Lecture 6:
Behavioral Economics and Energy Demand
ECO 567A

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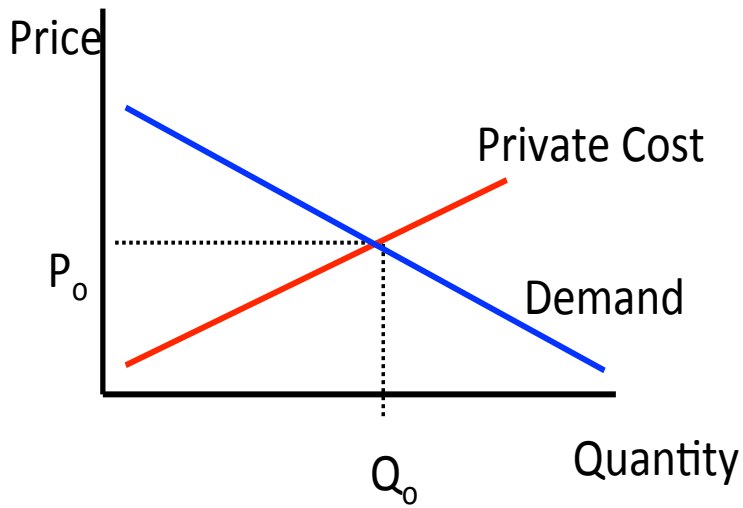
Syllabus

- Part I: Demand for Local Environmental Quality
  - Intro (Jan 10)
  - Demand I - Estimation (Jan 17)
  - Demand II - Sorting and Environmental Justice (Jan 24)
  - Amenities and Quant. Spatial Economic Models (Jan 31)
- Part II: Supply of Local Environmental Quality - Energy
  - Energy Production (Feb 7)
  - Energy Demand (Feb 14)
  - Energy Efficiency Innovation (Feb 21)
  - Trade and Pollution (March 7)
- Part III: Global Externalities
  - Climate Change (March 14)
- Final Exam March 19 9am - noon T5

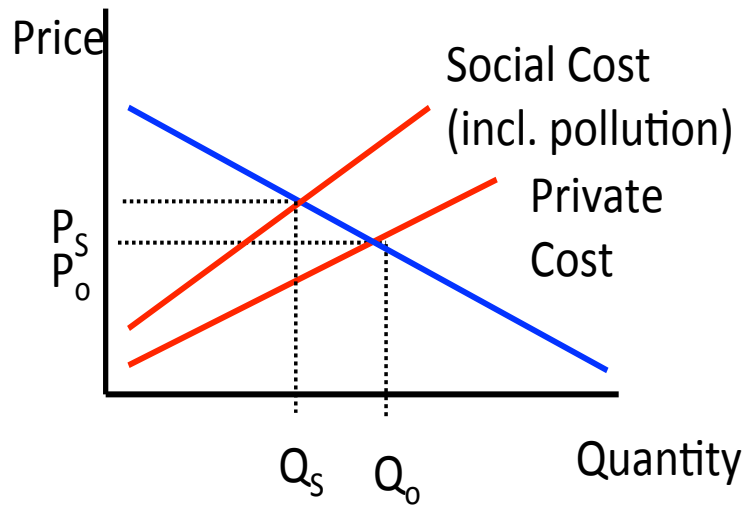
Regulation of Associated Markets

We'd like to have this:



Market for Environmental Good

But the best we can hope for is this:



Market for Associated Good

Associated Goods: The Case of Energy

- But energy (gas and electricity) is
  - Cheap
  - Not very salient
  - Subject to strange pricing
- Can we really assume that agents optimize consumption of electricity?

Behavioral Economics

- Standard Economic theory assumes
  - Individuals maximize utility functions
  - Preferences are independent of framing and affected only by own payoffs

Behavioral Economics

- Evidence from the lab suggests agents
  - Rely on heuristics ("rules of thumb")
  - Are influenced by framing and reference points
  - Over-project from current states of the world
  - Exhibit "other-regarding" preferences

In short, agents exhibit

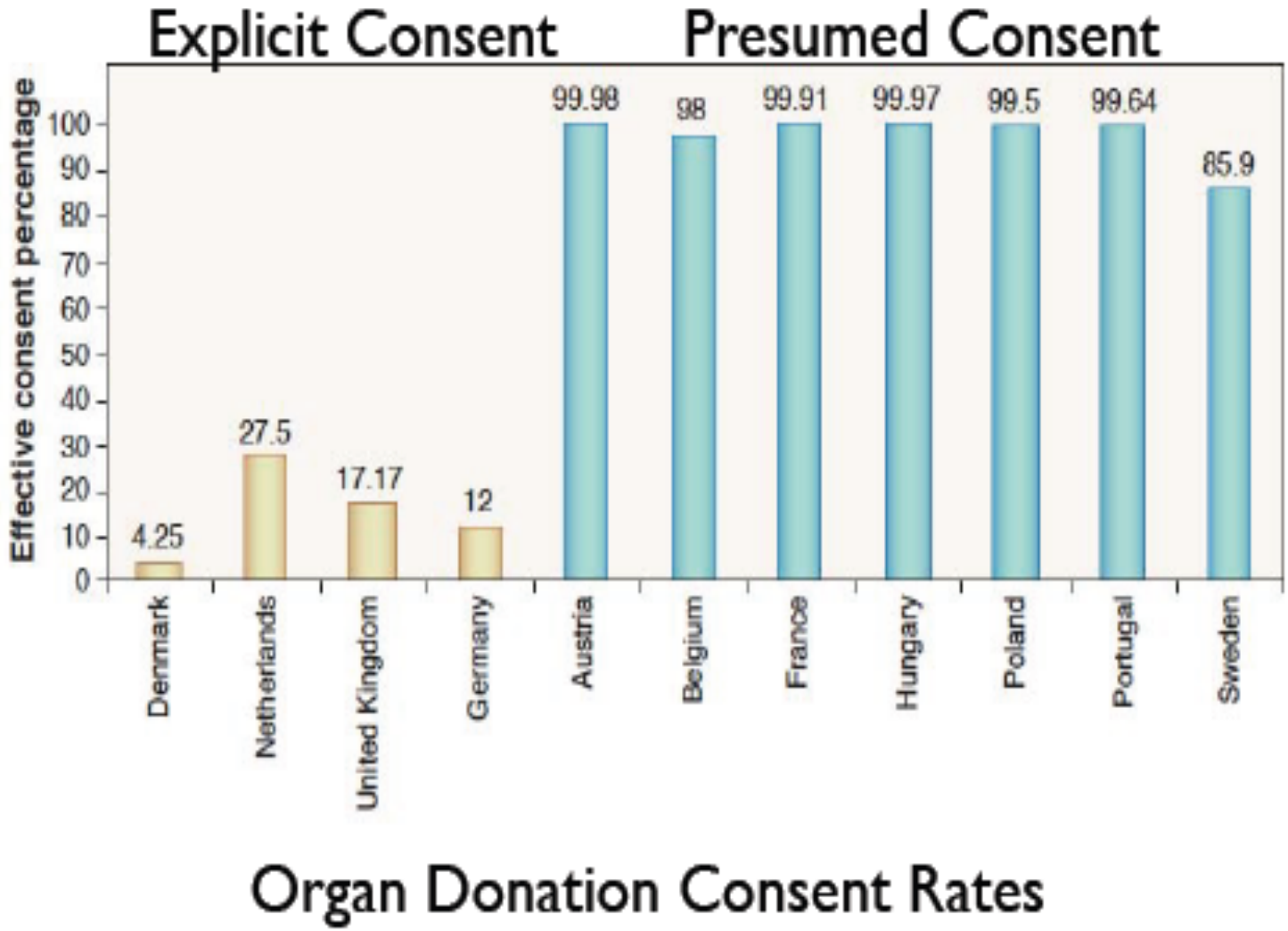
- Bounded rationality
- Bounded self-interest

Bounded Rationality: Defaults

- If preferences are complete and rationality is not bounded, then defaults should not affect choices when costs of deviating from defaults are low
- But defaults seem to matter

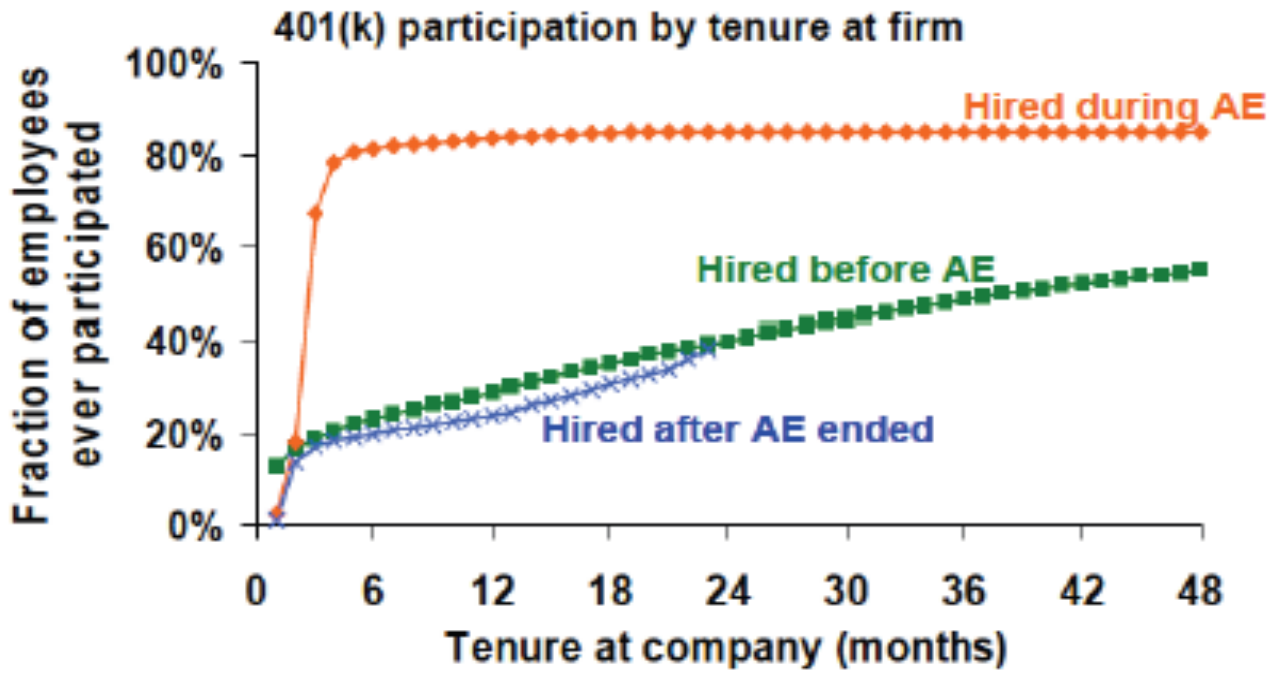
Bounded Rationality: Defaults

Johnson and Goldstein (2003)



Bounded Rationality: Defaults

Madrian and Shea (2001)



401K Participation Among Employees

Bounded Rationality: Salience

- Salience: individuals optimize imperfectly when incentives are not transparent and feedback is limited; inattention to components of price
  - Evidence from Taxes (Cheety, Looney, and Kroft (2007)):
    - When tax is included in posted price, demand falls
    - Changes in excise tax induces bigger demand response than sales tax changes

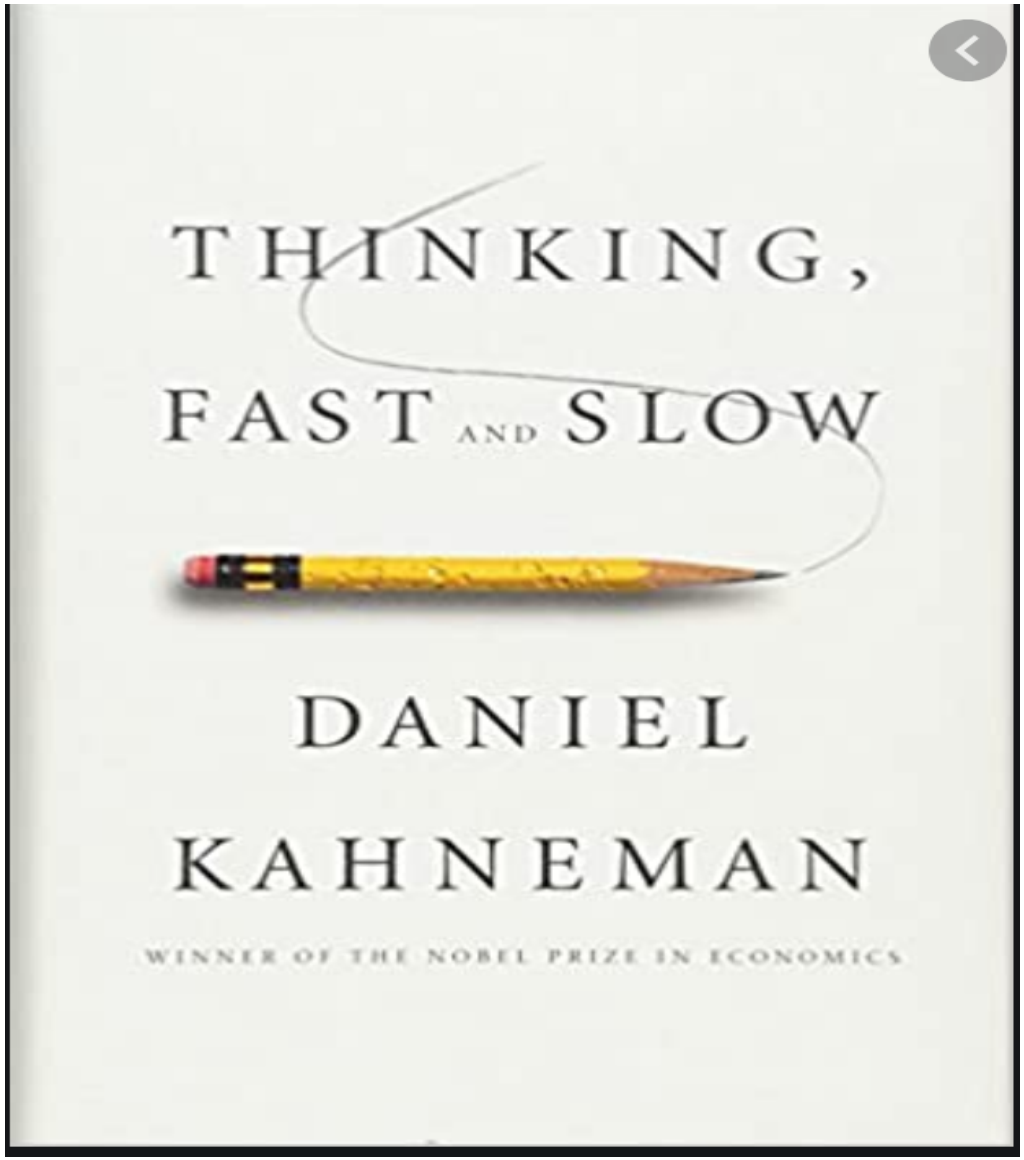
Bounded Self-interest

- Adam Smith: "It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard for their own interest. We address ourselves not to their humanity, but to their self-love, and never talk to them of our necessity, but of their advantage."

- Yet there is evidence that people do have other-regarding preferences

  - Organ and blood donations
  - Charitable contributions (= $300 billion in 2010)
  - Volunteerism

Behavioral Economics



Robustness and Relevance

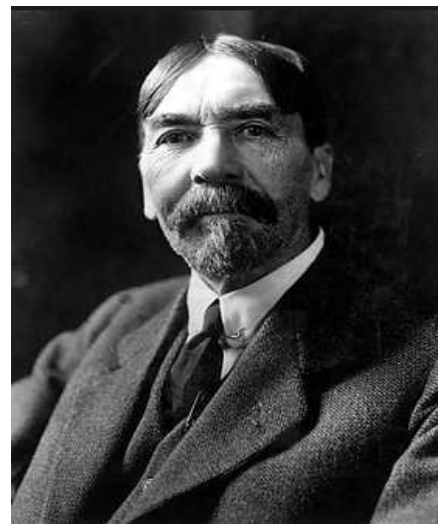
- To what extent do behavioral failures hold up in the market?
  - Are anomalies just in the tails, i.e. infrequent and insufficient to lead to substantial allocative inefficiencies?
- Shouldn't adaptation and evolution eliminate decision errors
  - market should enforce discipline
  - e.g. job markets, you learn from mistakes and correct them
- But with environmental goods, markets are missing
  - competition and arbitrage cannot enforce rationality
- We assume creation of markets can resolve environmental problems
  - But if people don't respond to incentives in consistent and systematic ways, policy may be ineffective or inefficient

Four Applications

- Signaling: Hybrid Cars (Sexton & Sexton, 2014)
- Salience: Automatic Bill Payment (Sexton, 2015)
- Heuristics: Average Cost Pricing (Ito, 2014)
- Reference Points: Neighbor Comparisons (Allcott, 2011)

Conspicuous Consumption

Thorstein Veblen explained in the Theory of the Leisure Class (1899):
"In order to gain and hold esteem of man it is not sufficient merely to posses wealth or power. The wealth or power must be put in evidence, for esteem is awarded only on evidence" (p. 36)



Prisoner's Dilemma

Scenario: Two prisoners are accused of a crime. They have two choices: Cooperate (stay silent) or Defect (betray the other). Their decisions lead to different outcomes.

	Prisoner B: Cooperate	**Prisoner B: Defect**
Prisoner A: Cooperate	(-1, -1)	(-3, 0)
Prisoner A: Defect	(0, -3)	(-2, -2)

Explanation:

- If both cooperate, they get light sentences (-1, -1).
- If one defects while the other cooperates, the defector goes free (0), while the cooperator gets a harsh sentence (-3).
- If both defect, they receive moderate sentences (-2, -2).

Dilemma: Rational self-interest leads both to defect, but cooperation would be better for both.

Conspicuous Conservation

Sexton & Sexton (2014):
"Consumers may therefore undertake costly actions in order to signal their preference for the environment, a phenomenon we term conspicuous conservation."

Signal Theory

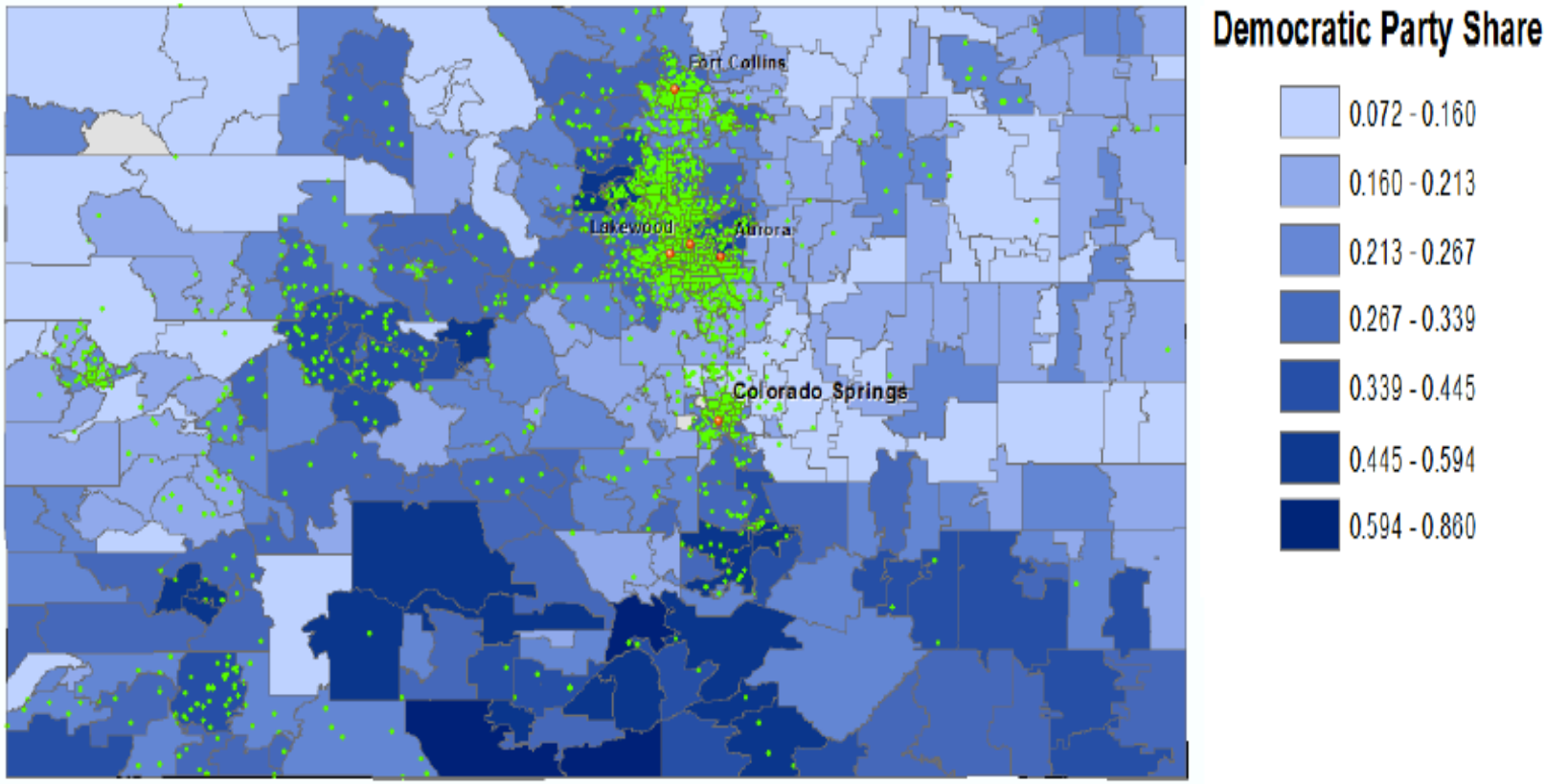
- When the people around you care about the environment, there is an incentive to "signal" that you care about the environment
- Democrats generally express more concern for climate change than republicans

Signal Theory

- When the people around you care about the environment, there is an incentive to "signal" that you care about the environment
- Democrats generally express more concern for climate change than republicans
- $\Longrightarrow$ Maybe in democratic communities, people buy conspicuous environmental products in order to signal that they are "green"

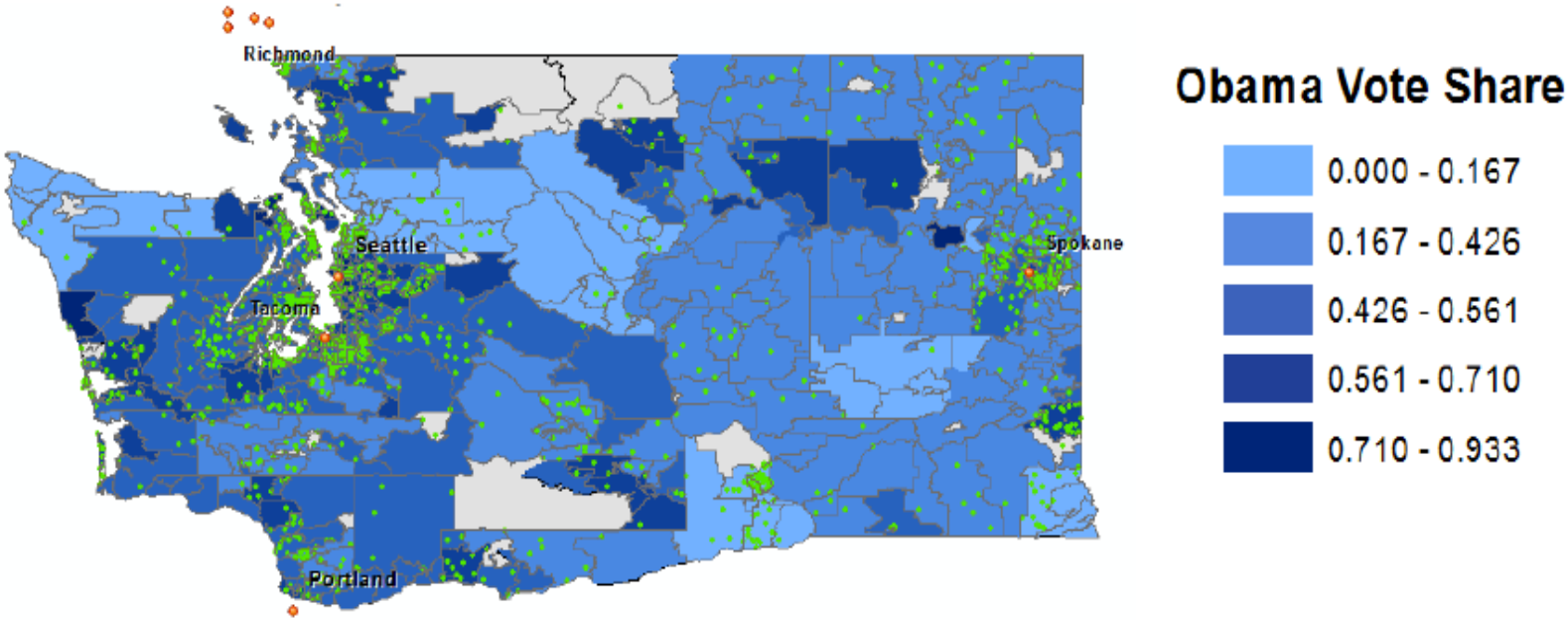
Sexton and Sexton (2014)

Democratic communities buy more Prius



Sexton and Sexton (2014)

Democratic communities buy more Prius



Is it Conspicuous Conservation?

- Maybe the democratic communities just care more about the environment
- The correlation does not prove the theory

It's definitely conspicuous

- Only hybrid with standard amenities and a design unique to the model (pre-2011)

The Prius Halo

- "I felt like the Camry Hybrid was too subtle for the message I wanted to put out there. I wanted to have the biggest impact that I could, and the Prius puts out a clearer message"
  –Prius owner in NYT 7/4/2007

In-Conspicuous

- Honda Civic: Find the Hybrid

In-Conspicuous

- Ford Escape: Find the Hybrid

Testing for Conspicuous Conservation

- "green" communities should like both Prius and Civic Hybrids
- But in "green" communities, Prius also confers a status benefit : the "Prius Halo"

Testing for Conspicuous Conservation

- "green" communities should like both Prius and Civic Hybrids
- But in "green" communities, Prius also confers a status benefit : the "Prius Halo"
- $\Longrightarrow$ In democratic communities, Prius sales should increase more than civic sales

Testing for Conspicuous Conservation

- With just Prius and Civic:

$$S_{jk} = \delta_j + \delta_k + \beta * \mathbb{1}(k = \textit{prius}) * \textit{VOTE}_j + \epsilon_{jk}$$

- With all models:

$$\begin{aligned} S_{jk} &= \delta_j + \delta_k + \beta * \mathbb{1}(k = \textit{prius}) * \textit{VOTE}_j \\ &+ \gamma_1 * \textit{GREEN}_k * \textit{VOTE}_j + \gamma_2 * \delta_k * \textit{MedIncome}_j \\ &+ \gamma_3 * \delta_k * \textit{Density}_j + \delta_{k,\textit{dealer}_j} + \epsilon_{jk} \end{aligned}$$

- S_{jk} is marker share of model k in community j
  $\textit{VOTE}_j$ is the vote share
  $\textit{GREEN}_k$ is the environmental score of model k
  $\mathbb{1}(k = \textit{prius})$ indicator variable for prius

Testing for Conspicuous Conservation

Table 2
Conspicuous conserv. effect on Prius market share: '2 × *N*' model for Colorado.

Dependent variable: product market share		
	(1) Democratic	(2) Green
PRIUS*VOTE	0.0094***	1.0139***
	(0.0007)	(0.1163)
	[0.59]	[0.42]

Robust standard errors in parentheses. Elasticity of Prius share with respect to Democratic share in brackets.

* $p < 0.1$, ** $p < 0.05$, and *** $p < 0.001$

Testing for Conspicuous Conservation

Table 3
Conspicuous conserv. effect on Prius market share: full model.

Dependent variable: product market share		
	(1) Colorado	(2) Washington
Product-specific marketing area effects		
PRIUS*VOTE	0.0052***	0.0113***
	(0.0024)	(0.0023)
	[0.33]	[0.18]
Product-specific marketing, income, and population density effects		
PRIUS*VOTE	0.0052***	0.0062***
	(0.0014)	(0.0026)
	[0.33]	[0.10]

Robust standard errors in parentheses. Elasticity of Prius share with respect to Democratic share in brackets.
* $p < 0.1$, ** $p < 0.05$, and *** $p < 0.001$

Elasticity

- Elasticity is the percentage change in one metric resulting from a 1% change in another metric

$$\epsilon = \frac{\frac{dS_k}{S_k}}{\frac{dVOTE}{VOTE}} = \frac{dS_k}{dVOTE}\frac{VOTE}{S_k}$$

- 1 percentage point change in democratic vote share (like .10 to .11) yields 0.000052 increase in Prius share. On a base of .00468 share (i.e. about half of 1 percent), this is $0.000052/0.00468 = 1.1\%$

- 1 percentage point change in democratic vote share at the mean (.30 to .31) is a 3.3% increase in democratic vote share. So a 1% increase in democratic vote share yields 1.1/3.3 or 0.33% increase in Prius vote share

Testing for Conspicuous Conservation

Table 4
Conspicuous conserv. effect on Civic Hybrid and Camry Hybrid market shares.

Dependent variable: product market share		
	(1) Colorado	(2) Washington
Honda Civic Hybrid		
CIVIC_HYB*VOTE	−0.0046***	−0.0047***
	(0.0009)	(0.0013)
	[−87.3]	[−90.4]
Toyota Camry Hybrid		
CAMRY_HYB*VOTE	−0.0036***	0.0028*
	(0.0012)	(0.0014)
	[−45.5]	[−44.4]

Robust standard errors in parentheses. Mean conspicuous consumption effect as percent of share in brackets.

* $p < 0.1$, ** $p < 0.05$, and *** $p < 0.001$

Testing for Conspicuous Conservation

- The signal value of the Prius is worth about $3,300 in CO and $1,000 in WA

Table 5
Estimated mean willingness to pay for the Prius Halo (in dollars).

Percent change in share	Price elasticity		
	−1.6	−2.0	−4.8
10.1 (WA)	1291.34 [229.11, 2353.57]	1033.07 [183.29, 1882.85]	430.45 [76.37, 784.52]
32.9 (CO)	4208.53 [2023.33, 6393.73]	3366.83 [1618.67, 5114.99]	1402.84 [674.44, 213,124]

95% confidence interval is reported in brackets holding elasticity constant.

Implications

- Conspicuous conservation can induce private provision of public goods
- Conspicuous consumption leads to wastefulness and welfare losses, but conspicuous conservation can lead to welfare gains
- But, inefficient conservation investment
  - Crowding out?
  - "low hanging fruit" passed over for visible green projects

Automatic Bill Payment

- Many household utility goods (electricity, water, gas) are not particularly salient
- But they become even less salient with Automatic Bill Payment (ABP)
  - Permit timely payment of recurring bills via automatic credit card transaction without requiring individuals to view the bill
  - decreased saliency may lead to over-consumption and less price elasticity (or possibly under consumption if people suddenly think the price is higher than it actually is?)
- Opportunity to test whether saliency matters for electricity consumption

Automatic Bill Payment

- ABP has grown rapidly in early 2000s
  - roughly 40% of all recurring payments are paid electronically by 2015
- Sexton (2015) analyzes panel of monthly electricity bills for 684,000 residential customers and 168,000 commercial customers between 1994-2010 from South Carolina

Event Study Specification

$$\log y_{it} = \sum_{j=-24}^{j=24} \beta_j * \mathbb{1}[\phi_{it} = j] + \lambda_t + c_i + \tau_{g,moy} + \epsilon_{it}$$

ϕ_{it} is the number of months before or after the switch to ABP.

For example, $\phi_{it} = -3$ indicates that consumer i will adopt ABP 3 months after month t.

$\tau_{g,moy}$ is postal code-by-month-of-year effects

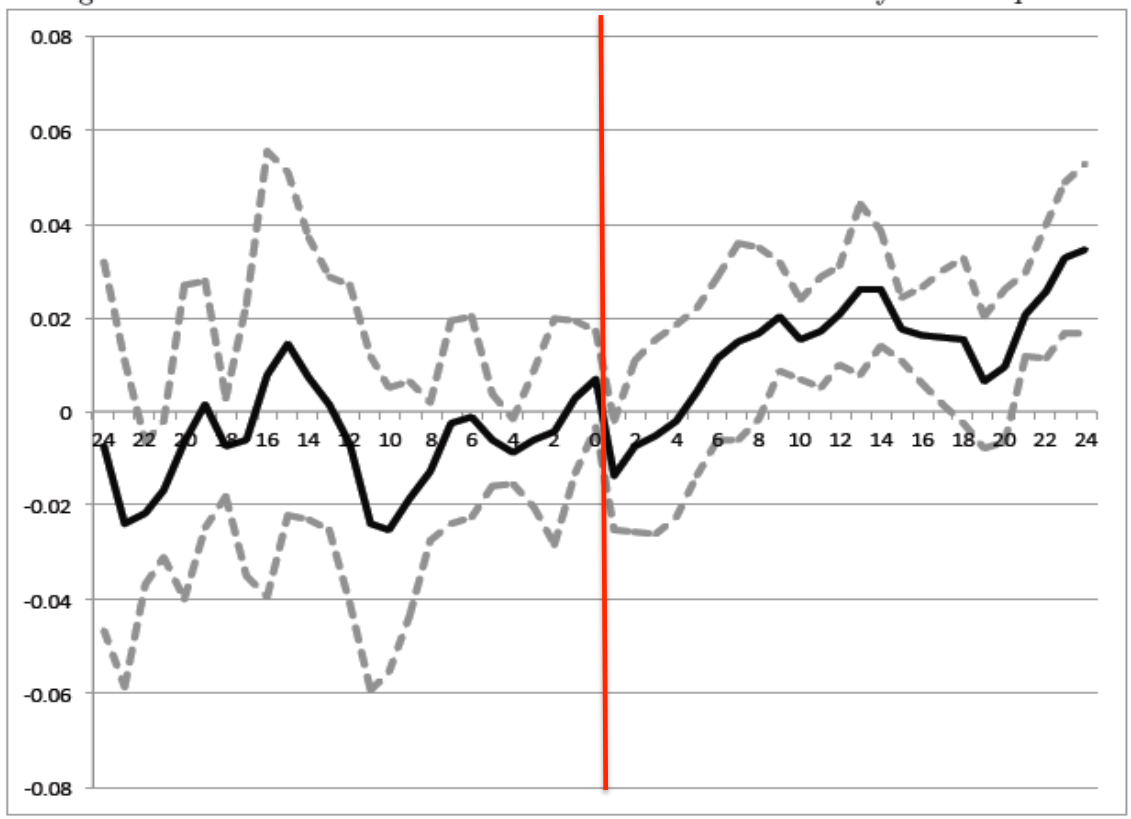
λ_t is month of sample effects

c_i is individual fixed effect

$\log y_{it}$ is log energy consumption in month t of individual i

Event Study Specification

Figure 2: Effect of ABP Enrollment on Residential Electricity Consumption



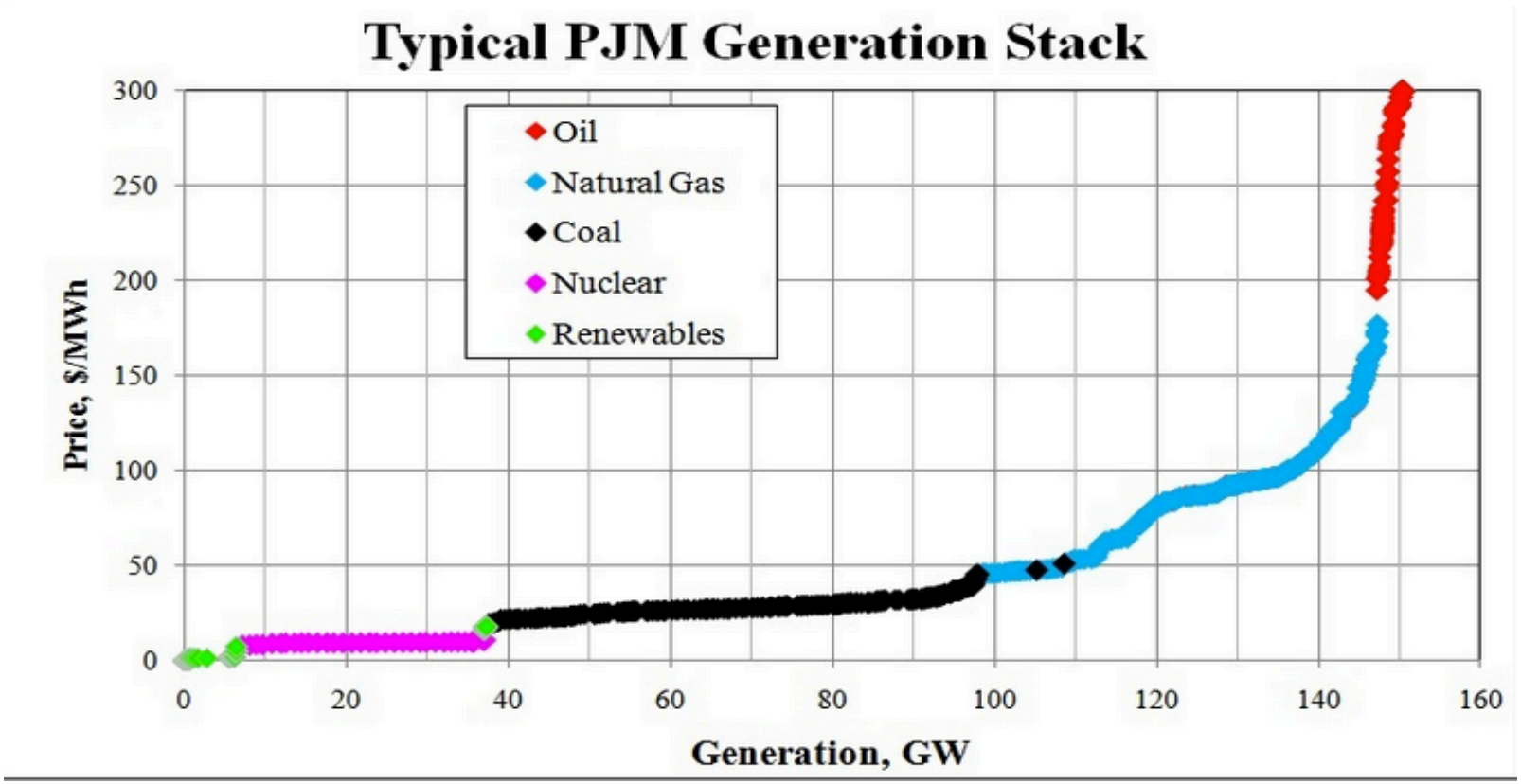
Note: This figure plots estimated coefficients and 95th percentile confidence intervals describing monthly electricity consumption before and after ABP enrollment. Time is normalized relative to the month of enrollment ($t = 0$). The regression includes household and zip-code-by-month-of-sample fixed effects. Standard errors are clustered by zip code.

Heuristics

- Electricity prices can be complicated
- If consumers use simple rules of thumb to optimize (heuristics) instead of marginal price, then optimal policy will be different than what we think it should be

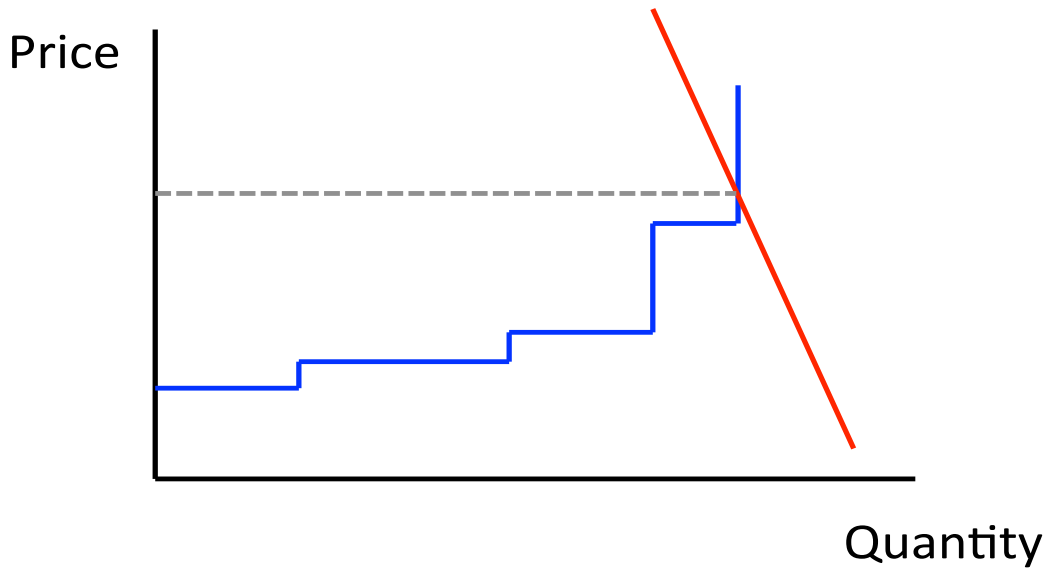
Electricity Supply

- The marginal cost of producing electricity is described as the "hockey stick": it gets very expensive very quickly at high outputs



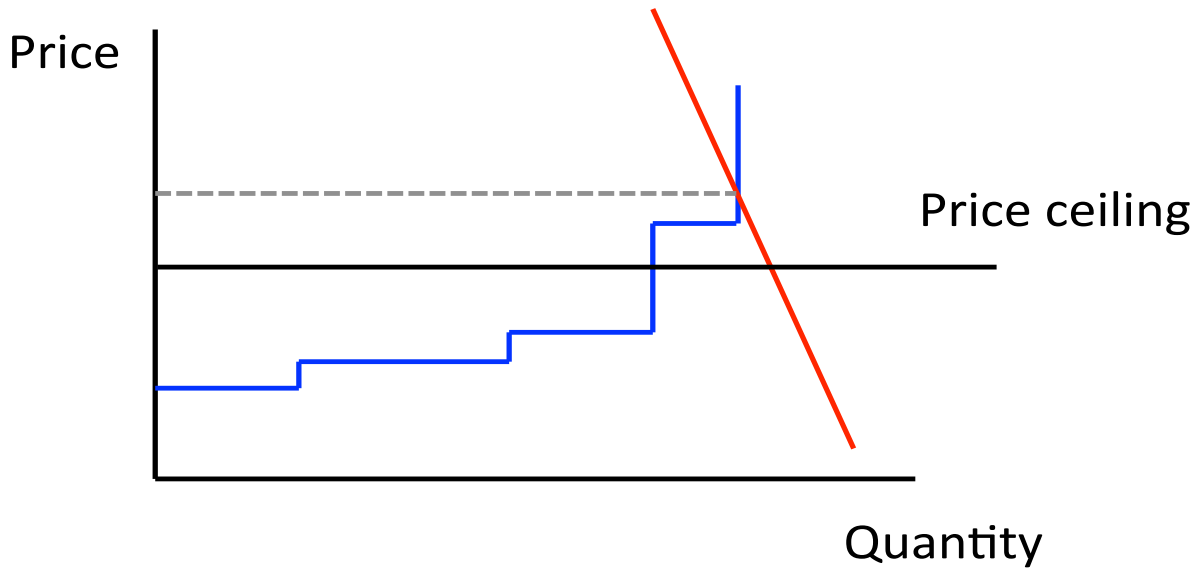
Electricity Supply

- If demand is high, the price gets very very high



Electricity Supply

- But the gov regulates with price ceilings
- Hence, the electricity providers want to keep production down



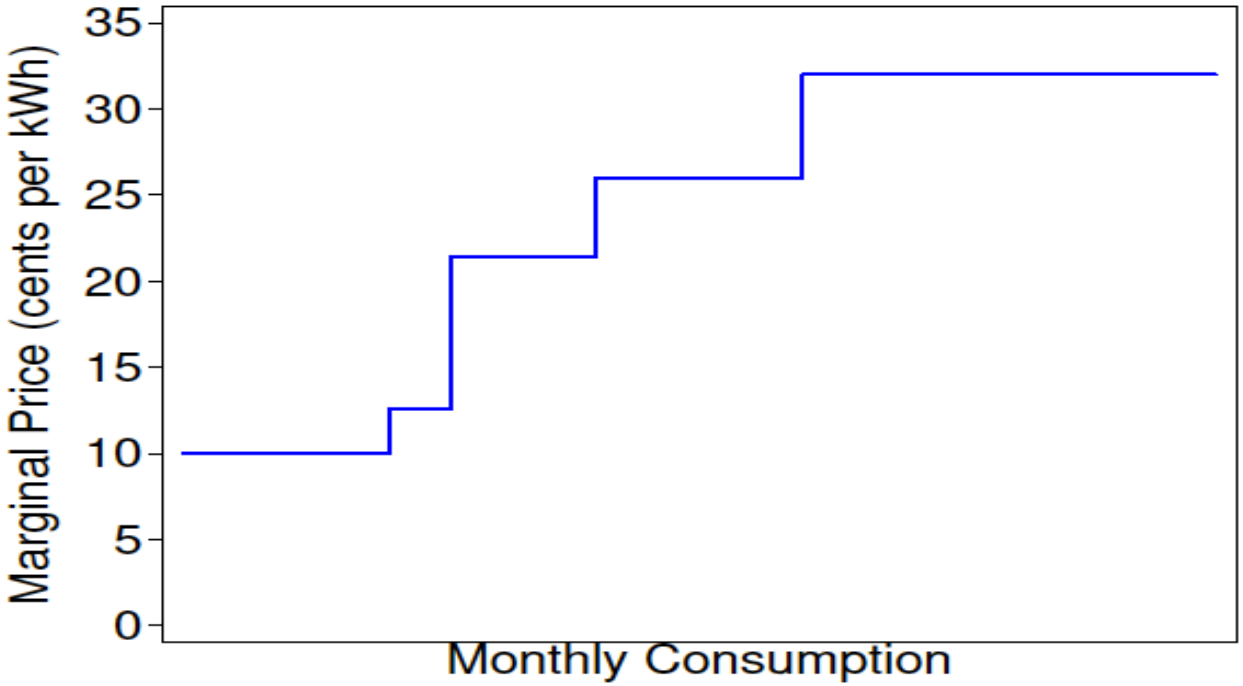
Electricity Supply

- As a result, utilities try many things to keep consumption down, especially during peak hours
  - Real time pricing
  - Behavioral interventions
  - And recently...

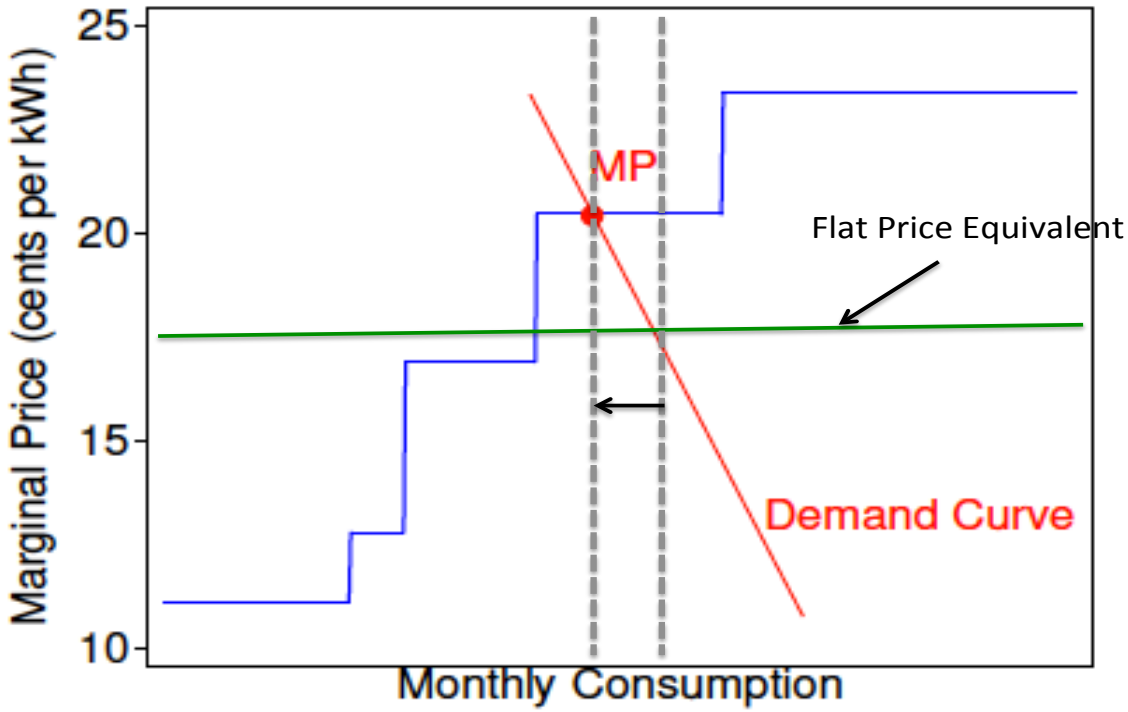
Non-Linear Pricing

- The first 10 kWh are priced at 10 cents per kWh, the next 5 are priced at 12 cents per kWh, etc
- The point is to flatten usage so that demand crosses before the steep increase in cost

Electricity prices (cents per kWh) in Southern California Edison in 2007

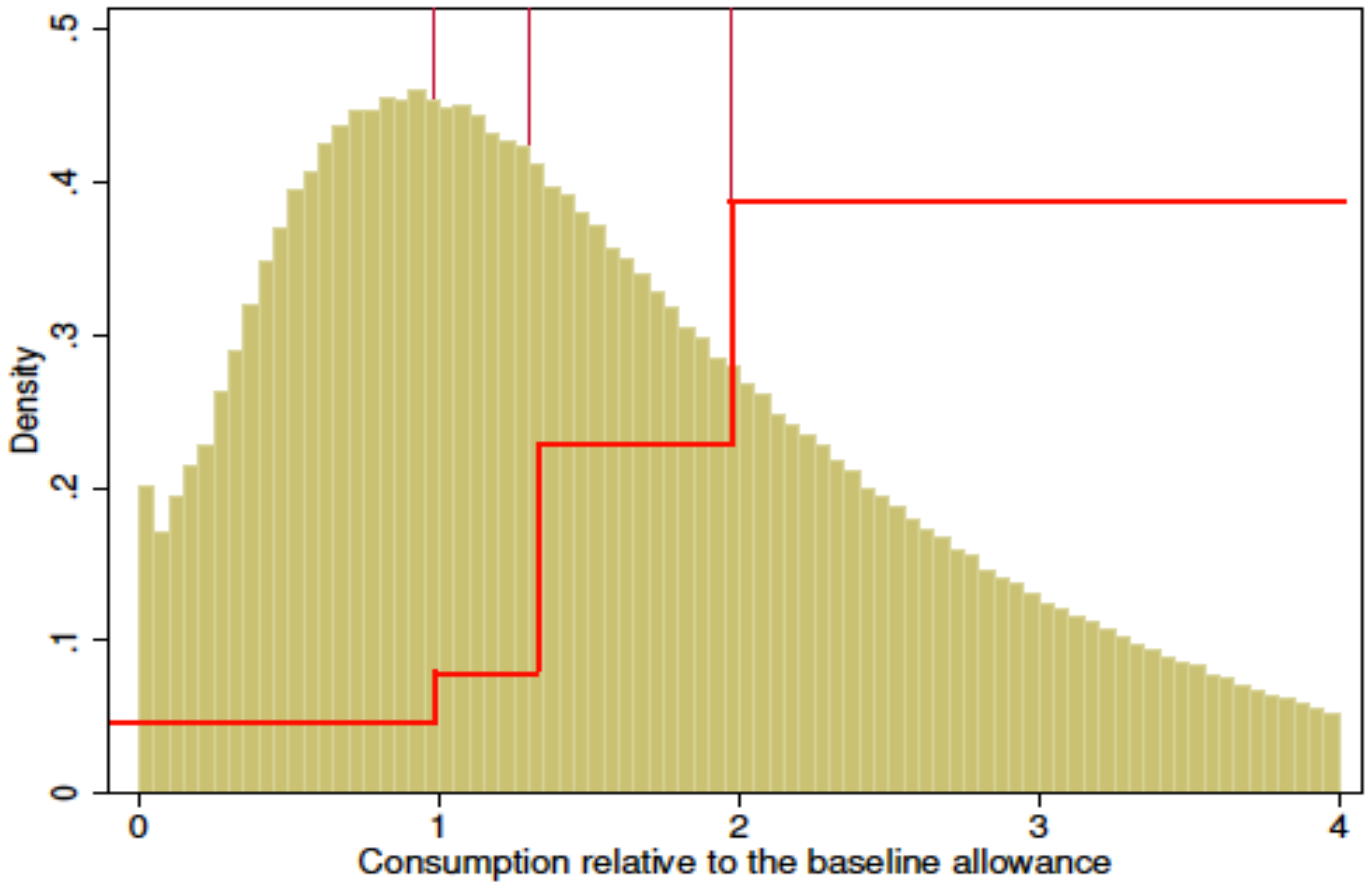


Non-Linear Pricing is designed to reduce consumption



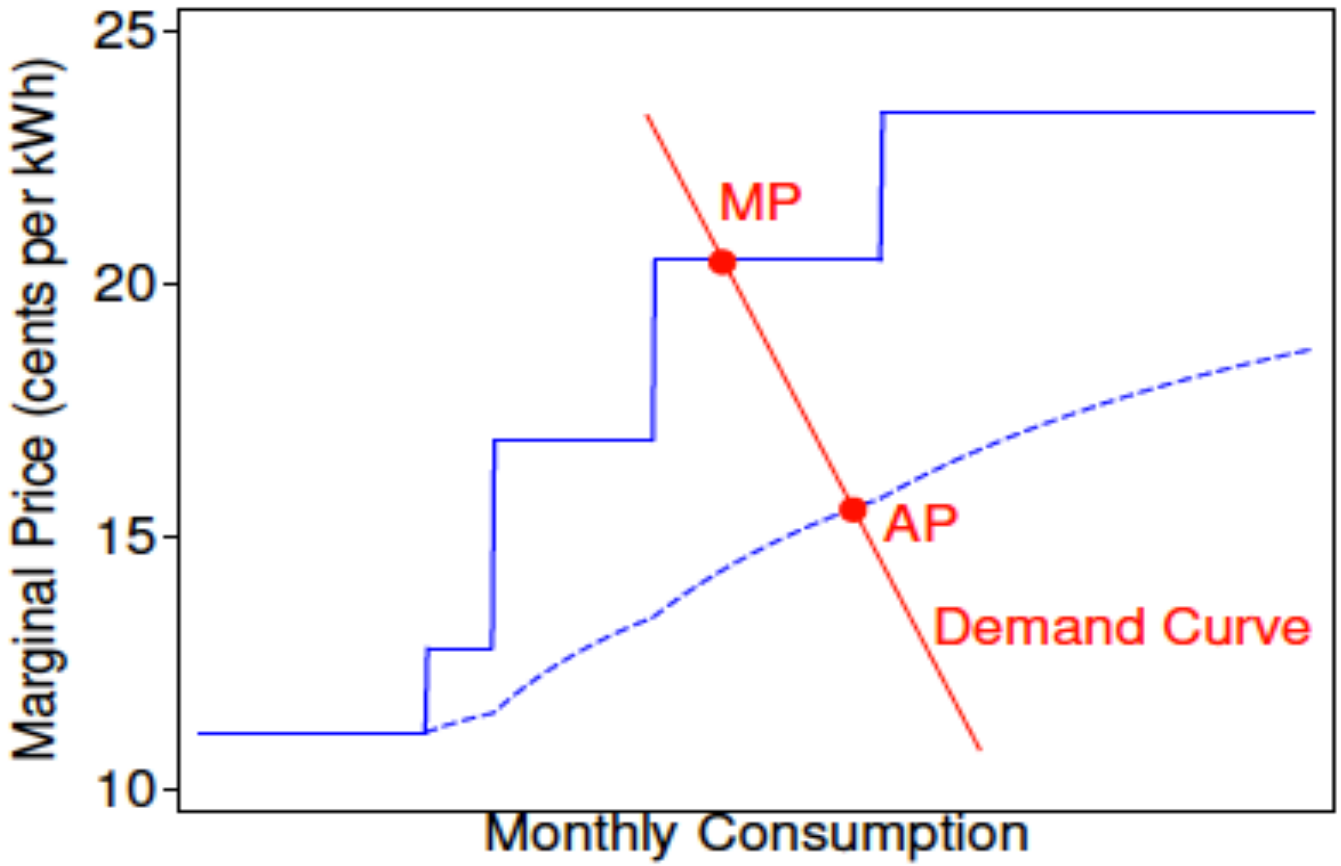
Flat rate equivalent is the flat price that generates the same profit as the nonlinear schedule

But there should be bunching



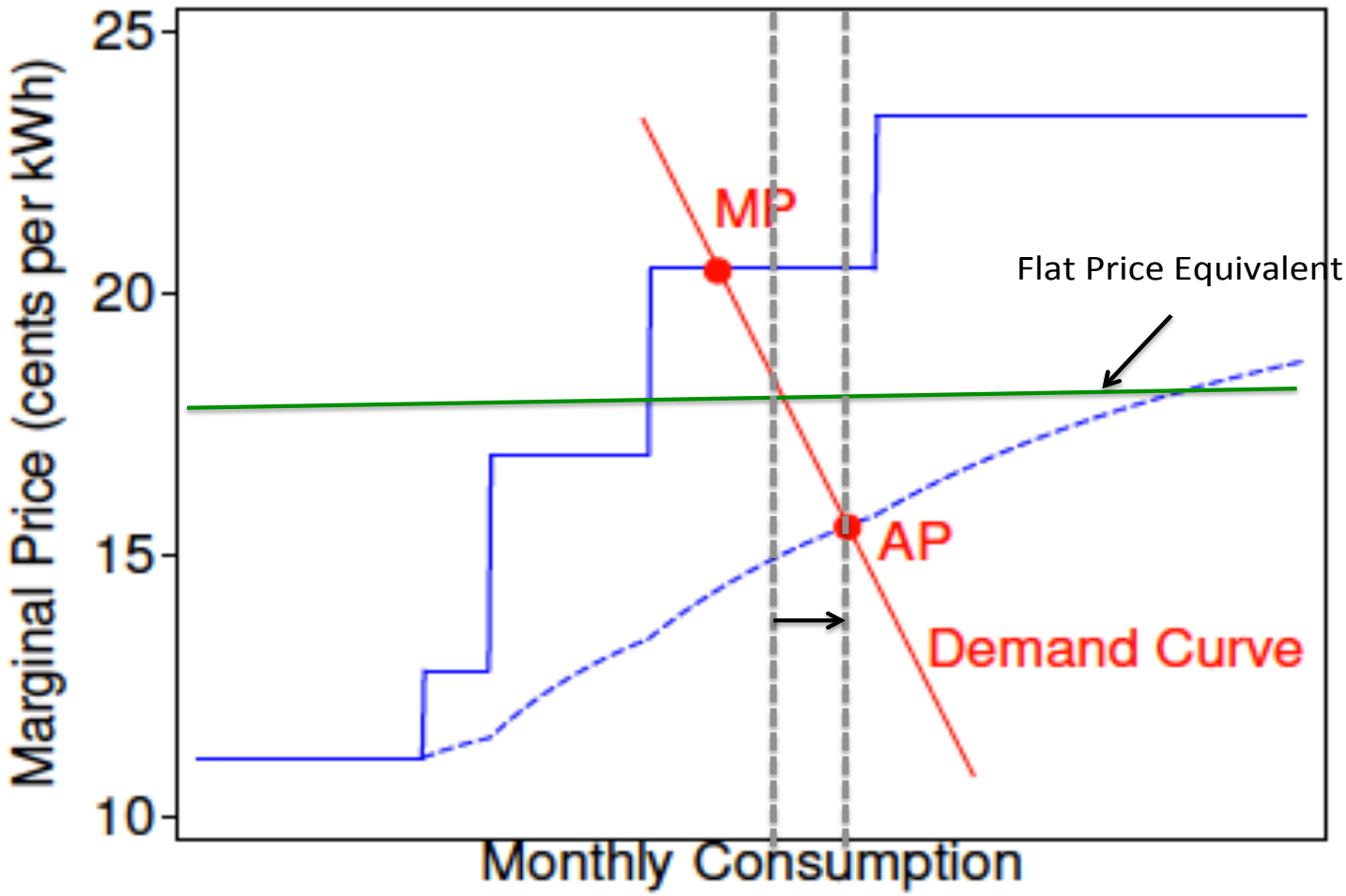
Inattention

- If people do not pay close attention to their electricity bill, maybe people track a different metric: average price



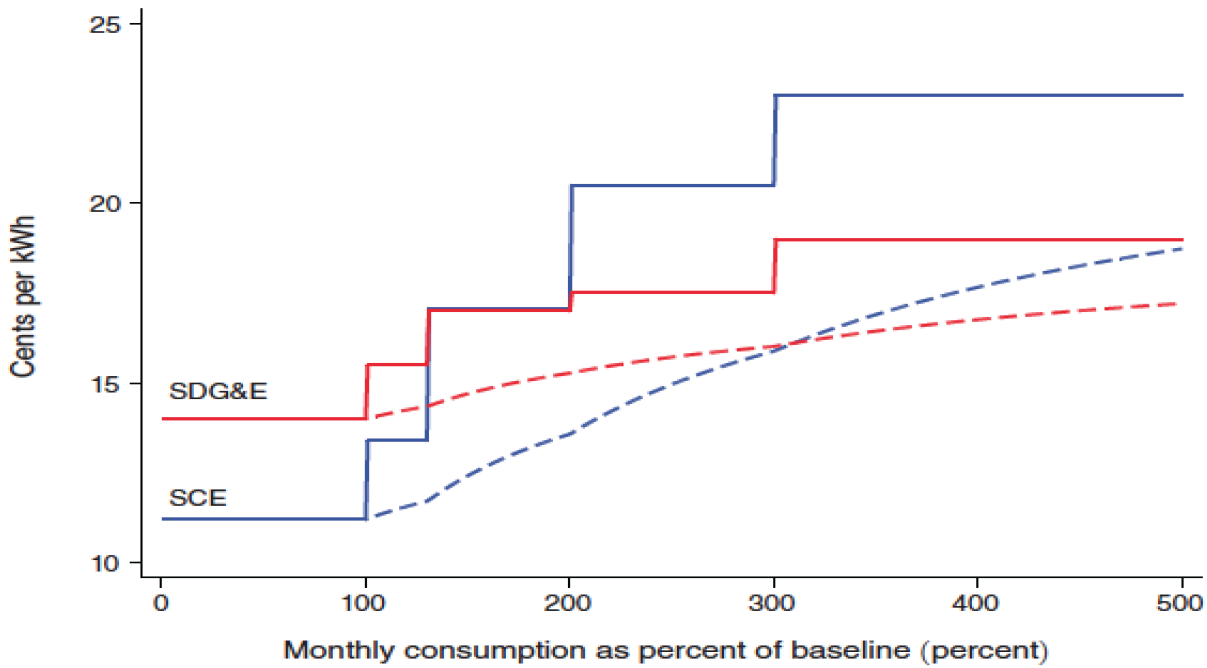
In which case:

- Non-linear pricing increases consumption relative to the flat price equivalent



Test: Compares changes in demand across utilities with diff price schedules

- Marginal price and average price often move together, so it is difficult to identify the differential impact on consumption. But with two utilities both changing different non-linear price schedules, we can get differential movements in MP and AVP



Estimation Equation

$$\Delta \ln x_{it} = \beta_1 \Delta \ln MP_{it} + \beta_2 \Delta \ln AP_{it} + \gamma_{ct} + f_t\left(x_{it_m}\right) + \delta_{bt} + u_{it}$$

- With instruments

$$\begin{aligned} \Delta \ln MP_{it}^{PI} &= \ln MP_t\left(x_{it_m}\right) - \ln MP_{t_0}\left(x_{it_m}\right) \\ \Delta \ln AP_{it}^{PI} &= \ln AP_t\left(x_{it_m}\right) - \ln AP_{t_0}\left(x_{it_m}\right) \end{aligned}$$

- MP indicates marginal price, AP indicates average price, and $\Delta \ln x_{it}$ is the change in log consumption between month t and last year's month t.
- γ_{ct} city month fixed effects
- δ_{bt} bill-cycle month fixed effects
- $f_t\left(x_{it_m}\right)$ controls for mid-point consumption

Ito (2015)

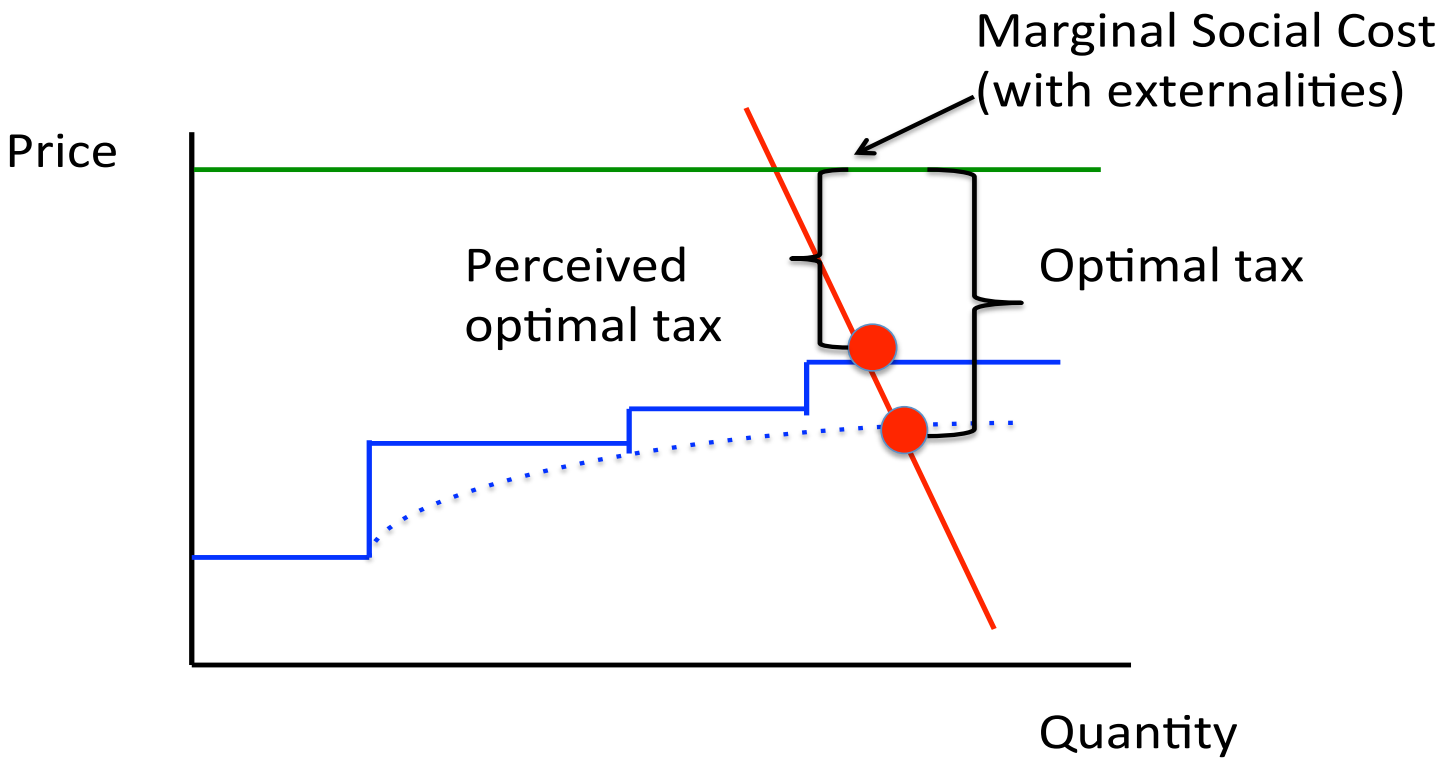
- Regressions imply that consumption responds to average price, not marginal price

TABLE 2—ENCOMPASSING TESTS: MARGINAL PRICE VERSUS AVERAGE PRICE

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(\textit{marginal price}_t)$	−0.034		0.002			
	(0.004)		(0.011)			
$\Delta \ln(\textit{average price}_t)$		−0.051	−0.054			
		(0.005)	(0.015)			
$\Delta \ln(\textit{marginal price}_{t-1})$				−0.050		0.006
				(0.004)		(0.011)
$\Delta \ln(\textit{average price}_{t-1})$					−0.074	−0.082
					(0.005)	(0.015)

Implication

Under non-linear pricing when consumers set marginal willingness to pay equal to average price not marginal price, the optimal tax is larger than what would be expected from rational behavior



Silver Lining

- Saliency problems revealed by ABP and non-linear pricing mean that optimal taxes need to be larger than what we would expect under the assumption of rationality
- But we can't implement carbon taxes anyway because of political constraints
- Maybe there is a silver lining:
  - Since it is politically infeasible to employ price instruments to address climate change, maybe it's a good thing that consumers base energy consumption on something other than price

Silver Lining

- Saliency problems revealed by ABP and non-linear pricing mean that optimal taxes need to be larger than what we would expect under the assumption of rationality
- But we can't implement carbon taxes anyway because of political constraints
- Maybe there is a silver lining:
  - Since it is politically infeasible to employ price instruments to address climate change, maybe it's a good thing that consumers base energy consumption on something other than price
- $\Longrightarrow$ Are there non-price mechanisms that can address the behavioral determinants of energy use?

Opower Experiment

- Allcott (2011) randomly sent some customers and not others information like the following:

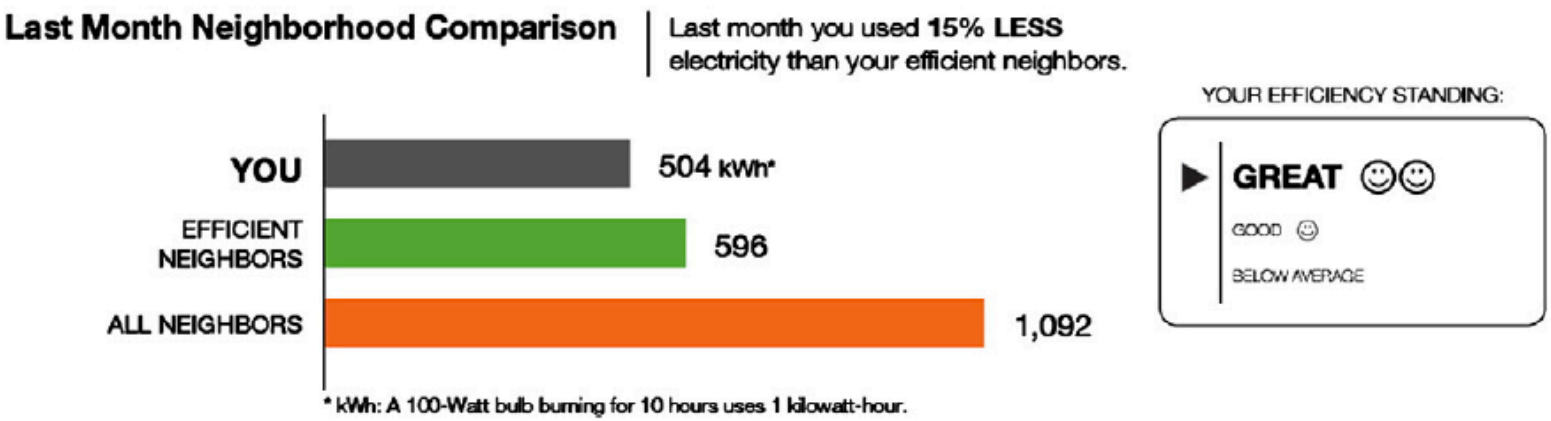


Fig. 1. Home energy reports: social comparison module.

Opower Experiment

- The hypothesis was that people could consume less if they found out that they consumed more than the average
- There was some concern that efficient households would increase consumption when they found out that they did better than average

Opower Experiment

Table 1
Overview of OPOWER projects.

Experiment			N		
Number	Region	Start date	Households	Treatment	Observations
1	Rural Midwest	February, 2009	8175	8175	343,729
2	Urban Midwest	July, 2009	37,484	18,790	1,264,375
3	Urban Midwest	July, 2009	56,187	28,027	1,873,482
4	Rural Midwest	January, 2009	78,273	39,024	3,421,306
5	Suburban Mountain	October, 2009	11,612	7,254	394,525
6	Suburban Mountain	October, 2009	27,237	16,947	914,344
7	West Coast	October, 2009	24,940	23,906	570,386
8	Rural Midwest	April, 2009	17,889	9,861	794,457
9	Urban Northeast	September, 2009	49,671	24,808	1,712,530
10	Rural Midwest	February, 2009	8429	8,390	360,577
11	West Coast	October, 2008	79,229	34,893	3,121,879
12	West Coast	January, 2009	25,211	5,570	985,148
13	West Coast	January, 2009	17,849	3,852	672,629
14	West Coast	January, 2009	22,965	22,846	893,322
15	West Coast	September, 2009	39,336	19,663	671,990
16	West Coast	March, 2008	59,666	24,761	2,543,372
17	West Coast	April, 2008	24,293	9903	1,036,768
Combined		March, 2008	588,446	306,670	21,574,819

Experimental vs Non-experimental Estimates

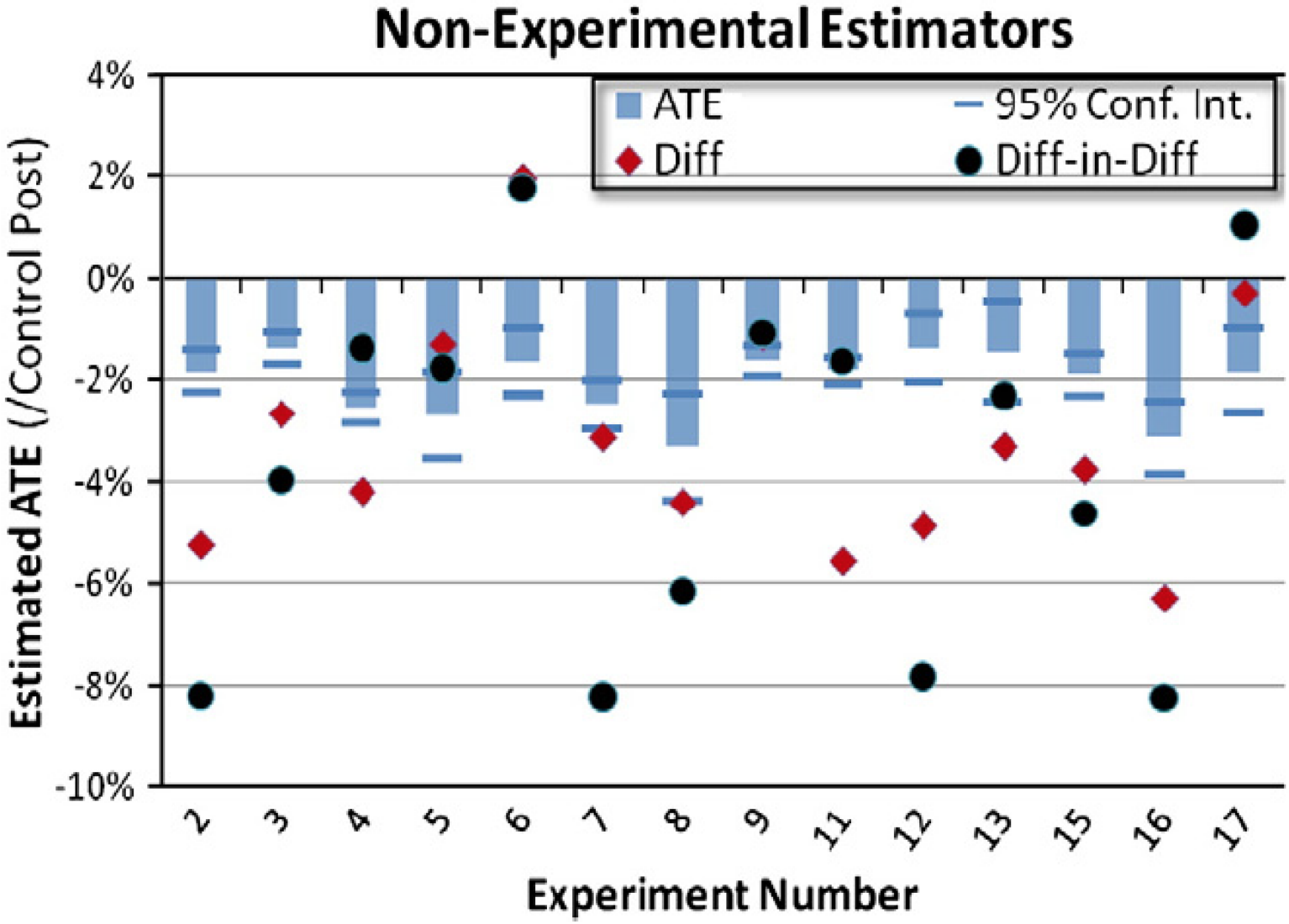


Fig. 6. Non-experimental specifications.

Opower Experiment

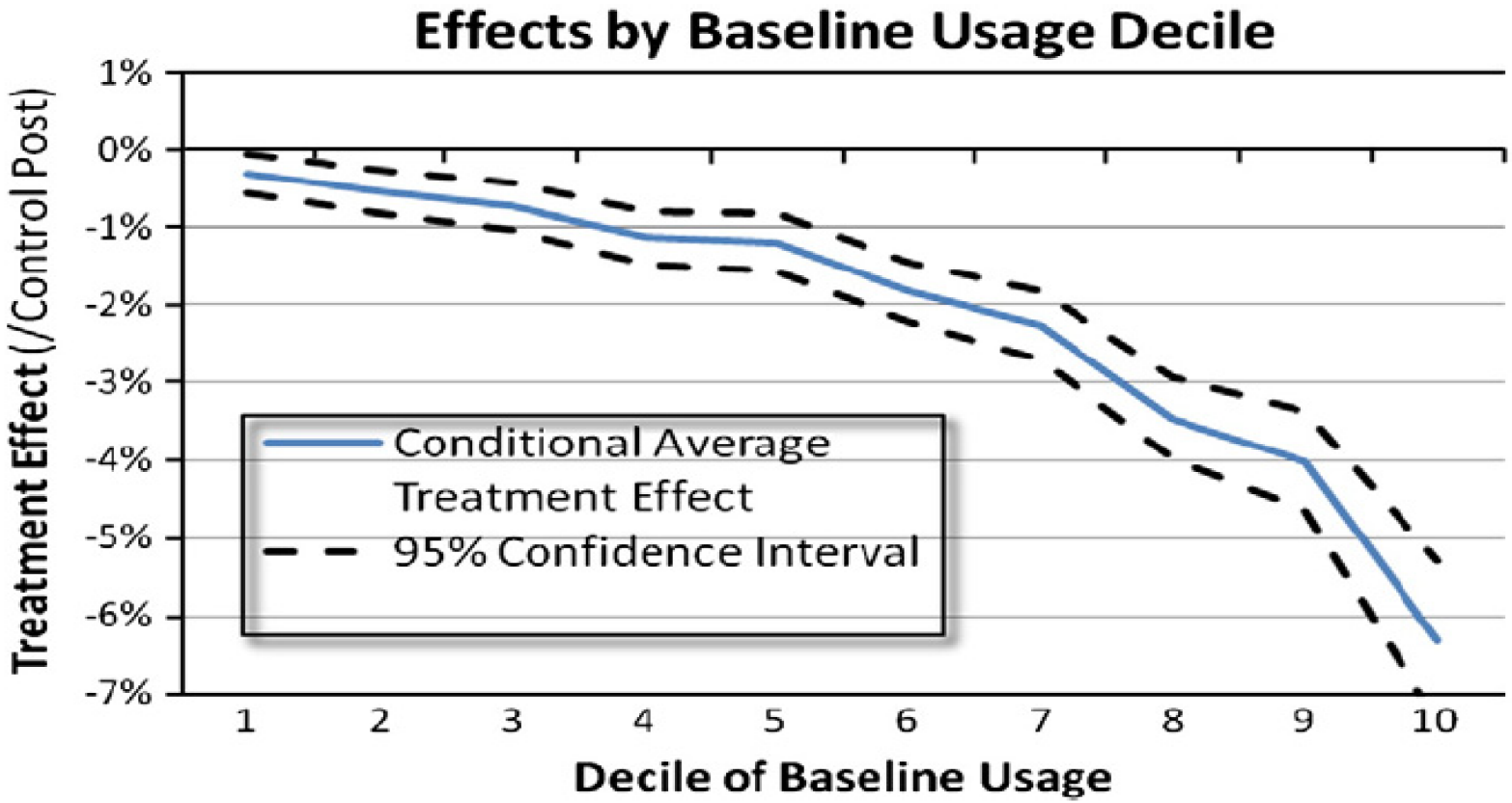


Fig. 8. Treatment effects by decile of baseline usage.

Electricity consumption drops on average 2% in treated households, with no increase for initially low consumption households

Opower Experiment

- At a cost of 3.3 cents per kWh saved to administer the program, merely sending letters to consumers represents an extremely cost-effective way to reduce electricity
- Understanding behavioral responses can improve policy

References

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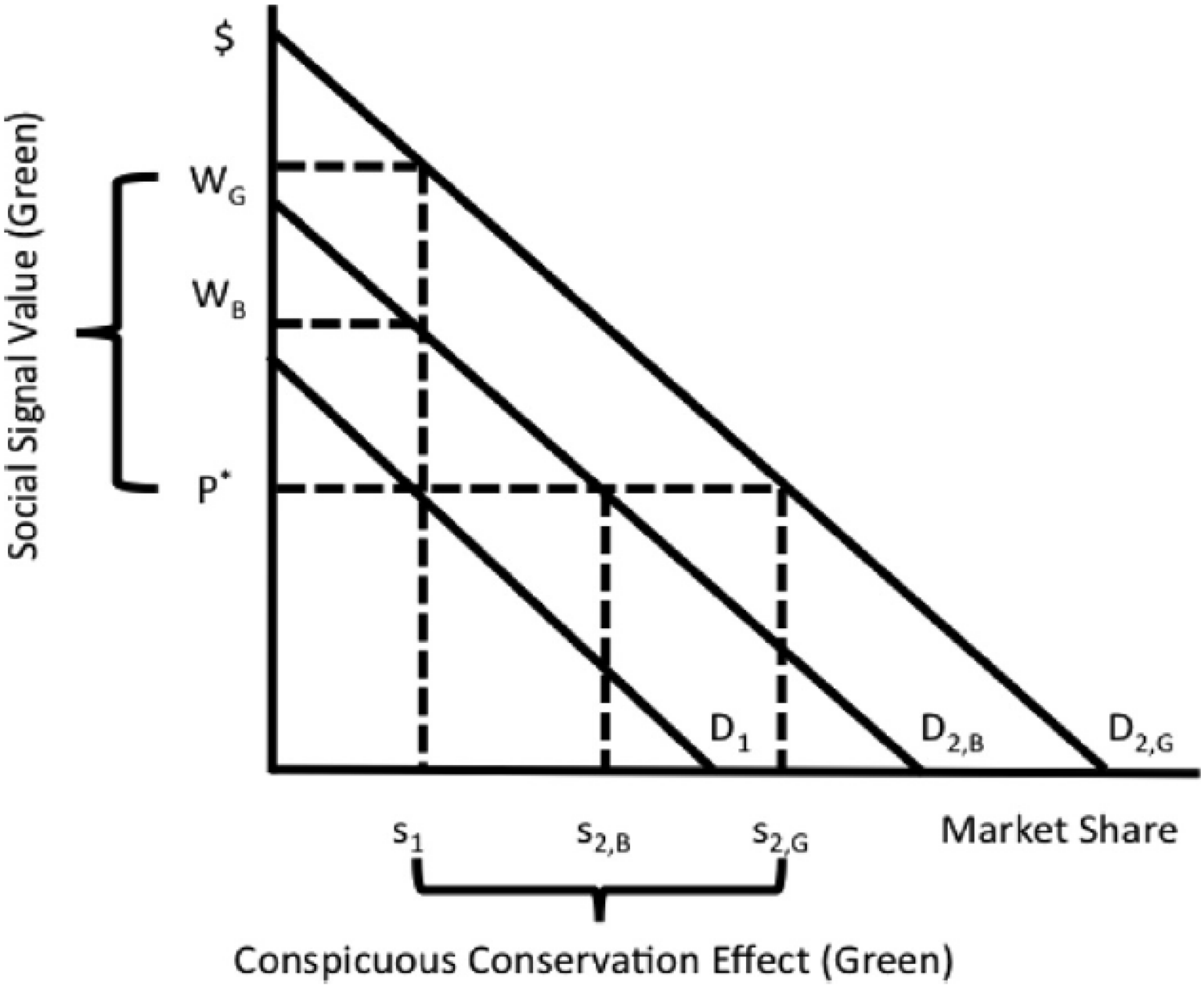
- Sexton, Steven E., and Alison L. Sexton. "Conspicuous conservation: The Prius halo and willingness to pay for environmental bona fides." Journal of Environmental Economics and Management 67.3 (2014): 303-317.

Testing for Conspicuous Conservation



Estimating Willingness to Pay

- Willingness to pay is measured by the change in price

$$dP = \frac{dQ}{Q} * \frac{P}{\epsilon_{price}}$$

- $\frac{dQ}{Q}$ is Percentage change in market share moving from average Dem share to 0

$$\frac{dQ}{Q} = \frac{-30 \text{ percentage points} * .000052}{.00468} = -.33$$

where .00468 is average prius share (i.e. about half of 1 percent) i.e. 33% change in market share

- Then for an $\epsilon_{price} = -2$

$$dP = -.33 * \frac{P}{-2} = \frac{1}{6}P$$