

Fostering Peer Interaction to Save Energy

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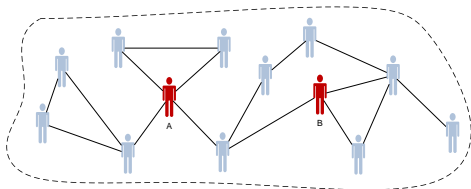
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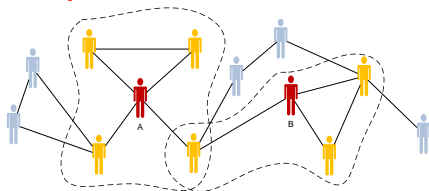
Background

- ▶ Peer enforcement of cooperative norms has been widely studied (**Ostrom, 2009 Nobel Prize Lecture, Kandori, 1992, Schulz et. al., 2007**).
- ▶ Evidence suggests that fostering peer interaction leads to cooperation (**Dietz, Ostrom, Stern, 2003, Breza, 2012**)
- ▶ (**Calvo-Armengol and Jackson, 2010**) show that cooperation can be achieved through peer pressure.

Mani, Rahwan, Pentland. *Inducing Peer Pressure to Promote Cooperation*, Scientific Reports, 2013



Global externality: Individual's action affects all of society



Local externality: Individual action only affects their peers

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Externalities model with peer pressure, actor's utility is:

$$U_i(\mathbf{x}, \mathbf{p}) = u_i(x_i) - v_i \left(\sum_{j \neq i} x_j \right) - (x_i - x_i^\circ) \sum_{j \in \text{Nbr}(i)} p_{ji} - c \sum_{j \in \text{Nbr}(i)} p_{ij}$$

where:

x_i is actual consumption.

x_i° is the socially optimal consumption.

p_{ij} is the pressure by i on j

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Social mechanism **rewards peers for individuals cooperative action**, thus localizing the externalities instead of internalizing them.

Reward to i given consumption of j :

$$r_{ji}(x_j) = (\alpha_j + \beta_i) (x_j - x_j^*)$$

where $\alpha_j = cu_j''(x_j^\circ)$ depends upon the consumer

and $\beta_i = v_i' \left(\sum_{k \neq i} x_k^\circ \right)$ depends upon the peer

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Main results:

- ▶ The budget for the rewards in the **Pigouvian Mechanism** (direct reward) is at least twice the budget for the rewards in the social mechanism.

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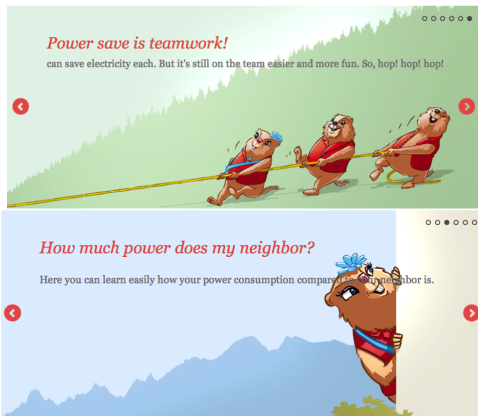
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- ▶ Under low budget, the outcome under the social mechanism is superior (has higher social surplus) to the outcome under the Pigouvian mechanism.
- ▶ When there is no budget, just sharing information about individual actions among the peers achieves a better outcome than the equilibrium outcome.
- ▶ Validated by experiment to improve physical activity in a community.

Program



- ▶ Advice on how to save energy on <http://munx.ch>
- ▶ Earned points (1 point = 0.10 CHF) used in online shop
- ▶ 10 points per week for entering meter readings (verified by a software and random visits to households)

Program



- ▶ Each user can invite up to five buddies (teams of two)
- ▶ If a user reduced consumption compared to the previous week, her buddy gets 5 points

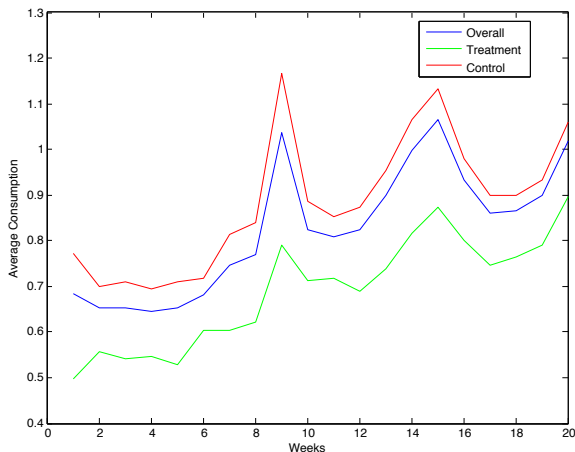
Data Characteristics

- ▶ Only 5% of the population uses electricity for heat.
- ▶ 401 customers out of 1055 users of the web portal signed up in the first 20 weeks.
- ▶ 132 customers made buddies and were in the treatment group.
- ▶ 208 customers entered meter readings more than once.
- ▶ The annual average daily consumption for the year 2011 was 14 Kwh/day.
- ▶ The customers that made buddies had similar consumption statistics as the customers who did not make buddies before the experiment (p-value was 0.91).

Results: Quick Overview

- ▶ Customers who made buddies reduced consumption over previous weeks 30.27% times while customers who did not make buddies reduced consumption over previous weeks 25.23% times.
- ▶ Before making buddies the customers reduced consumption only previous weeks only 25.56% times.

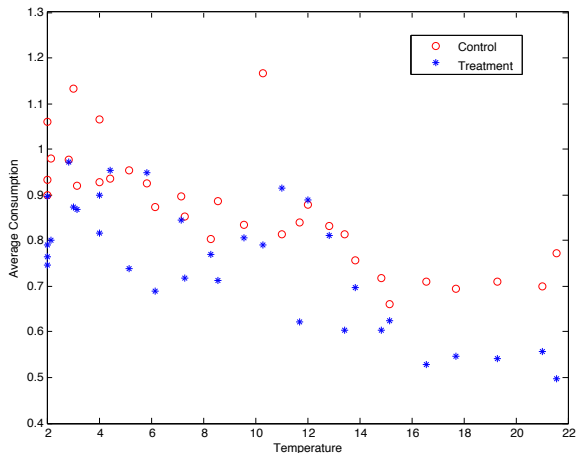
Other Results: Average Consumption in Different Groups



Green: consumption after forming buddies

Overall fluctuation due to temperature

Other Results: Average Consumption Against Temperature



Both decrease, but treatment always below

Other Results: Effect of Treatment on Consumption

Empirical Strategy:

$$y_{i,t} = \alpha + \beta t + \gamma x_i + \nu_{i,t}$$

- ▶ t : average weekly temperature
- ▶ $y_{i,t}$: average hourly consumption over the entire week of the i th consumer when the average weekly temperature is t
- ▶ x_i is the treatment indicator
- ▶ α : the average baseline consumption of the population
- ▶ β : the temperature effect
- ▶ γ : is the treatment effect
- ▶ $\nu_{i,t}$: the estimation error.

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Variable	Regression Coefficient	p-value
Average Consumption	1.035	2.250e-136
Temperature	-0.018	1.395e-05
Treatment Effect	-0.180	0.00065

Putting the Results into Context

- ▶ Treatment effect is 4.32 Kwh/day. It is reasonable to assume it does not come from infrastructural changes in the short term.
- ▶ Reducing the use of hot water by 5 gallons/day saves 1 Kwh/day.

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- ▶ Switching off 40 watt light bulbs for 30 hours or reducing the use of 3 extra light bulbs reduces 1.2 Kwh/day.

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- ▶ Using dishwashers only when completely full saves 0.7 Kwh/day.

Comparison with Price Effects

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- ▶ The long term price elasticity (1 year) estimates in California is 0.39 (**Reiss and White (2005)**). The treatment effect is equivalent to the effect of a long term prices increase of 45%.
- ▶ The US Energy Information Administration estimates that a recently-proposed carbon cap-and-trade program would increase electricity prices by 2.5% in 2020 and 20% in 2030.

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- ▶ **Allcott (2011)**: normative effects can reduce consumption by 2%, which otherwise require price increase of 11–20%
- ▶ It turns out that while the high consumers reduce consumption, the low consumers increase consumption.
 - ▶ Unless you show them a smiley :) or grades like "A+" (Injunctive norms) **Loock et. al. 2013**.

Ongoing Work

- ▶ Generalizability to larger subject groups
- ▶ Dynamics of peer pressure
- ▶ Limits of peer pressure

Thank You