A Theory of Investment for Energy-Efficient Technologies

Part I

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Review

Research Question

What places attract energy-efficient buildings? How do neighborhood and area characteristics relate to the number of certified energy-efficient buildings?

We need some theory to describe how economic agents might invest in energy-efficient technologies.

Paper & Purpose

Hausman, Jerry A, "Individual discount rates and the purchase and utilization of energy-using durables," *The Bell Journal of Economics*, 1979, pp. 33–54.

How do households decide

(i) what appliance to purchase?

(ii) how often to use that appliance?

The Model

Setup, Utilization Decision, Purchase Decision

Defining the Agent's Preferences

The model focuses on Air Conditioners specifically.

$$U(x, z(\tau)) = x - \eta \left(\frac{a}{2}\right) (z(\tau))^2 \tag{1}$$

- x : Composite Good
- $z(\tau)$: Degree-hours of discomfort at thermostat setting τ
- η : Proportion of time at home
- a : Constant

Defining the Agent's Budget

$$y = \underbrace{p\left(\frac{\eta\lambda H(\tau)}{EER}\right)}_{\text{Operating Cost}} + \underbrace{\psi\rho}_{\text{AC Cost}} + \underbrace{x}_{\substack{\text{Non-AC} \\ \text{Spending}}} \tag{2}$$

- y : Income
- p : Price of Electricity
- $KWH = \frac{\eta\lambda H(\tau)}{EER}$: "Quantity" of Electricity
  - λ : "Size" of the AC
  - $H(\tau)$: Degree-Hours Operating
  - EER : Energy Efficiency Rating
- ψ : Discount/Durability Factor
- ρ : Price of the AC

Defining the Agent's Objective

$$\max U(x, z(\tau)) \qquad \text{s.t.} \qquad y = p\left(\frac{\eta\lambda H(\tau)}{EER}\right) + \psi\rho + x$$

Or better yet,

$$\max U = y - p\left(\frac{\eta\lambda H(\tau)}{EER}\right) - \psi\rho - \eta\left(\frac{a}{2}\right)(z(\tau))^2 \qquad (3)$$

Figure 1: Utilization Decision

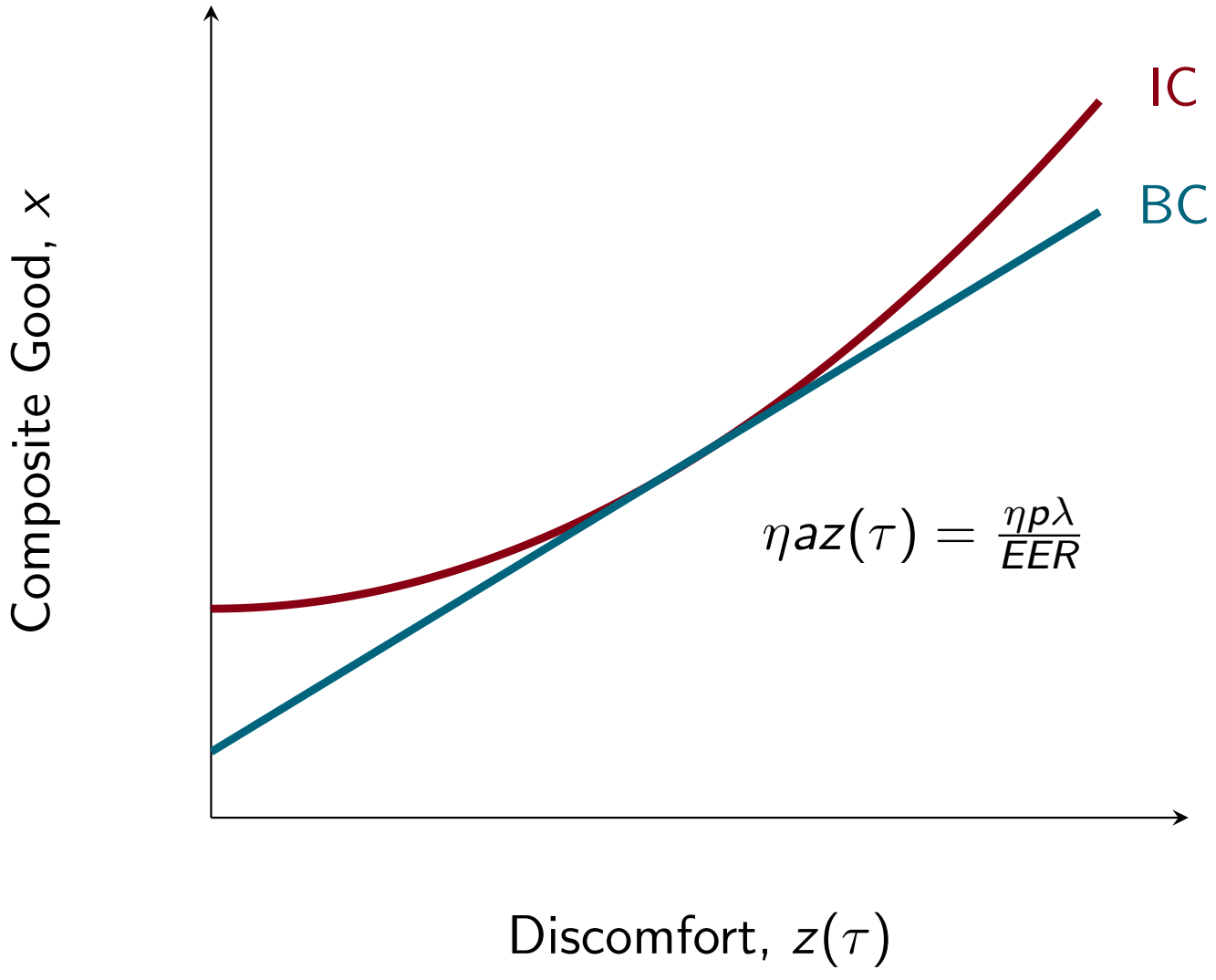
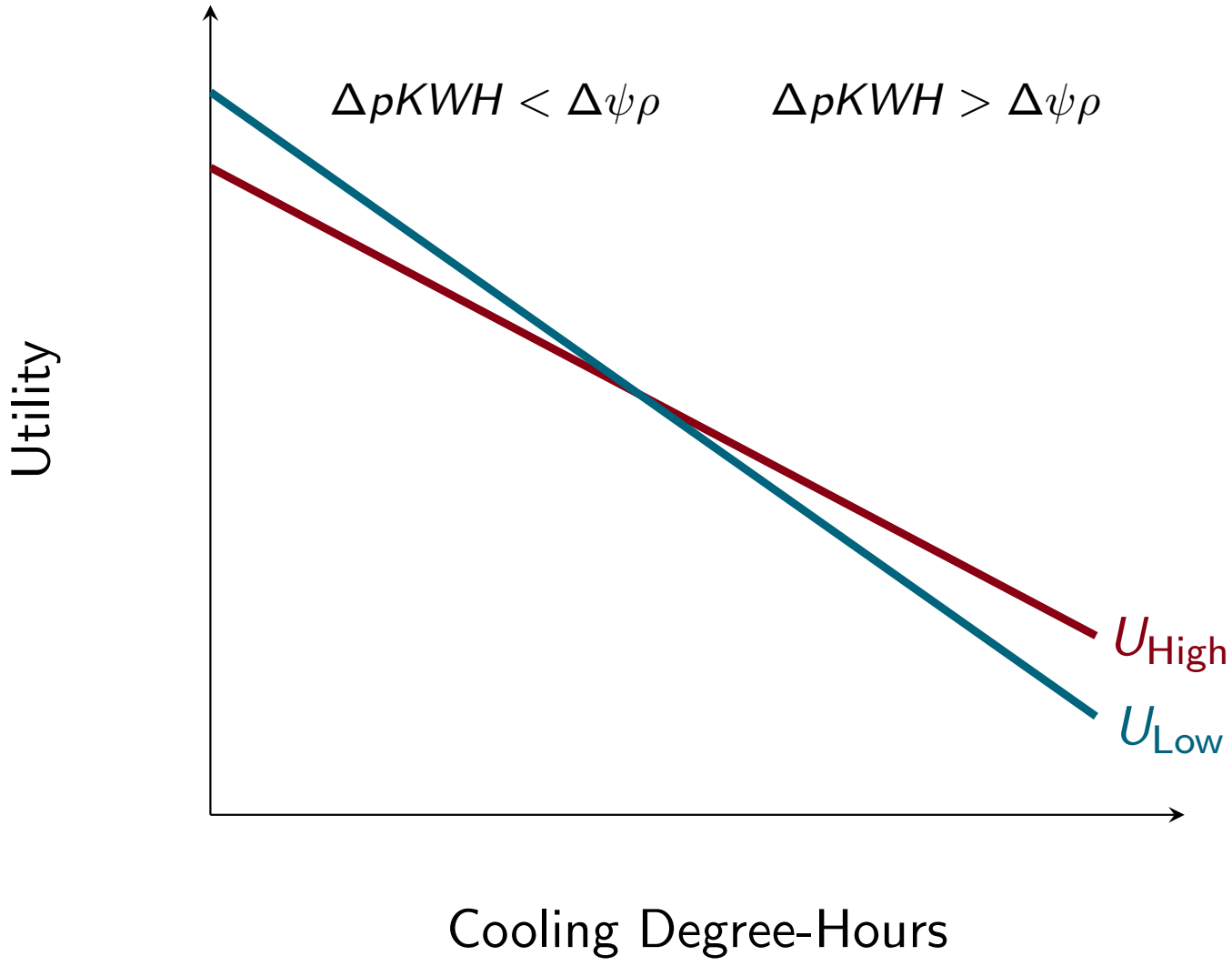


Figure 2: High-Efficiency and Low-Efficiency ACs



Purchase Decision

Agent k's utility from appliance i is:

$$u_{ik} = \underbrace{y + \bar{\beta}_1 p_k KWH_{ik} + \bar{\beta}_2 \rho_i + \bar{\beta}_3 (p_k BTU_k / EER_{ik})^2}_{\text{Deterministic}} + \underbrace{\varepsilon_{ik}}_{\text{Stochastic}} \tag{4}$$

The probability that appliance i maximizes agent k's utility is:

$$s_{ik} = \Pr\{u_{ik} > u_{jk}, \text{for all } j \neq i\} \tag{5}$$

Two main factors that affect this probability: Climate and the Price of Electricity

Figure 3: Climate Simulation

$$u_{ik} = y + \bar{\beta}_1 p_k KWH_{ik} + \bar{\beta}_2 \rho_i + \bar{\beta}_3 (p_k BTU_k / EER_{ik})^2 + \varepsilon_{ik}$$

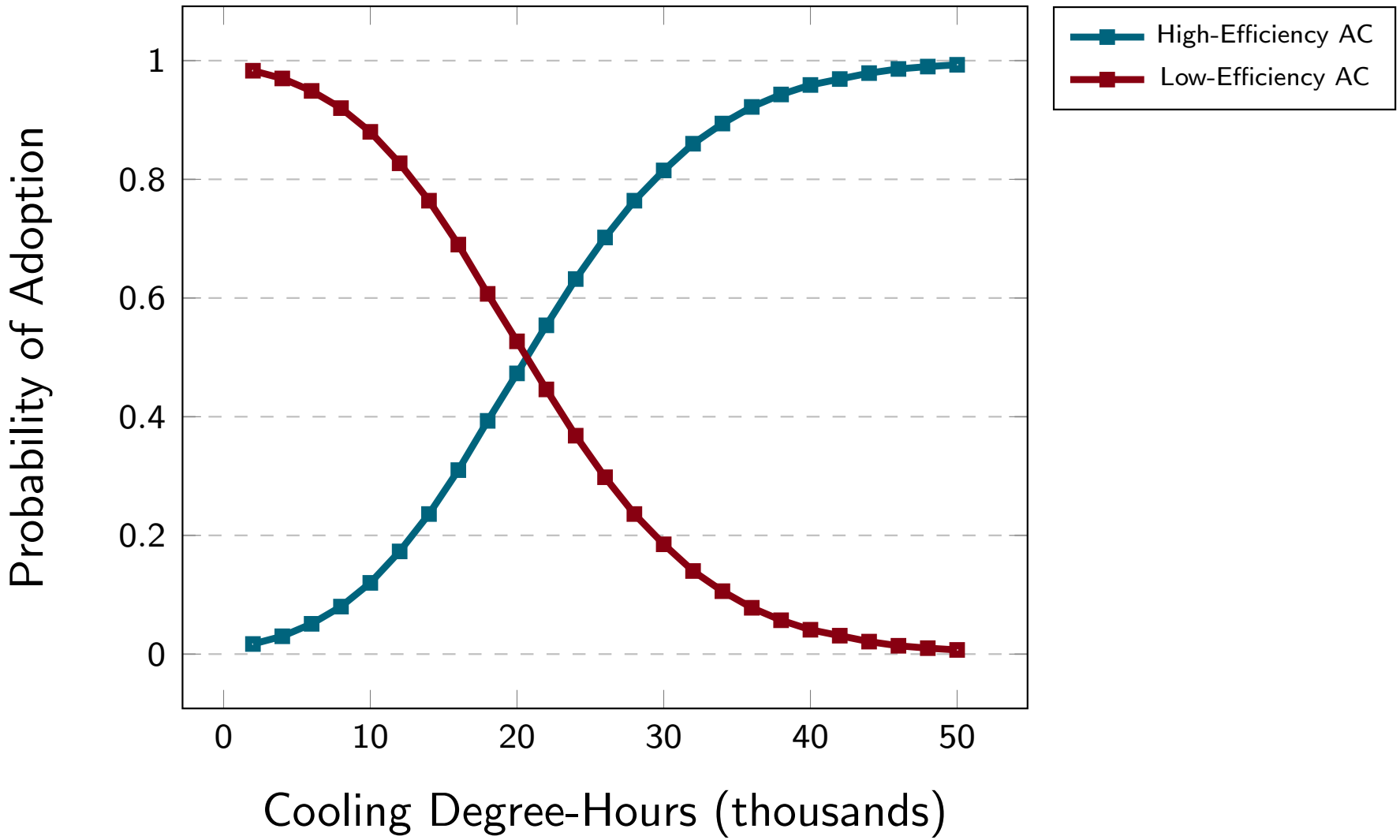
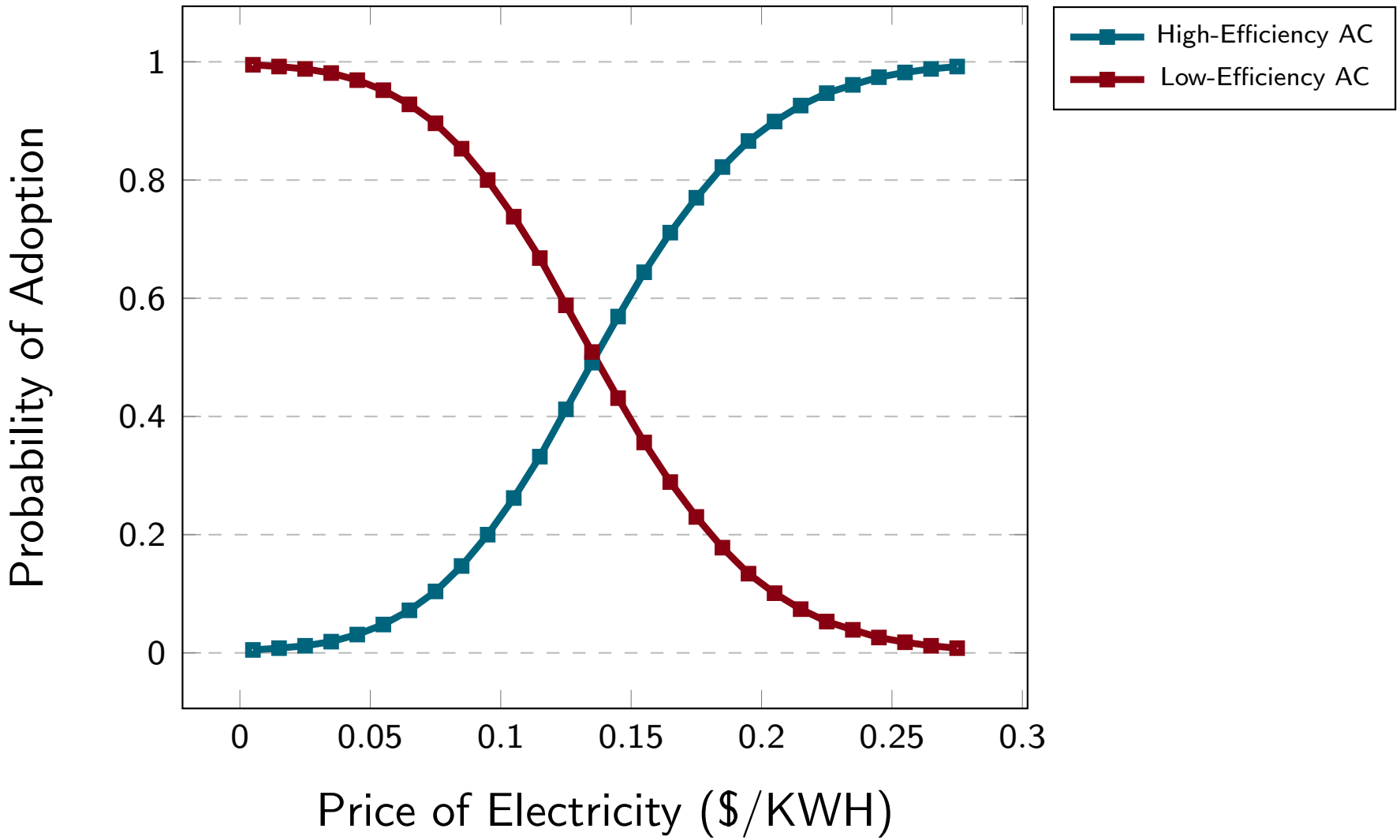


Figure 4: Electricity Price Simulation

$$u_{ik} = y + \bar{\beta}_1 p_k KWH_{ik} + \bar{\beta}_2 \rho_i + \bar{\beta}_3 (p_k BTU_k / EER_{ik})^2 + \varepsilon_{ik}$$



Results

Table 1: Implied Discount Rates by Income

Income	Observations	β_2	Discount Rate
$< \$6000$	6	-0.118	89%
\$6000 – \$10000	15	-0.075	39%
\$10000 – \$15000	16	-0.061	27%
\$15000 – \$25000	17	-0.049	17%
\$25000 – \$35000	8	-0.039	8.9%
\$35000 – \$50000	3	-0.031	5.1%

Adapted from (Hausman, 1979)

Contribution & Summary

- This paper is the first major paper to suggest that the under-utilization of energy-efficient technologies is more than just an externality problem

$$\text{High } r \Rightarrow \text{High } \beta_2 \Rightarrow \text{Emphasize Purchase Price}$$

- Leads to a wider literature exploring this apparent gap

- Provides an interesting model for the adoption of EE technology

Next Week

- Incorporate Hausman's random utility model into an urban sorting model

- **Allcott, Hunt and Michael Greenstone**, "Is there an energy efficiency gap?," *Journal of Economic Perspectives*, 2012, *26* (1), 3–28.

References

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