Time Preferences and Energy Efficiency
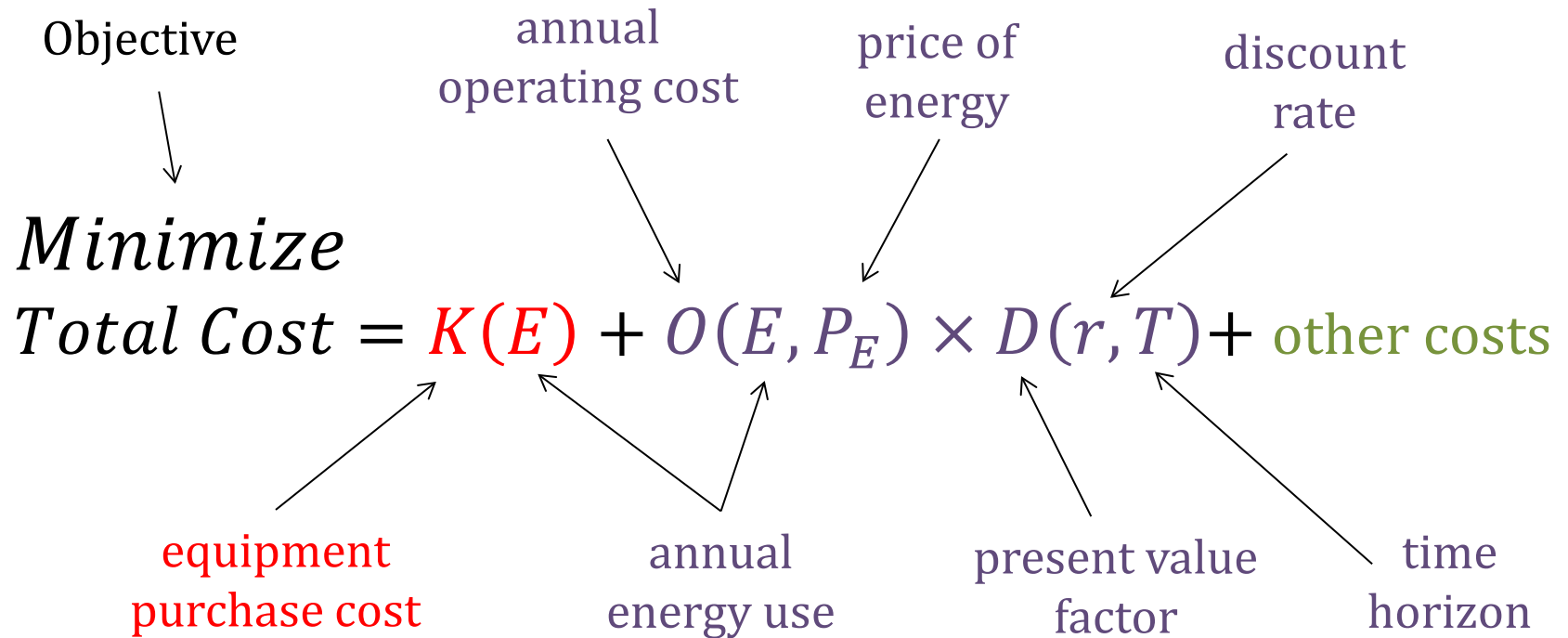
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Energy efficiency: the economic decision problem

Objective

annual operating cost

price of energy

discount rate

$$Minimize$$
$$Total\ Cost = K(E) + O(E, P_E) \times D(r, T) + \text{other costs}$$

equipment purchase cost

annual energy use

present value factor

time horizon

Role of time preference in energy efficiency choices

- Prior studies have not considered the role of individual time preference in evaluating the degree to which there is an energy-efficiency "gap" or "paradox"

- Instead, the standard approach is to either:
  - assume observed choices are cost-minimizing, and compute an average "implicit discount rate" (e.g., Hausman 1979)
  - or assume a particular discount rate and then judge the degree to which observed choices are "rational" (i.e., cost-minimizing) (e.g., Alcott and Wozny 2014)

- Surprising, given the central importance of individual time preferences to the profitability of energy efficiency choices

- Importance of individual discount rates is further heightened by experimental findings that elicited time preferences are quite heterogeneous (e.g., Frederick, Loewenstein, O'donoghue 2002)

Prior findings from energy efficiency choice experiment
"Nudging Energy Efficiency Behavior: The Role of Information Labels"
Newell and Siikamäki (2014) *J Assoc Env Res Econ*

- Willingness to pay for energy efficiency is significantly affected by
  - information content of labels
  - discount rate assumptions (individual vs. uniform 5%)
- Monetary operating cost information is most important
  - information on physical energy and CO_2 emissions have additional, but lesser impact on choices
- Whether you "accept" individual discount rates has a significant implication for the degree of labeling "nudge" and/or support for other efficiency policies
  - using *individual discount rates*, current Energy Guide label yields roughly cost-efficient WTP for energy efficiency
  - using a *lower 5% discount rate*, the more suggestive Energy Star logo or EU-style efficiency grade appear to induce more cost-efficient behavior

This paper: Closer examination of individual time preferences and energy efficiency

- What influence do individual discount rates have on indicators of household preferences for energy efficiency?
  - choices about energy operating costs of products
  - required payback periods
  - tax credits for energy efficient products

- What are the most important determinants of individual discount rate heterogeneity?
  - demographics (eg, education, household size, race)
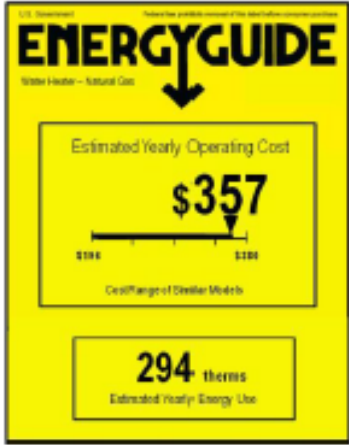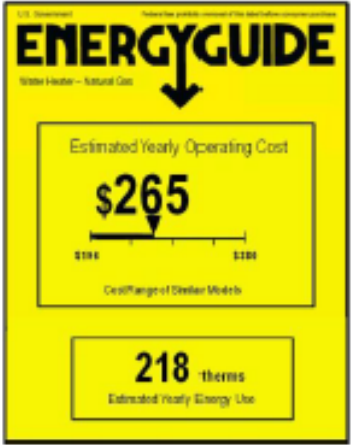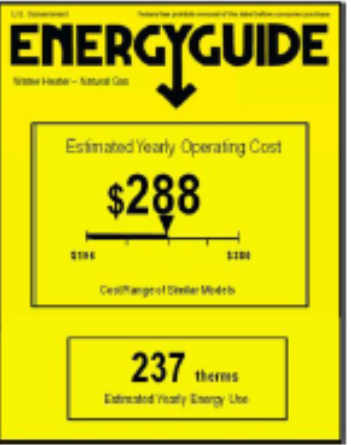 - financial situation (eg, credit score, income)

Background on household choice experiment

- Household survey (1,217 representative sample US single-family households)
- Elicit choices between different water heater alternatives that vary randomly (but realistically) by price and energy use and the type of information available for decisions (i.e., labels)
- State-of-the art choice experiment design
  - fully computerized survey instrument which is customized as each survey respondent progresses through it
  - labeling approach randomly varied by respondent (~100 per label)
- Use elicited data to estimate households' valuation of energy efficiency under different labeling treatments
- Also elicit data on individual discount rates, credit situation, likelihood of moving, payback requirements
- Survey data also includes rich individual demographic information
- Choice experiment data estimated in combination with random utility and multinomial logit models, controlling for heterogeneity

Choice Question Example 1

Consider choosing between the following three water heater options. Please think that these are the only options available to you and you have to make the purchase.

Water Heater Decision 1

	Water Heater A	Water Heater B	Water Heater C
Purchase price	**$400**	**$650**	**$550**
Energy Use	Estimated Yearly Operating Cost **$357** 294 therms Estimated Yearly Energy Use	Estimated Yearly Operating Cost **$265** 218 therms Estimated Yearly Energy Use	Estimated Yearly Operating Cost **$288** 237 therms Estimated Yearly Energy Use

Your choice from these options?	☐ A	☐ B	☐ C

Choice Question Example 2

Consider choosing between the following three water heater options. Please think that these are the only options available to you and you have to make the purchase.

Water Heater Decision 1

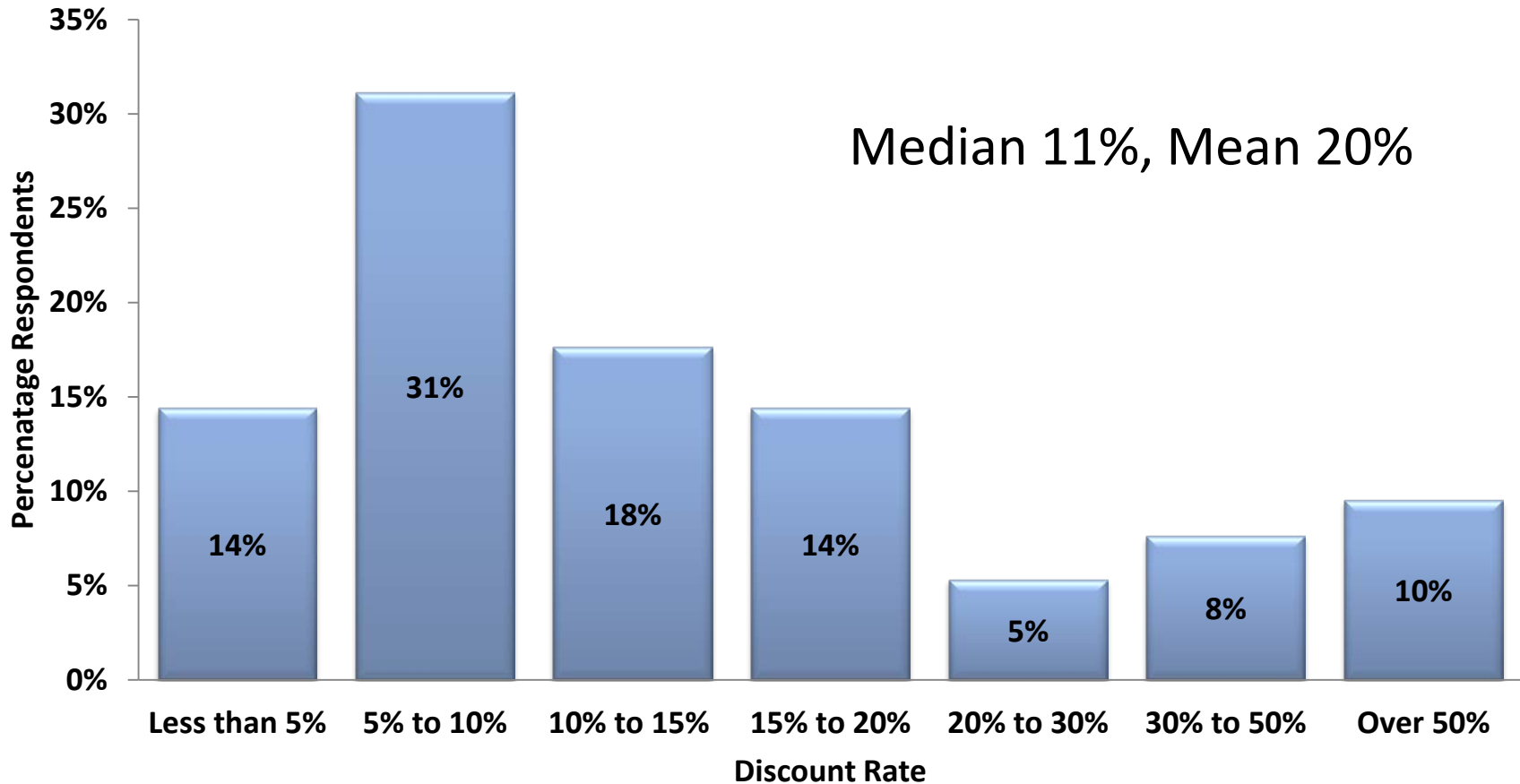|	Water Heater A	Water Heater B	Water Heater C
Purchase price	**$400**	**$650**	**$550**
Energy Use	More efficient A B C D E F G (G selected) Less efficient — Estimated Yearly Operating Cost **357**	More efficient A B C D E F G (C selected) Less efficient — Estimated Yearly Operating Cost **$265**	More efficient A B C D E F G (D selected) Less efficient — Estimated Yearly Operating Cost **$288**
Your choice from these options?	☐ A	☐ B	☐ C

Eliciting individual-specific discount rates

- Cash-over-time choice approach similar to prior work
  - e.g., "Eliciting Individual Discount Rates," M Coller, M Williams, *Experimental Economics, 1999)*
- Elicit choices between two cash payment alternatives
  - Payment A is delivered in one month
  - Payment B is delivered in 12 months
  - Both tax free, certain, the only difference is the delivery date and payment amount
- Payment A always equals $1000; Payment B is greater
- Sequence of questions that vary Payment B
  - Payment B has increasing values ($1019-$2500) equal to $1000 present value at discount rates of 2% up to 100%
  - Stop when the respondent switches to the 12-month option
- Individual discount rate implicit in the choices

Cash-over-time choice problem

Payment A (in 1 month)	vs.	Payment B (in 1 year)	Discount rate for PV of Payment A and B to be equal
$1,000		$1,019	2%
$1,000		$1,037	4%
$1,000		$1,057	6%
$1,000		$1,076	8%
$1,000		$1,096	10%
$1,000		$1,116	12%
$1,000		$1,137	14%
$1,000		$1,158	16%
$1,000		$1,179	18%
$1,000		$1,201	20%
$1,000		$1,258	25%
$1,000		$1,317	30%
$1,000		$1,443	40%
$1,000		$1,581	50%
$1,000		$1,733	60%
$1,000		$1,989	75%
$1,000		$2,501	100%

What individual discount rates are revealed by the cash-over-time choice task?

**Individual Discount Rates, Percentage Distribution by Category (n=1217)**

Median 11%, Mean 20%

Chart — Percentage Respondents (y-axis, 0% to 35%) vs. Discount Rate (x-axis):
- Less than 5%: 14%
- 5% to 10%: 31%
- 10% to 15%: 18%
- 15% to 20%: 14%
- 20% to 30%: 5%
- 30% to 50%: 8%
- Over 50%: 10%

WTP for $1 reduction in PV operating costs, by label

UNDERVALUATION OF SAVINGS — OVERVALUATION OF SAVINGS

A. Simple operating cost information
- $0.70 (individual discount rates)
- $0.55 (5% discount rate)

B. Relative operating cost and Energy Guide added to Label A
- $0.68
- $0.52
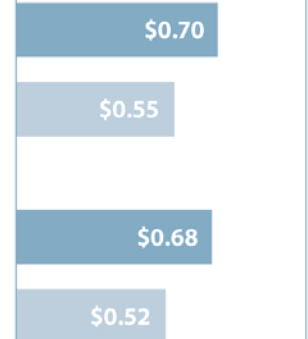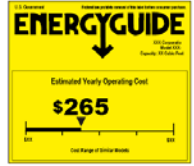
C. CO_2 information added to Label B
- $0.93
- $0.61
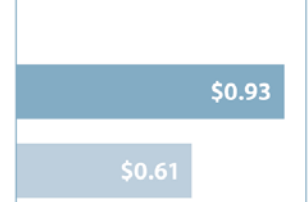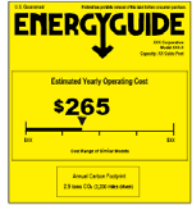
D. The current Energy Guide: Physical energy information added to Label B
- $1.02
- $0.70
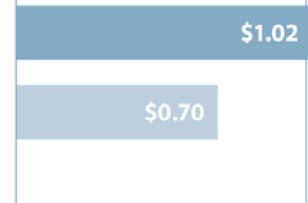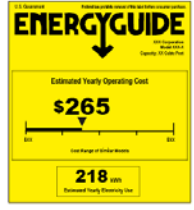
E. Energy Star added to Label D
- $1.36
- $0.99

F. EU style relative grade
- $1.34
- $1.01
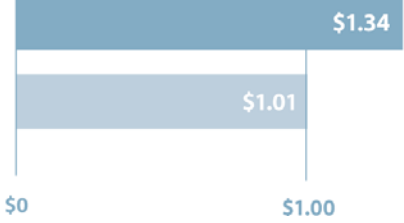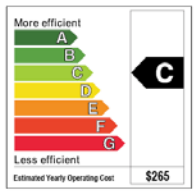
WTP based on individual discount rates
WTP based on 5% discount rate

$0 $1.00

12

Time preferences and energy efficiency choices

- Estimate energy efficiency choices as a function of individual discount rates, controlling for characteristics of respondent/their household/home
    1. WTP for energy efficiency based on product choice experiment, using random utility/multinomial logit model
    2. WTP for energy efficiency based on separate question that directly asked maximum WTP for $10 reduction in annual energy costs, using OLS
    3. Payback period required to recover energy efficiency investments, using OLS
    4. Energy efficiency tax credit claims, using OLS

What *payback period* do these consumers use?

How quickly should a more energy-efficient alternative recover its additional purchase cost? (n=1217)
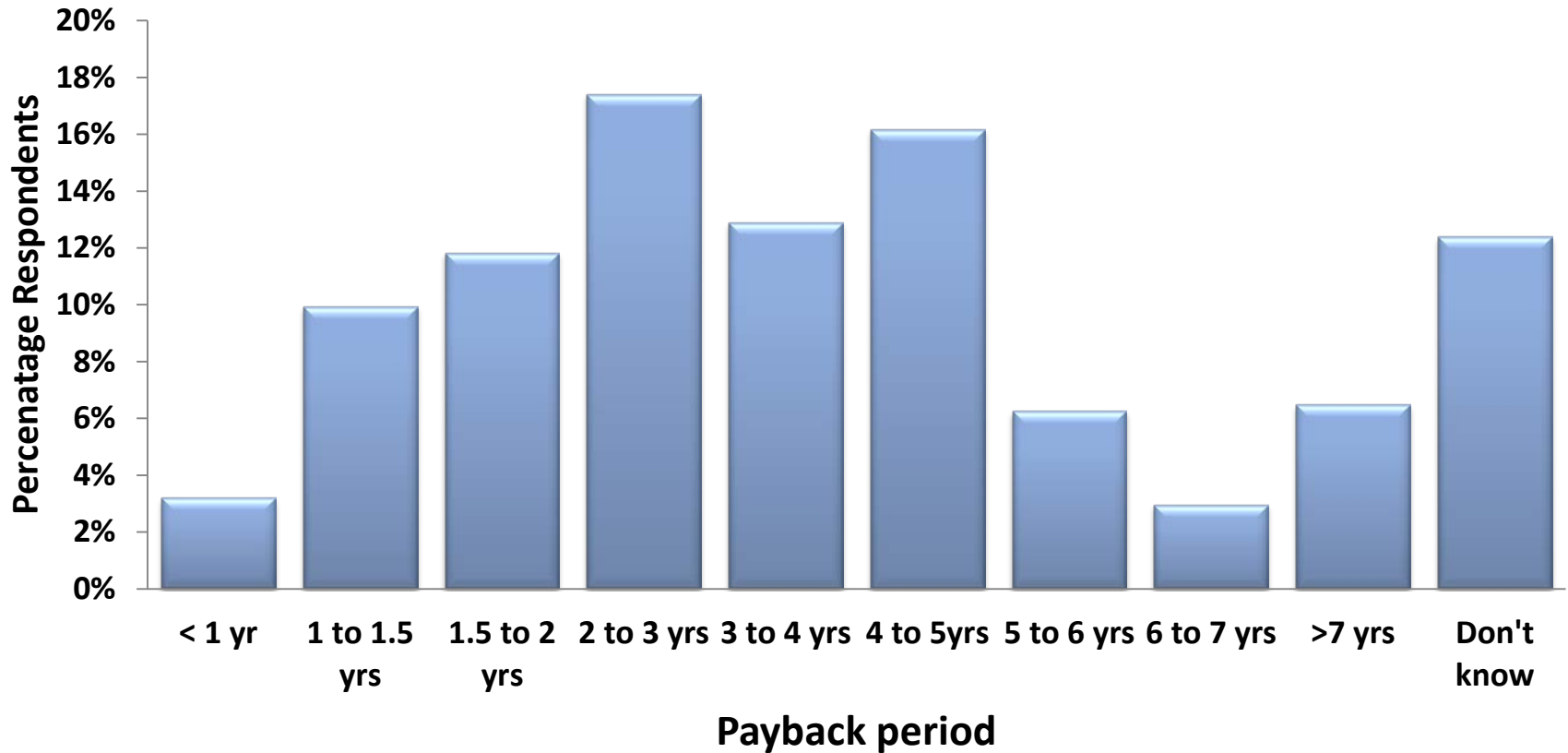
median and mean = 3 to 4 years

Estimated coefficient on individual discount rate when predicting preferences for energy efficiency

	Choice-based WTP for $1 annual energy savings	Stated WTP for $10 annual energy savings	Payback Period Required for EE	Federal EE Tax Credit Claims
Model 1 (simple)	-0.017***	-0.100***	-0.076***	-0.028*
Model 2 (incl. income)	-0.016**	-0.100***	-0.075***	-0.024*
Model 3 (incl. income, credit score)	-0.016***	-0.080**	-0.061***	-0.019
Model 4 (incl. many controls)	-0.016***	-0.079**	-0.046*	-0.017

Significant at the 1***, 5**, and 10* percent levels.

Influence of characteristics of respondent and their household on their time preferences

- OLS prediction of individual elicited discount rates to understand drivers of heterogeneity
- Education matters greatly for discount rates
  - some college (8-9% lower) and bachelors or more (13-14% lower) than no college, ceteris paribus
- Black, non-hispanic respondents had higher discount rates, as did larger households
- Income has a distinct association, but not always statistically significant
  - results suggests discount rates may spike at very low incomes (<$10K annually)
- Lower credit scores are associated with significantly higher individual discount rates

Conclusions

- Individual willingness to invest in energy efficiency is systematically lower for those with higher discount rates

- Individual discount rates are quite heterogeneous, and systematically depend on education, financial status, and other demographic factors

- Overall, findings imply that individual discount rates are critical for understanding energy efficiency investments, the energy efficiency gap/paradox, and for guiding energy efficiency policy