Homework in Climate Economics: Household Production, Carbon Emissions, and Climate Policy

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Federal Reserve Bank of San Francisco, CEPR
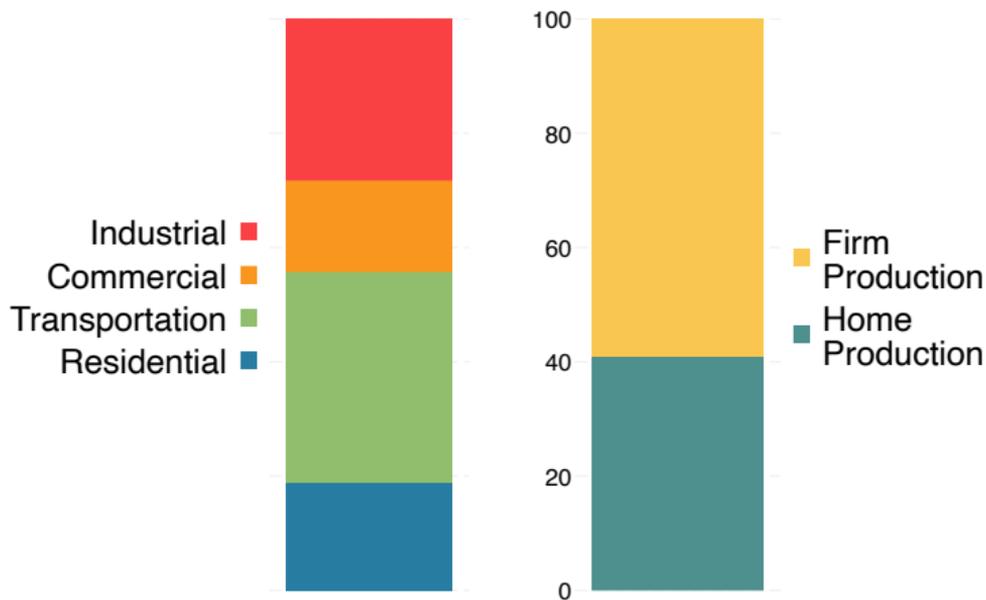Boston University, NBER, CEPR
Boston University

Bank of Spain
November 14, 2024

Home Production is a Large Contributor of US Emissions

US Carbon Emissions by Sector
(share of total emissions)

Data sources: EIA, BTS

What We Do

1. Household survey

2. Model of home production

3. Simulate effects of policies targeted towards households

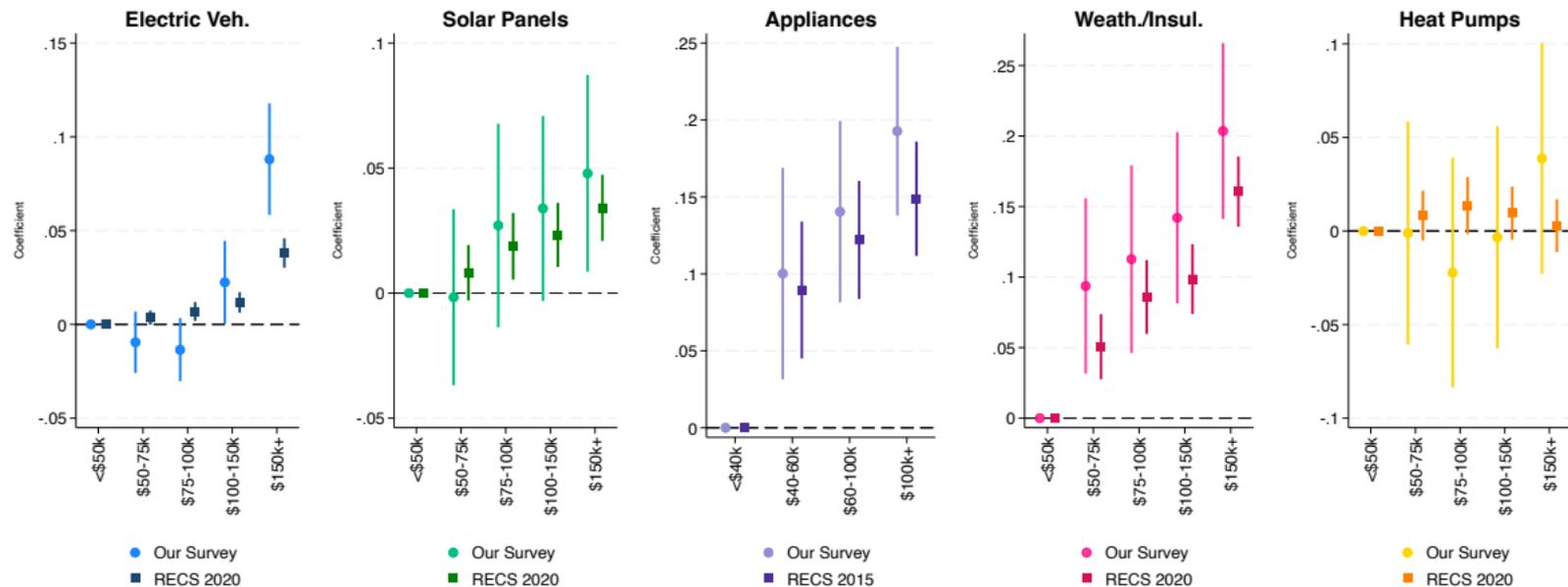# Survey

Survey Design

- Online survey of 3,300 households from November 2023 - February 2024

- Asked households:

  - Own/lease or consider purchasing energy-saving equipment
    - EVs, hybrids, solar panels, heat pumps, energy efficient appliances, weatherization

  - Rank different reasons for owning/leasing or considering

  - Yale Six Americas' Survey questions on climate change (at end)

Survey Validation: Correlations With Income

$$Y_{ik} = \alpha_k + \sum_j \beta_{jk}\text{Income}_{ij} + \gamma_{ik} + \eta_{ik} + \epsilon_{ik}$$

Four Facts

1. Reducing emissions is important for some households' decisions to buy energy-saving equipment

2. Environmental preference is uncorrelated with income

3. Environmental preference is correlated with climate change concern

4. Environmental preference is correlated with energy-saving equipment ownership

Fact 1

Reducing emissions is important for some households' decisions to buy energy-saving equipment

Households Ranking Each Factor as First or Second Most Important

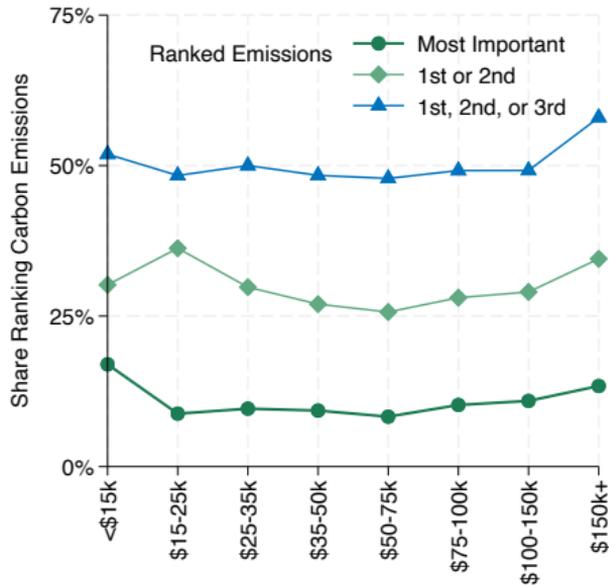| %	Electric Veh.	Hybrid (NPI)	Solar Panels	Heat Pumps	Appl./Weath.
Reduce carbon emissions	**48**	**36**	**29**	**18**	**24**
Reduce fuel costs	69	75			
energy costs			90	86	89
Tax credits and rebates	32	27	46	22	25
Performance, quiet, safety	40	46			
Raise home value			24	48	49
Other	5	7	5	17	5
N	154	477	152	203	1747

Environmental preference

- Distaste for individual emissions, varies across households

Fact 2
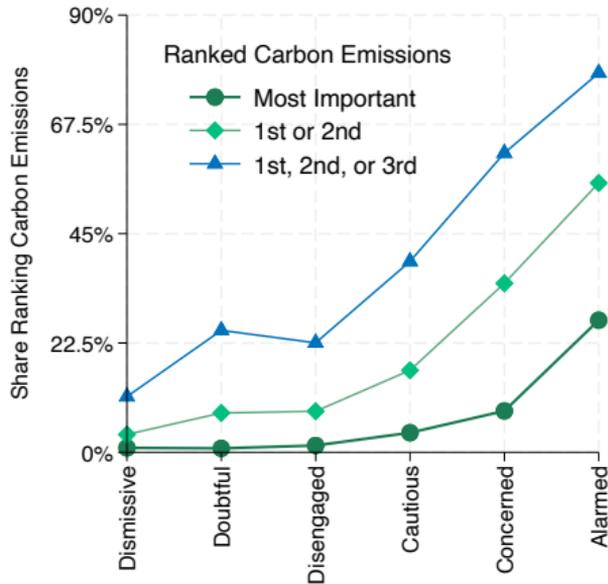
Environmental preference is uncorrelated with income

Fact 3

Environmental preference is correlated with climate change concern

Fact 4

Environmental preference is correlated with energy-saving equipment ownership

Energy-Saving Equipment Decisions

%	(1) Electric Veh.	(2) Hybrid (NPI)	(3) Solar Panels	(4) Heat Pumps	(5) Appl./Weath.
(a) Own/Lease					
More Concerned	10	19	24	29	82
Less Concerned	4	17	14	29	80
(b) Considered					
More Concerned	45	45	69	18	42
Less Concerned	18	20	55	15	28

Model

Overview

Households

- Utility from consumption, time, and energy tasks
- Dis-utility from emissions
- Differ based on labor productivity and environmental preferences

Firms

- Produce the goods and equipment necessary for the economy

Competitive equilibrium

- No dynamics
- Households and firms optimize, markets clear

Preferences

$$u(z_i, e_i) = \ln(z_i) - \theta_i e_i$$

- z: bundle of goods, time, and energy tasks (Becker 1965)

- e: household emissions

- θ: environmental preference

Bundle z

Combine goods, c, time, n_h, and energy tasks, Q

$$z = c^\chi n_h^\eta Q^{1-\eta-\chi}$$

Q is an aggregate of energy tasks

$$Q_i = \left[\int_0^1 q_i(j)^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

Production Function For Each Energy Task

Produce each energy task using dirty or clean technology

$$q_i(j) = \begin{cases} \min[x^d(j), \frac{1}{\mu}e(j)] & : \text{dirty technology} \\ x^c(j)\Phi(j) & : \text{clean technology} \end{cases}$$

Relative productivity of clean equipment

$$\Phi(j) = \phi j$$

Household Optimization

$$\max_{c,n_m,n_h,\{x^c(j),x^d(j),e(j)\}\forall j} \ln(z) - \theta e$$

subject to

$$w\zeta n_m = c + p^c \int_0^1 x^c(j)dj + p^d \int_0^1 x^d(j)dj + p^e \int_0^1 e(j)dj$$

$$n_m + n_h = 1$$

Proposition: Cutoff For Clean Equipment

Household i uses clean equipment for all tasks with $j \geq J_i^\star$

$$J_i^\star = \frac{p^c}{\phi\left(p^d + \mu p^e + \frac{\theta_i \mu \nu}{\lambda_i}\right)}$$

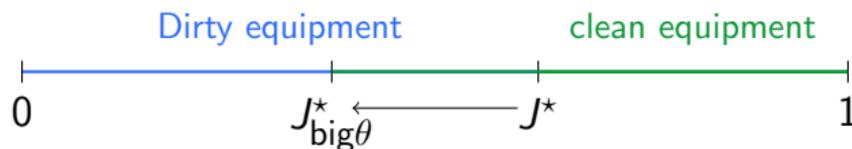Dirty equipment   clean equipment

0        $J^\star$ 1

Properties of $J^\star$

$$J_i^\star = \frac{p^c}{\phi\left(p^d + \mu p^e + \frac{\theta_i \mu \nu}{\lambda_i}\right)}$$

Dirty equipment | clean equipment

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1. Decreasing in θ: $\Rightarrow$ HHs with stronger environmental preferences use clean equipment for more tasks
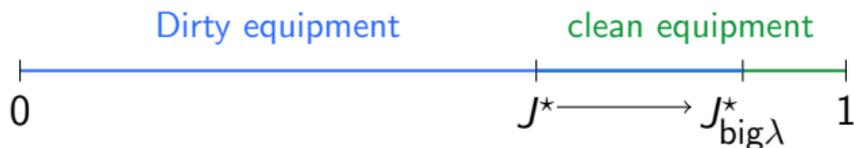
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Dirty equipment   clean equipment

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Dirty equipment ⟶ clean equipment

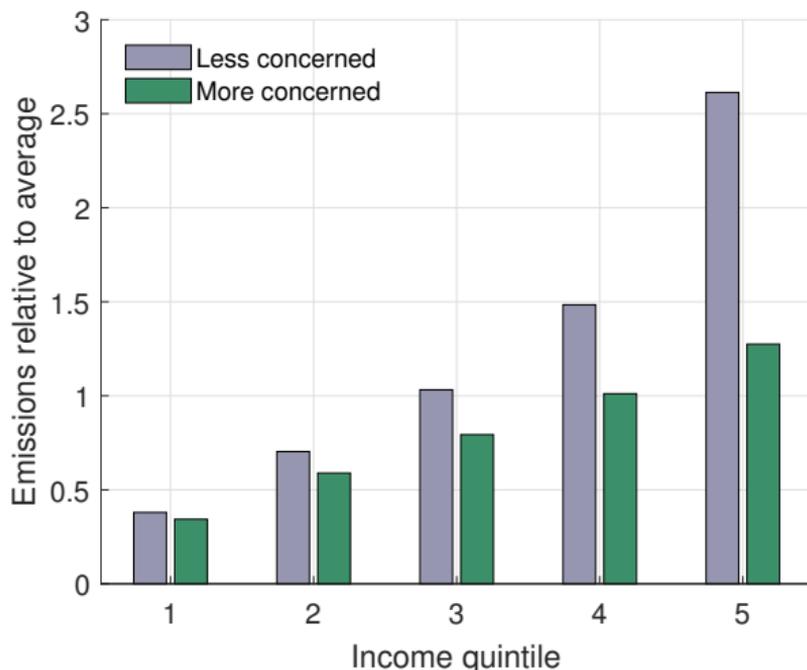0 ⟶ $J^\star \longrightarrow J_{\text{big}\lambda}^\star$ ⟶ 1

1. Decreasing in θ: $\Rightarrow$ HHs with stronger environmental preferences use clean equipment for more tasks
2. Increasing in λ: $\Rightarrow$ HHs with lower income use clean equipment for less tasks
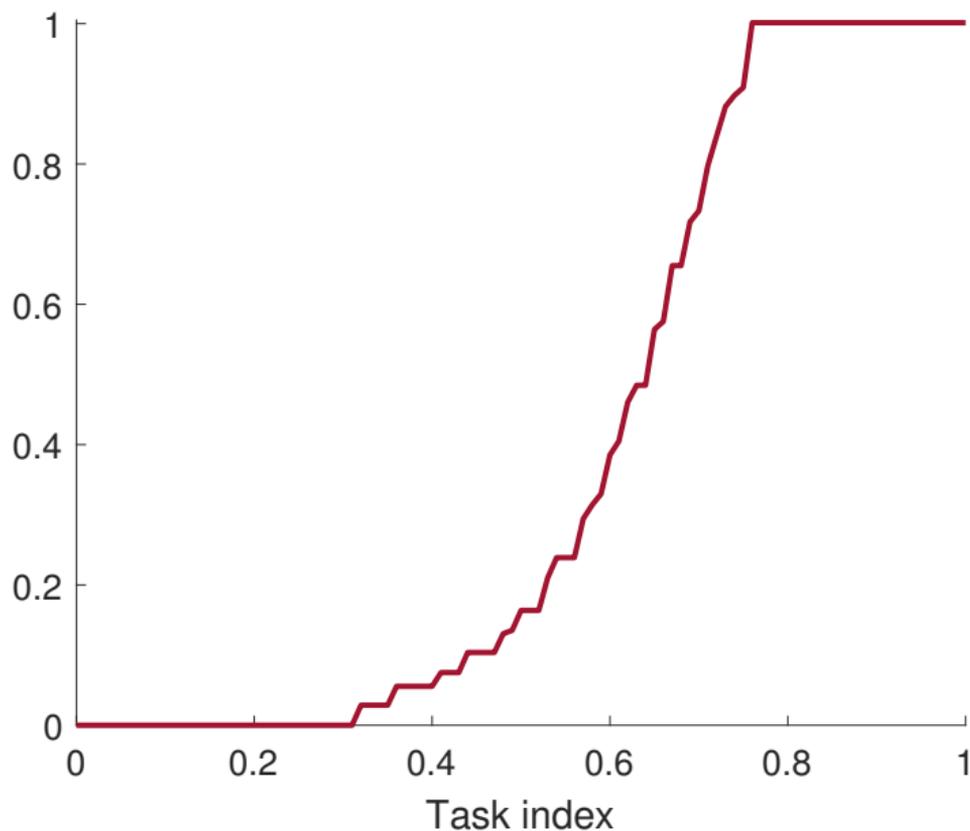
Calibration

Results

Distribution of Household Emissions in the US Economy

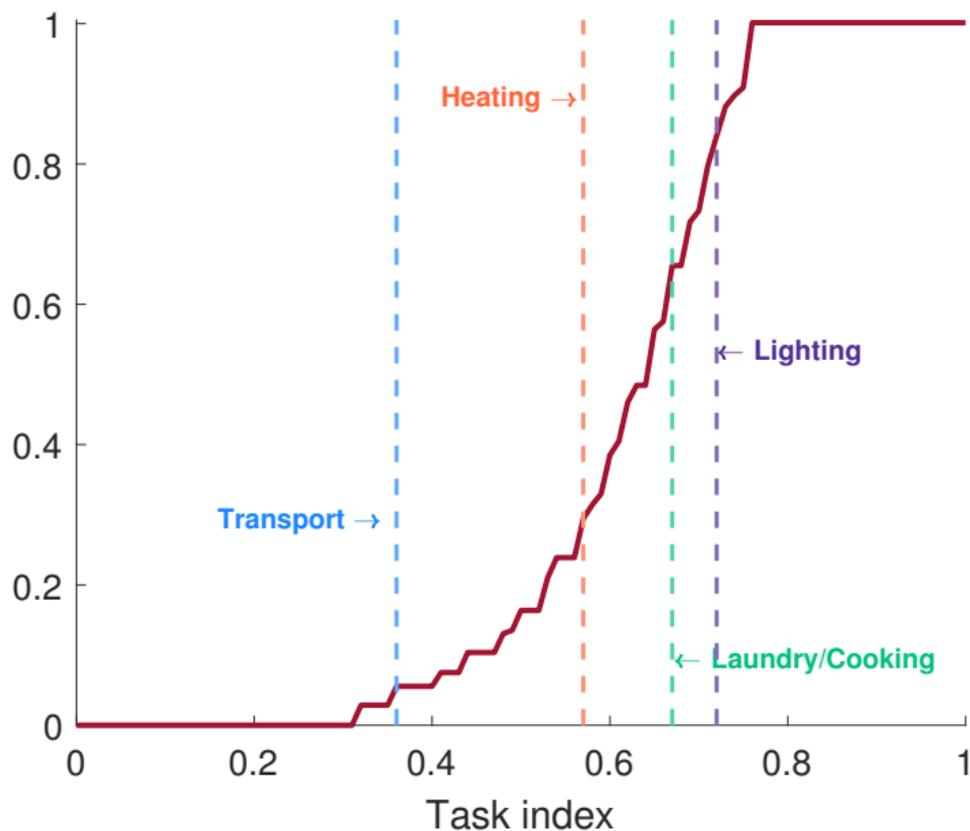- Biggest emitters: high-income less-concerned households
- Smallest emitters: low-income households
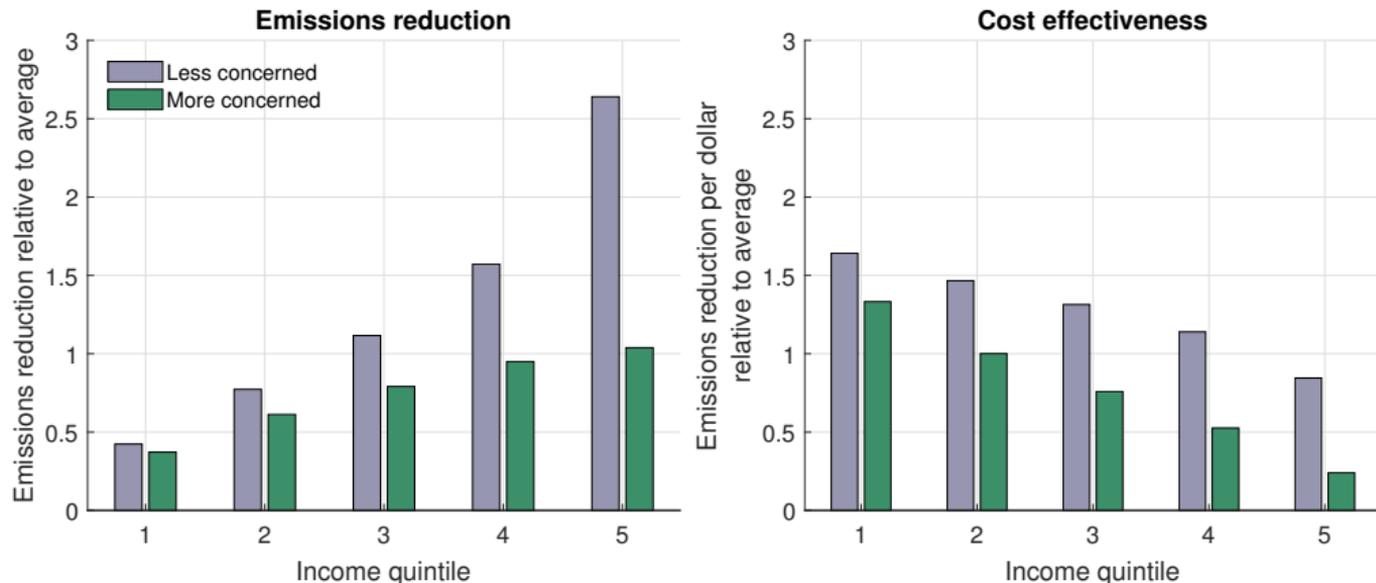
Fraction of HHs Using Clean Equipment For Each Task

Experiment 1: Uniform Subsidy

- Reduces price of all clean equipment from p^c to $(1-s)p^c$

- Choose subsidy to reduce household emissions by 10 percent

  - IRA projected to reduce economy-wide emissions by ≈ 15 percent
  - Much of this is through improvements in electricity sector

- Finance with proportional income tax

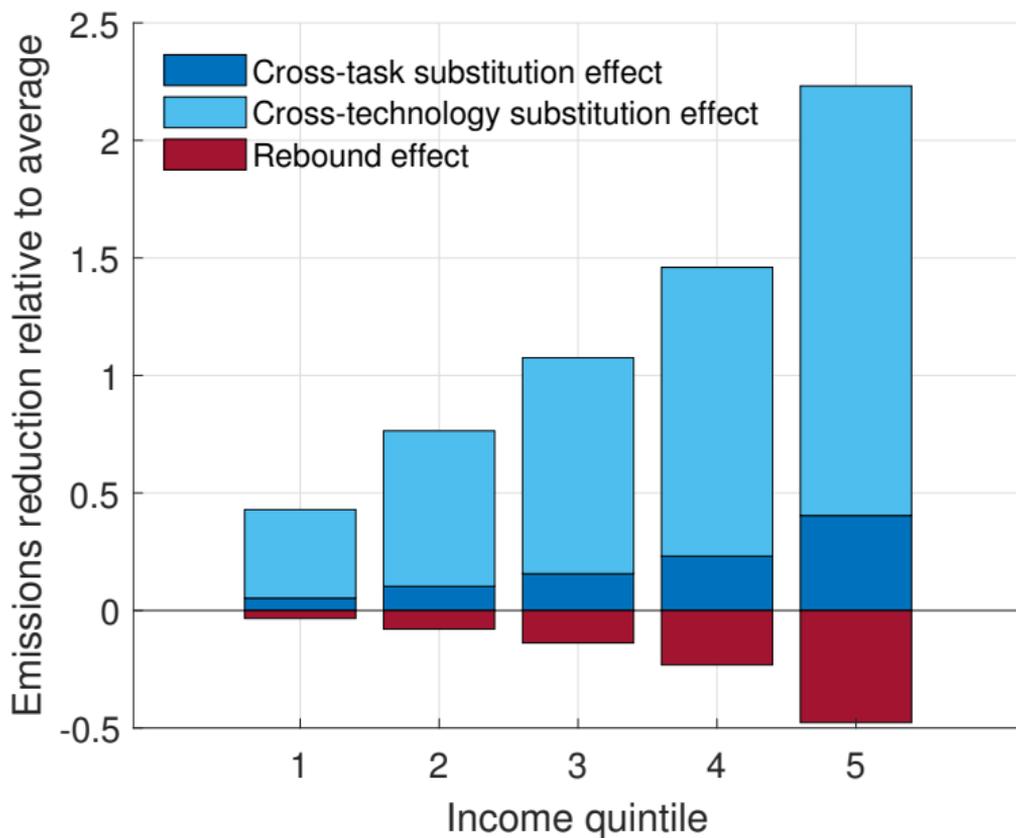# Distribution of Emissions Reduction and Cost Effectiveness

- Biggest reducers: high-income less-concerned households
- Most cost effective: low-income households

Three Channels Through Which the Subsidy Affects Emissions

1. Cross-technology substitution: use clean equipment for more tasks

2. Cross-task substitution: substitute clean for dirty tasks

3. Rebound effect: change level of energy tasks

Decomposition

Experiment 2: Cost-Minimizing Subsidy

- 10% reduction in household emissions, finance with tax on labor income

- Policymakers choose:

  1. Strength of income phase out
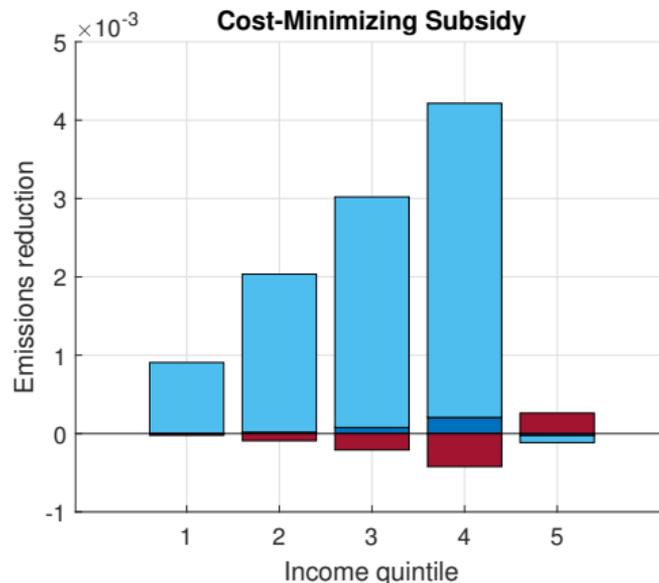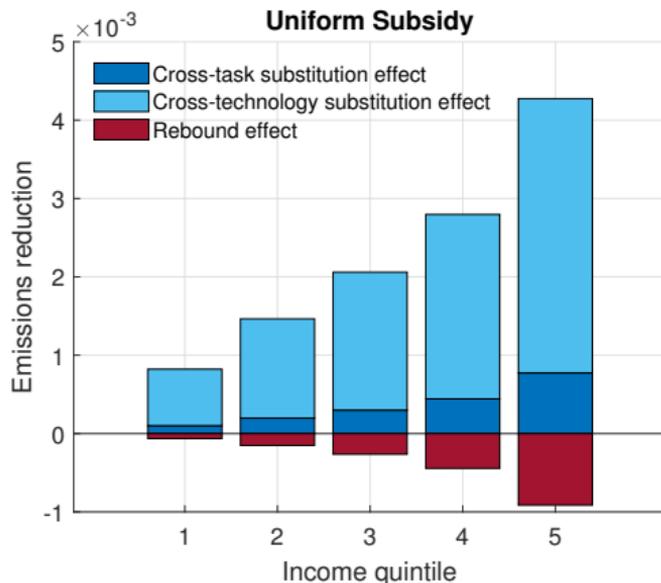
  2. Which range of clean equipment to subsidize

Cost-Minimizing Subsidy vs. Uniform Subsidy

	Subsidy (percent)	Cost (percent of GDP)	Eligible HHs (income deciles)	Eligible tasks
Cost-minimizing	19	0.3	1-8	$j \in [0.35, 0.66]$
Uniform	11	2.4	1-10	$j \in [0, 1]$

Which equipment is subsidized?

- Heat pumps, cooking and laundry appliances are within the targeted range

- LEDs and EVs are outside the targeted range

Decomposition: Cost-Minimizing Subsidy

Conclusion

- Households are motivated to reduce emissions by both financial and environmental factors

- Model of home production and climate that incorporates both motives

- Find large cost-savings from carefully designing household subsidies

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Thank you!