A Comparison of Contests and Contracts to Deliver Cost-Effective Energy Conservation

Teevrat Garg	Jorge Lemus	Guillermo Marshall	Chi Ta
UCSD	UIUC	UBC Sauder	Virginia Tech

Questions

- In many countries, the electrical grid experiences strain during the summer months.

- When electricity prices are fixed by regulation, electric utilities use non-price mechanisms to incentivize energy conservation.

- Incentivizing costly, unobservable effort (e.g., energy conservation) remains a long-standing challenge in economics.

- Two widely used mechanisms to incentivize effort:
  - <u>individual contracts</u> (e.g., a bonus for meeting a fixed target)
  - <u>contests</u> (e.g., a prize for the top performer).
  - Which is more cost-effective is theoretically ambiguous (e.g., Green and Stokey, 1983)

Questions

1. Does giving households incentives to conserve energy work?
   - May increase reliability by decreasing demand at peak hours
   - May decrease emissions when marginal plants burn fossil fuels
2. What is the best way to design incentives to conserve energy?
   - Long-standing economics question: Contests or Contracts? (Green and Stokey, 1983)
3. Is there a business case for energy conservation programs?
   - Even without carbon pricing?

This Paper

- Partnership with utility company in Hanoi, Vietnam (EVN Hanoi)
- A randomized controlled trial (RCT)
    - Households are assigned to contracts or contests with payouts tied to energy reduction relative to their own prior consumption
- Build a structural model of household energy use
    - Estimate using experimental data
    - Compare contests and contracts fixing expected payment
- Compute marginal abatement costs

Contests versus Contracts

Contests versus Contracts

- Households asked to save energy (measured relative to own prior consumption).

- A household's consumption depends on
  - expected needs
  - effort to conserve
  - a common shock (e.g., weather)
  - and an idiosyncratic shock (e.g., visitors)

Contests versus Contracts

Two options to incentivize effort:

1. Contract (aka rebate)
   - Absolute performance: e.g., $5 if you save 5%
   - Performance standard is fixed
     - May be ineffective in the presence of "common shocks" (e.g., extreme heat)

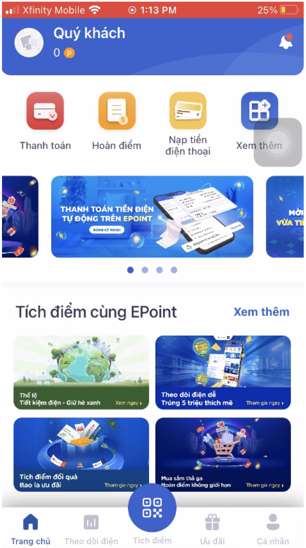
2. Contest
   - Relative performance
   - Performance standard is random
     - Standard becomes "harder" when the variance of idiosyncratic shocks increases

Which dominates is theoretically ambiguous (Green and Stokey, 1983)

Experiment

Experimental Design: Background and Interface

- Hanoi, Vietnam
- Utility company: EVN Hanoi
- +2.8 million electricity consumers
- Utility's mobile app has +800,000 users
- App features: display of daily electricity use and estimated bill, online payment, point-based rewards



Experimental Design: Sample

- 11,194 residential customers
  - These households registered for the study
- Randomized participants into 1 control and 3 treatment groups
- Treatment duration: July 15, 2023 – August 13, 2023

Experimental Design: Treatments

1. Control: no incentive
2. Treatment 1: Contract 1
   - \$4.34 for 5% savings, \$6.52 for 10% savings, \$10.86 for 15%
3. Treatment 2: Contract 2
   - \$6.52 for 10% savings, \$10.86 for 15%, \$15.22 for 20% savings
4. Treatment 3: Contest
   - 50 participants
   - \$87 prize to household that saved most

$$\text{Energy savings} = \frac{\text{Energy use during treatment period} - \text{Energy use in baseline}}{\text{Energy use in baseline period}}$$

where baseline period is July 15, 2022 – August 13, 2022.

Experimental Design: Data

Household level

- Daily electricity use panel data starting from July 1, 2022
- Time logs of app usages

Balance analysis

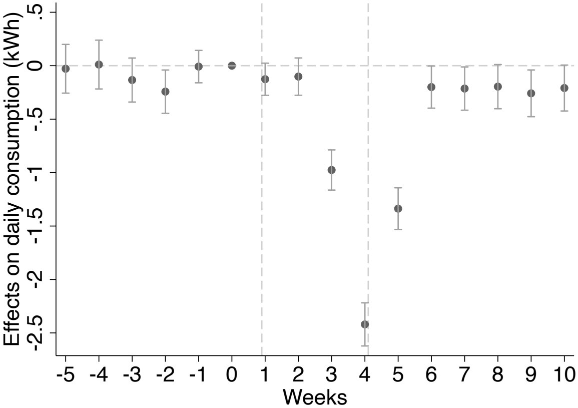
Results

Cross-sectional Variation

	Daily consumption (kWh)	
Contract 1	-0.763	-0.914
	(0.180)	(0.087)
Contract 2	-0.538	-0.794
	(0.182)	(0.089)
Contest	-0.629	-0.835
	(0.182)	(0.093)
Controls	No	Yes
Observations	329,752	329,192
Mean	12.998	12.999
Test	0.454	0.346

Notes: Standard errors clustered at the household level in parentheses. All specifications include day fixed effects.

Within-household Variation



Notes: Standard errors clustered at the household level in parentheses. An observation is a household–day combination. All specifications include day fixed effects and household fixed effects.

Treatment-by-treatment graphs

Summary of Results

- During the experimental period, all three incentives led to reductions in monthly electricity consumption of 28-30 kWh

- We cannot reject that treatment effects are equal

- Average payout per household:
  - Contract 1: \$3.14
  - Contract 2: \$3.21
  - Contest: \$1.86

Bottom line: Contests are 40% cheaper while delivering similar energy savings

Empirical Model

Empirical Model

- Propose and estimate a structural model of household energy use
- Why a model?
  - Compute optimal contract and compare against a contest, keeping average payout fixed
  - Theory is ambiguous

Empirical Model

- Household i's ideal energy consumption: $S_i \geq 0$

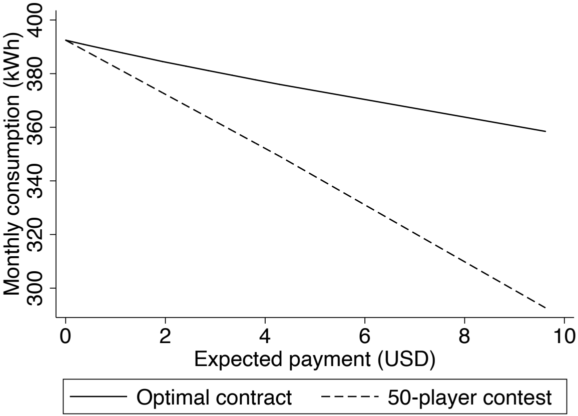
- Realized consumption: $\hat{e}_i = e_i + \varepsilon_i$
  - e_i: choice variable
  - $\varepsilon_i \sim F_i$: idiosyncratic shock

- $I_i(\hat{e}_i, \hat{e}_{-i})$: expected reward from an incentive program

- Household chooses e_i by solving:

$$\max_{e_i} E_{\varepsilon_i} \left[\underbrace{-\gamma_i \cdot (e_i + \varepsilon_i - S_i)^2}_{\text{loss function}} + \underbrace{E_{\varepsilon_{-i}}[I_i(e_i + \varepsilon_i, \hat{e}_{-i})]}_{\text{incentive}} - \underbrace{c \cdot (e_i + \varepsilon)}_{\text{power bill}} \right]$$

Empirical Model



- Our model estimates suggest that a contest outperforms the optimal contract, keeping average payout fixed

Concluding Remarks

- New evidence on the question of “contests vs contracts”
- Energy conservation programs can be a tool to tackle reliability and emissions
- These programs can make business sense
  - MAC < 0 with the inefficient, marginal plant (Oil) Details
  - MAC $= \$84.54$ with an inframarginal coal plant Details
  - Carbon offset revenue can give these programs a boost
- Next on the agenda: scalability

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Feedback welcome. Thank you.

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icom
Together we make changes

UC San Diego
DEEP DECARBONIZATION INITIATIVE

Balance Analysis: Past Electricity Consumption

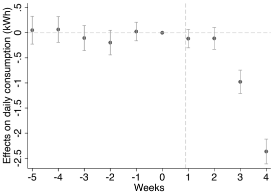
Back to data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Control	Treatment 1		Treatment 2		Treatment 3		F-test
Month	Mean (kWh)	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	p-value
July 2022	12.388	0.233	0.164	0.111	0.500	0.130	0.430	0.581
August 2022	11.488	0.211	0.170	0.160	0.295	0.154	0.312	0.543
September 2022	10.621	0.140	0.329	0.134	0.350	0.116	0.413	0.733
October 2022	8.441	0.077	0.482	0.123	0.260	0.099	0.366	0.697
November 2022	8.324	0.079	0.462	0.131	0.222	0.133	0.215	0.562
December 2022	8.601	0.097	0.423	0.164	0.174	0.072	0.549	0.594
January 2023	8.814	0.114	0.377	0.223	0.081	0.027	0.827	0.294
February 2023	8.762	0.086	0.480	0.134	0.265	0.079	0.512	0.733
March 2023	8.423	0.116	0.309	0.119	0.286	0.055	0.619	0.677
April 2023	9.053	0.026	0.832	0.168	0.173	0.070	0.566	0.541
May 2023	11.447	0.120	0.439	0.235	0.130	0.214	0.166	0.410

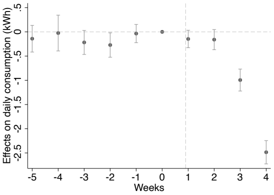
Notes: An observation in each row is a household. Columns 2-7 report the coefficients and p-values from OLS regressions of average daily consumption on three indicators: treatment 1, treatment 2, and treatment 3. Column 8 reports the p-value from a joint test of statistical significance of all three indicators.

Within-household Variation

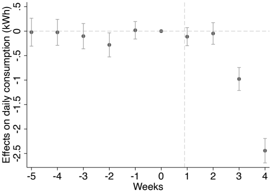
Go back



A) Contract 1 vs Control



B) Contract 2 vs Control



C) Contest vs Control

Marginal Abatement Cost

Go back

Marginal Plant (Oil)

- Price per kWh: \$0.11
- Marginal cost of generation of marginal plant: \$0.2609
- Reduction per month per household (kWh): 28.14
- Avoided loss per household: \$4.24
- Average payout per household: \$1.86
- Reduction in emissions per household (tons of CO2): 0.0292

$$MAC = \frac{\$1.86 - \$4.24}{0.0292} = -\$81.66$$

Marginal Abatement Cost

Go back

Second-last Plant (Coal)

- Price per kWh: \$0.11
- Marginal cost of generation of marginal plant: \$0.0913
- Reduction per month per household (kWh): 28.14
- Lost profit per household: \$0.52
- Average payout per household: \$1.86
- Reduction in emissions per household (tons of CO2): 0.0282

$$MAC = \frac{\$1.86 + \$0.52}{0.0292} = \$84.54$$