption on heating degree days, interacted with HOLC grade and income, conditional on thermostat setpoint

	Dependent Variable: Energy consumption (therms)		
	Model 1	Model 2	Model 3
hdd	0.311***	0.280*	
	(0.089)	(0.111)	
hdd x Grade D (Red)	0.121	0.112	0.144
	(0.244)	(0.245)	(0.247)
hdd x Avg rent 37-39	-0.001	-0.001	0.001
	(0.001)	(0.002)	(0.001)
Num.Obs.	3623	3623	3623
R2 Adj.	0.564	0.563	0.556
FE: CZT24			X
FE: IDENT	X	X	X
Hdd x avg inc	X	X	X
hdd x thermostat setting		X	X
Hdd x thermostat setting x Climate Zone			X
Hdd x controls for 1937 incl. rent, presence of Blacks	X		X

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Using only households with natural gas as primary heating fuel
Omitted grade is "C"

Conclusion

Evidence of lingering differences in heating technology in/out of redlined areas

- Remains after controlling for observable differences in 193X
- Useful for targeting of energy efficiency programs

Evidence of larger consumption responses to cold weather shocks in redlined areas

- Conditional on 193X observables
- Conditional on thermostat setpoints

Further work

- Understanding selection into Grade D (red)
- "Stickiness" of redlined areas

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Thanks!

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