Using Big Data To Solve Economic and Social Problems

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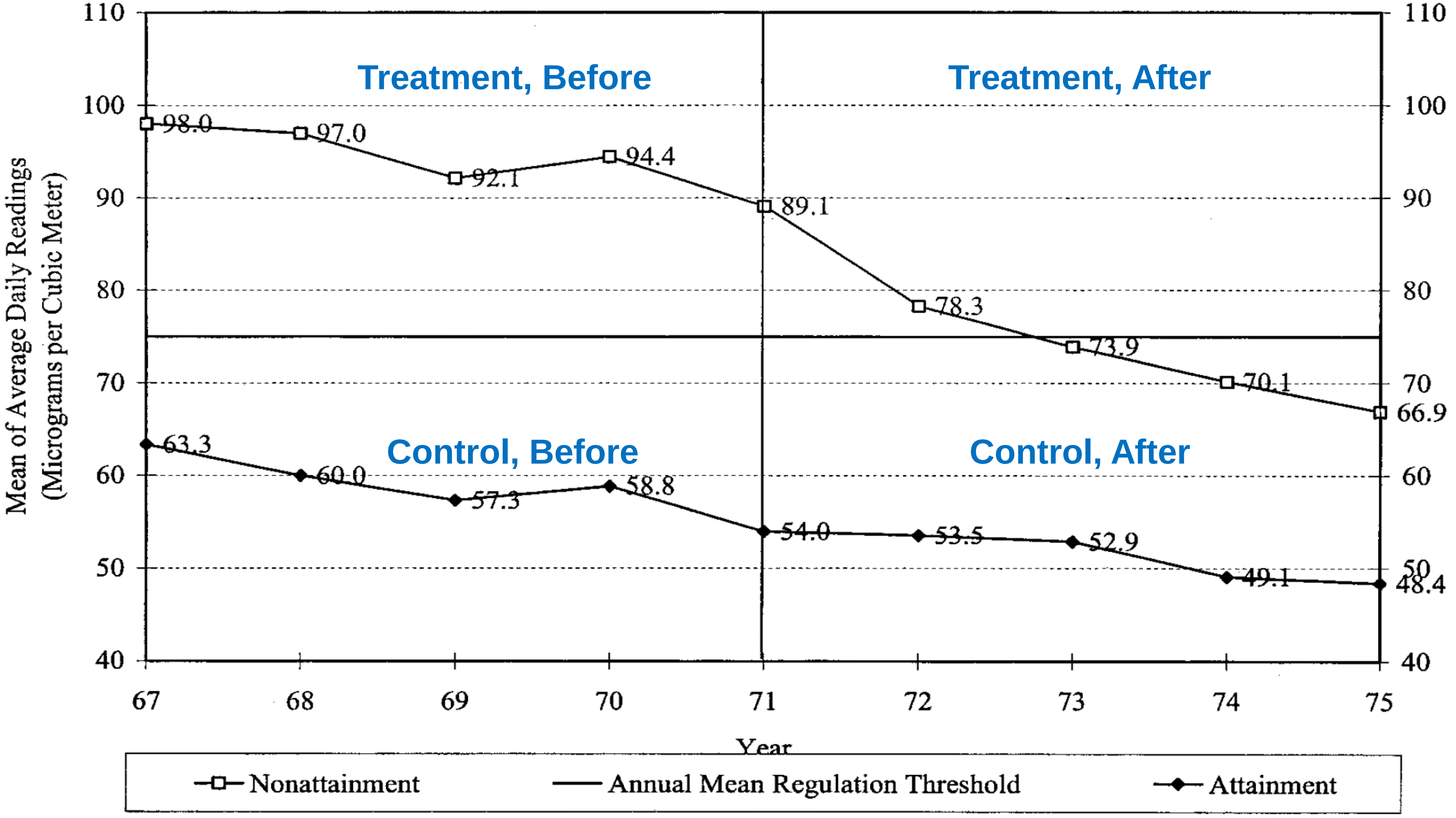
Photo Credit: Florida Atlantic University

Impact of Clean Air Act on Air Pollution (Total Suspended Particulates)



Source: Chay and Greenstone 2005

Diff in Diff Estimate = (TA – TB) – (CA – CB)

Difference-in-Differences Quasi-Experimental Methodology

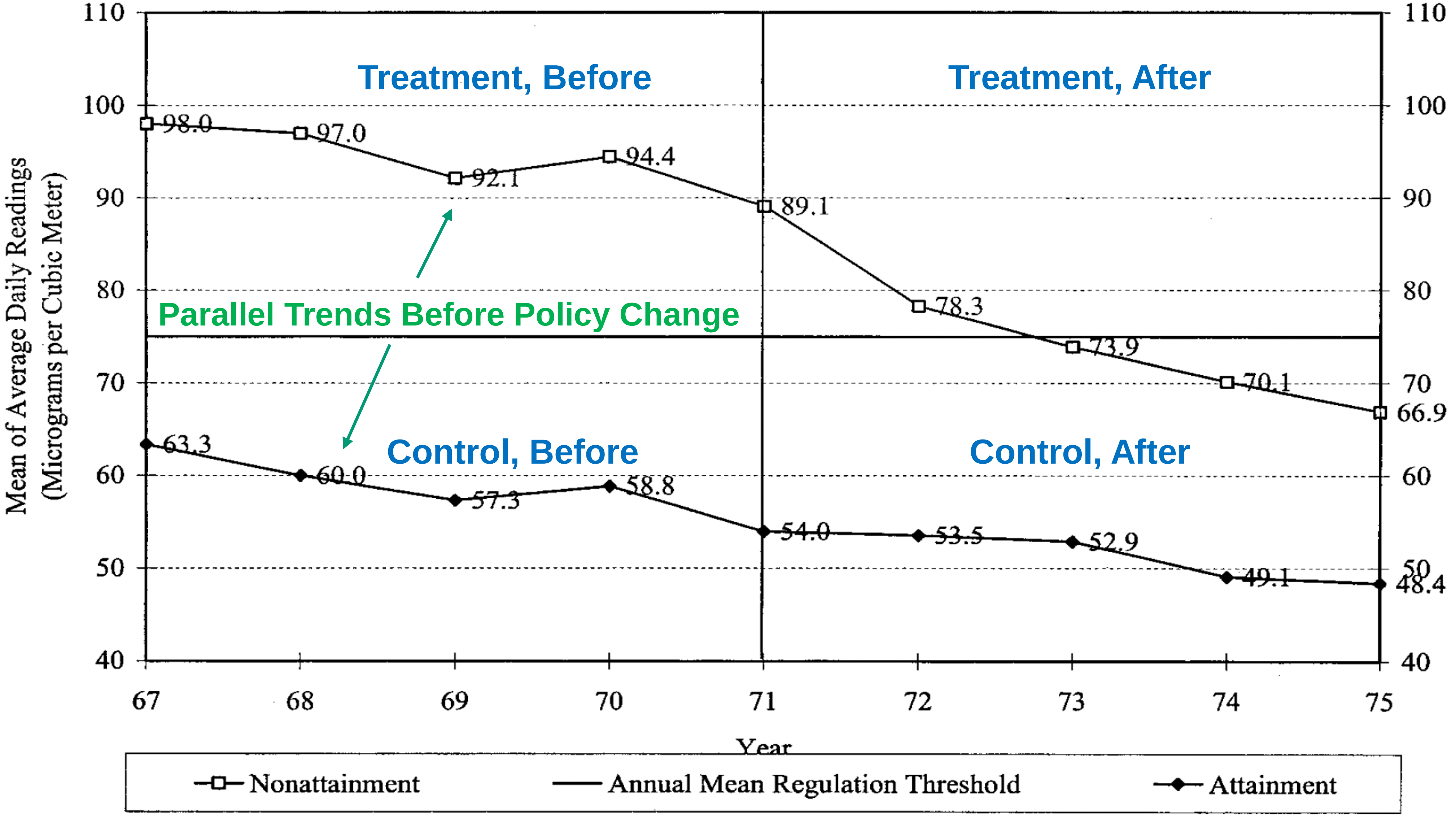
- Diff-in-diff avoids biases that can arise from comparing different types of places or simply examining changes over time in a single place

- Key identification assumption to make diff-in-diff as good as an experiment: **parallel trends**

  - Absent the policy reform, outcomes would have changed similarly across the two types of areas

  - Does not necessarily have to hold, but can be evaluated by examining data *before* the policy change

Impact of Clean Air Act on Air Pollution (Total Suspended Particulates)



Source: Chay and Greenstone 2005

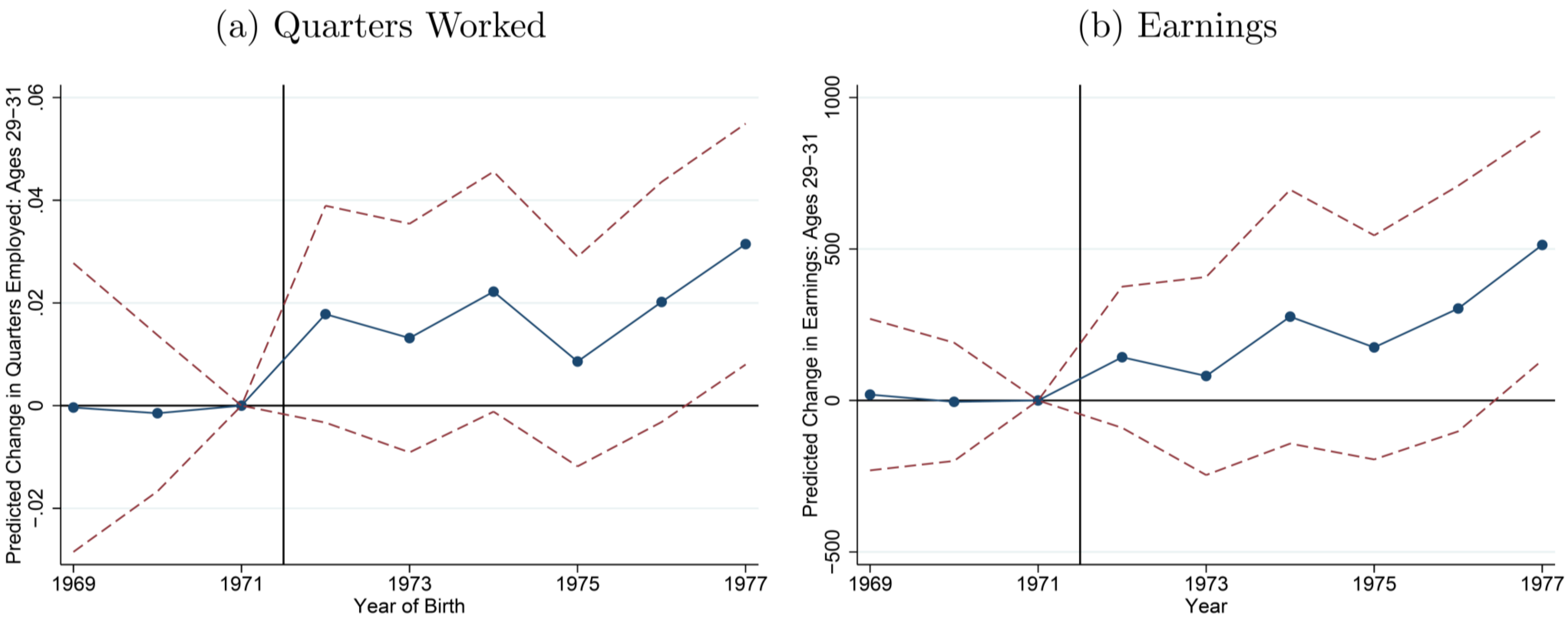
Diff in Diff Estimate = (TA – TB) – (CA – CB)

Effects of Pollution on Economic Outcomes

- Isen et al. examine economic outcomes at age 30 vs. year of birth using this approach

- Plot *difference* between outcomes in treated and control areas vs. birth cohort

Impact of Clean Air Act on Children's Economic Outcomes at Ages 29-31



Impacts of Air Pollution: Summary

- Reduction in pollution in non-attainment counties increased children's earnings by about 1%

- Implies that total gain in earnings was about $6.5 billion per birth cohort

- Excludes other potential gains that may have accrued to society, but shows that benefits were quite substantial even purely in terms of earnings

Discounting Future Costs

- Studies discussed thus far examine costs of environmental damage in a single year
  - Ex: loss of GDP of 23% in 2100 due to climate change or $6.5 billion cost of greater air pollution for kids born each year
- Final step in calculating social costs of environmental damage: add up this sequence of costs to generate a single current value
- Critical question in this step: how much is money tomorrow worth today?
  - If we don't care about future generations, then costs are not large
  - If we care equally about all generations, costs can be infinite

Estimating Long-Run Discount Rates

- Challenge: how can we estimate how people value cash flows over a period of hundreds of years using real-world data?

- Giglio, Maggiori, and Stroebel (2015) develop an innovative approach

- Use data on all residential properly sales in the U.K. and Singapore in 2000s

- Compare how much people pay for two different types of housing contracts
  - Freeholds: perpetual ownership (like in the U.S.)
  - Leasehold: ownership for a fixed period (e.g., 100 years or 1000 years)


Price Discount by Remaining Lease Length
Average Discount to Freehold
0
-.05
-.1
-.15
-.2
People pay 12% less for a house that
they will own for 100 years relative to a
house they will own forever
80-99
100-124
125-149
150-300
700+
Lease Length Remaining

Estimating Long-Run Discount Rates

- Price discount even for 100 yr+ leaseholds shows that they place substantial value on money then will have more than 100 years from now

- Implied annual discount rate is 2.6%, i.e. $1,000 a year from now is worth $974 today

Summary: Social Cost of Carbon

- Putting together all of these estimates, what is the social cost of carbon?

- Obama Interagency Working Group on Social Cost of Carbon was tasked with answering this question

- Compiled data on estimated impacts of carbon emissions

- Applied a discount rate of 3% to future costs

→ Social cost of carbon set at $40 per ton of CO_2 emitted

  - This number is now used in numerous policy decisions, ranging from fuel-economy rules for cars to regulations on power plants

Summary: Social Cost of Carbon

- But this social cost estimate is not set in stone and is highly debated

- Trump administration suggests using a 7% discount rate instead
  - Yields a social cost of carbon of $5 per ton [Greenstone *NYT* 2016]

- Would dramatically change the set of policies that the government will pursue

Policies to Mitigate Climate Change

How Can We Mitigate Climate Change and Reduce Pollution?

- Given estimates of the costs of climate change, we can agree on targets in terms of reducing carbon emissions or air pollution
- What policies can we use to change human behavior to achieve these social goals?
- Most common policy tool: corrective ("Pigouvian") taxes that increase private costs of consumption

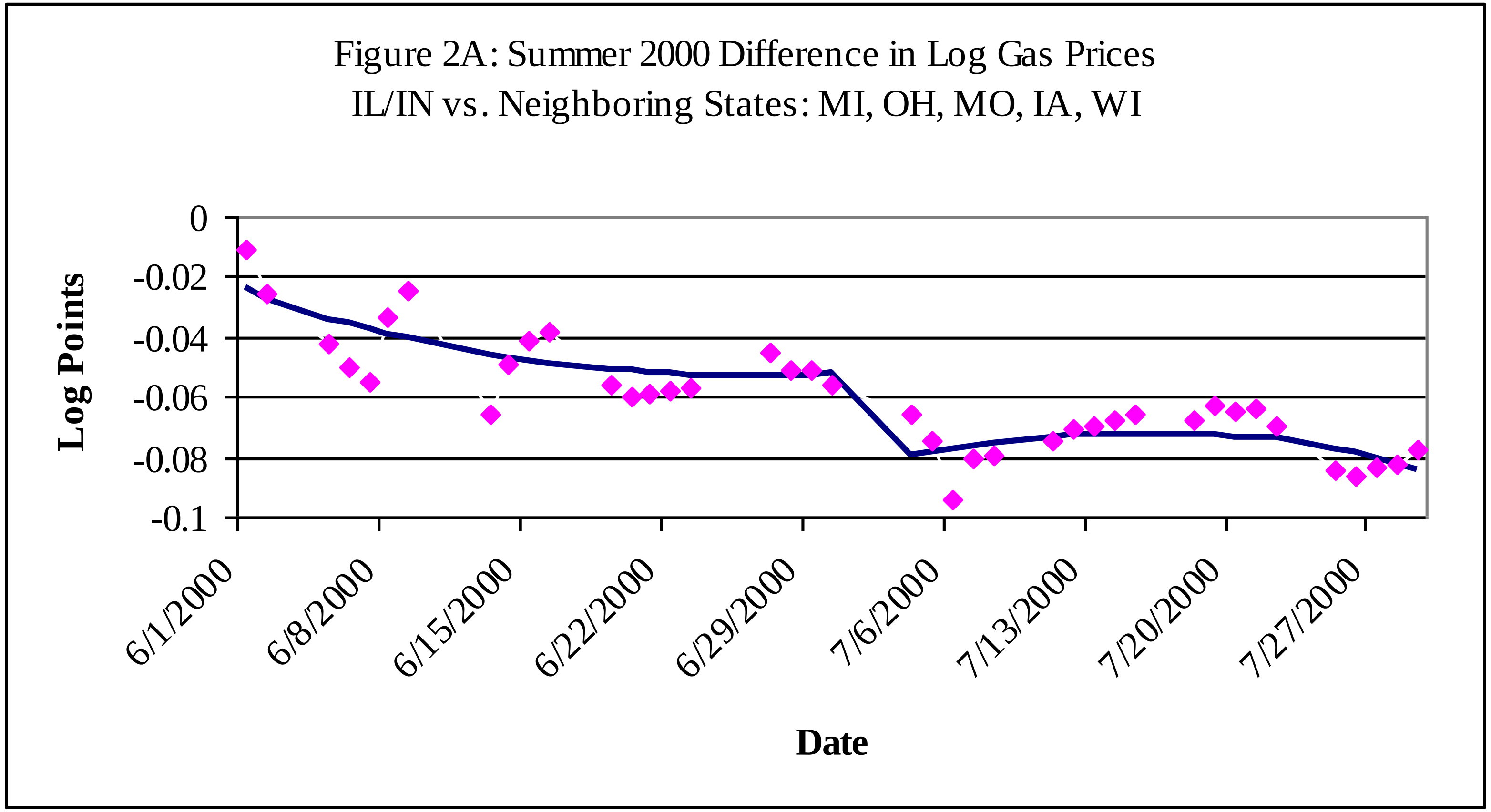
Effects of Gasoline Taxes

- Taxes on gasoline are one potential way to reduce gas consumption and CO_2 emissions

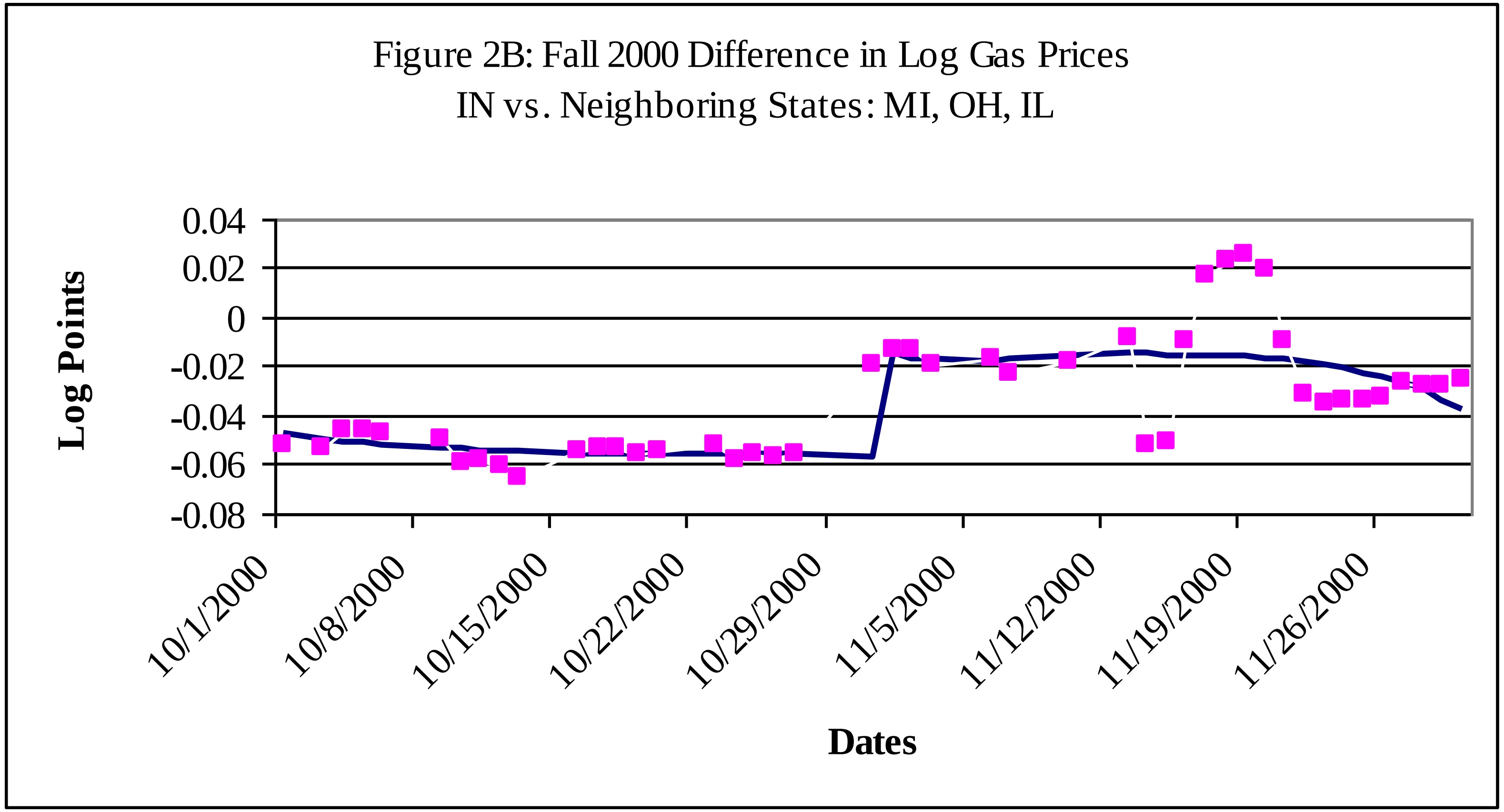
- First question: are gas tax changes passed through to consumers or do just they affect the profits of oil companies?

- Doyle and Sampatharank (2008) study this question using state-level gas tax reforms and a difference-in-differences design
  - Gas prices spiked above $2.00 in 2000
  - IN suspended its gas tax on July 1 and reinstated it on Oct 30
  - IL suspended its gas tax on July 1 and reinstated it on Dec 31

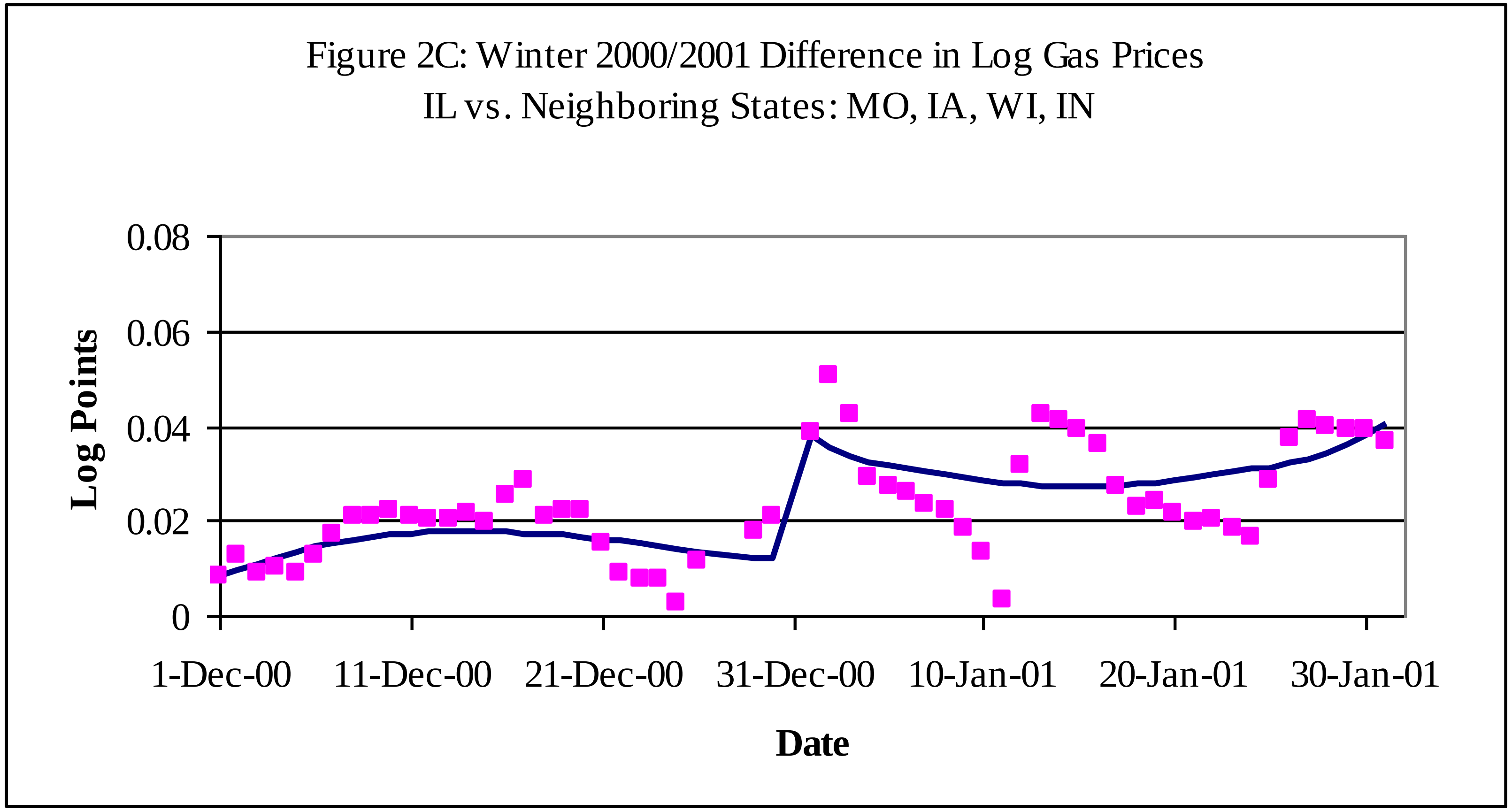
Summer 2000 Difference in Log Gas Prices
IL/IN vs. Neighboring States: MI, OH, MO, IA, WI



Fall 2000 Difference in Log Gas Prices
IL/IN vs. Neighboring States: MI, OH, IL



Winter 2000/2001 Difference in Log Gas Prices
IL vs. Neighboring States: MI, IA, WI, IN



Effects of Gasoline Taxes on Gasoline Prices

- Finding: 10 cent increase in gas tax → 7 cent increase in price paid by consumers

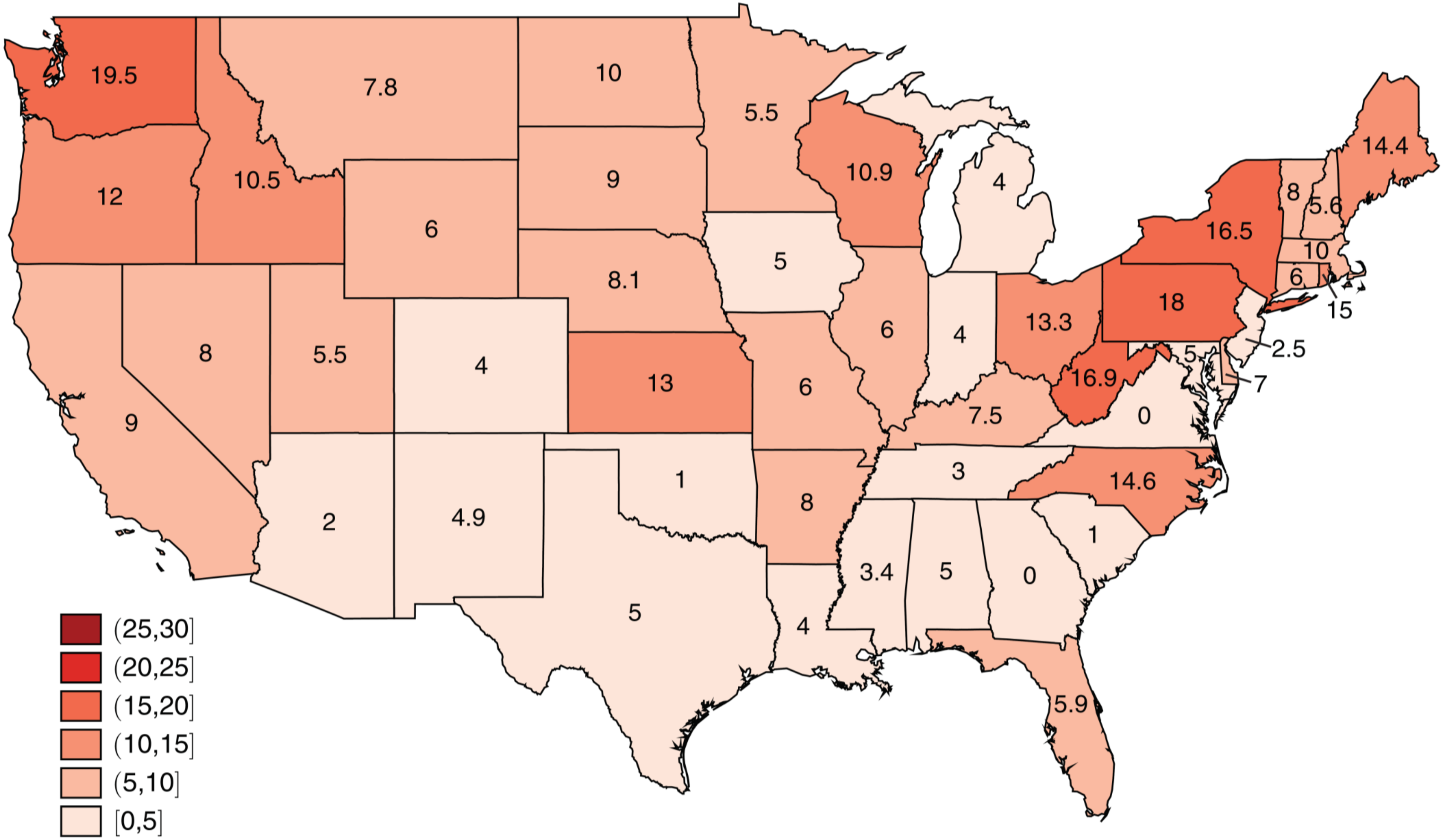
- Implies that gas taxes could potentially reduce consumption of gas

- Next question: how much less gas do people use when prices go up?

Effects of Gasoline Taxes on Gasoline Demand

- Li et al. (2014) generalize this approach to estimate effects of state tax changes on demand for gas
- Use data covering all 50 states and exploit changes in tax rates in *all* states from 1966-2008

Changes in State Gas Taxes from 1987-2008 (cents per gallon)



Effects of Gasoline Taxes on Gasoline Demand

- To generalize diff-in-diff approach to 50 states and 44 years (more than 500 "experiments"), use a method called fixed effects regression

- Relate differential changes in a state's gas consumption (relative to avg. national change in a given year) to differential change in its tax rate
  - Regress $\Delta g_{sy} - \Delta g_y$ on $\Delta tax_{sy} - \Delta tax_y$

- Resulting coefficient represents causal effect of tax change assuming that trends would be parallel across states absent tax changes

Table 5—Gasoline Taxes, Tax-Exclusive Prices, and Consumption, Monthly

	Levels		First-differenced		First-differenced seasonal data	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
log (gas price)	–0.196***		–0.248***		–0.109*	
	(0.030)		(0.030)		(0.057)	
log (tax-excl. gas price)		–0.217***		–0.365***		–0.172***
		(0.028)		(0.047)		(0.061)
log (1 + tax ratio)		–0.414***		–0.769***		–0.394***
		(0.046)		(0.157)		(0.140)
p-value: $\alpha = \beta$		$<$ 0.001		$<$ 0.001		0.038
Observations	14,898	14,898	14,763	14,763	4,893	4,893
R^2	0.987	0.987	0.446	0.446	0.466	0.467

Notes: The dependent variable is the log of gasoline consumption per adult. All specifications include time fixed effects. Levels regressions also include state fixed effects. Robust standard errors are clustered by state.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Effects of Gasoline Taxes on Gasoline Demand

- 10 cent increase in gas tax → 1.7% reduction in gasoline consumption
- Transportation sector accounts for about 1/3 of carbon emissions → 10 cent increase in gas tax reduces carbon emissions by about 0.5%
[Davis et al. 2011]
- For comparison, scientists predict that we need to cut CO2 emissions by about 50% to stop increase in global temperatures
- Lesson: gas taxes make a difference, but need very large taxes to have a meaningful impact on climate change

Incentives to Purchase Hybrid Cars

- Alternative approach: encourage people to buy more fuel-efficient cars

- Federal and state governments offer incentives for purchase of hybrid cars
  - Two types of incentives: sales tax rebates and income tax rebates

- Gallagher and Muehlegger (2011) examine effects of these incentives on demand for hybrid cars exploiting state policy changes (diff-in-diff method)

Incentives to Purchase Hybrid Cars

- Key result: sales tax rebates have 10 times as large an effect on hybrid car demand as income tax rebate of same amount
- Why? Sales tax rebate offered at point of purchase and is very salient to consumer; income tax rebate is obtained months later and is less clear
- Furthermore, changes in gas prices have small effects on purchase of hybrid cars
- Results imply that way in which incentives are structured matters as much as dollar amounts
    - Income tax rebates for hybrid cars cost the government money but do not effectively achieve policy goal of reducing emissions

Effect of Electricity Prices on Electricity Usage

- Next, consider effects of prices on electricity consumption

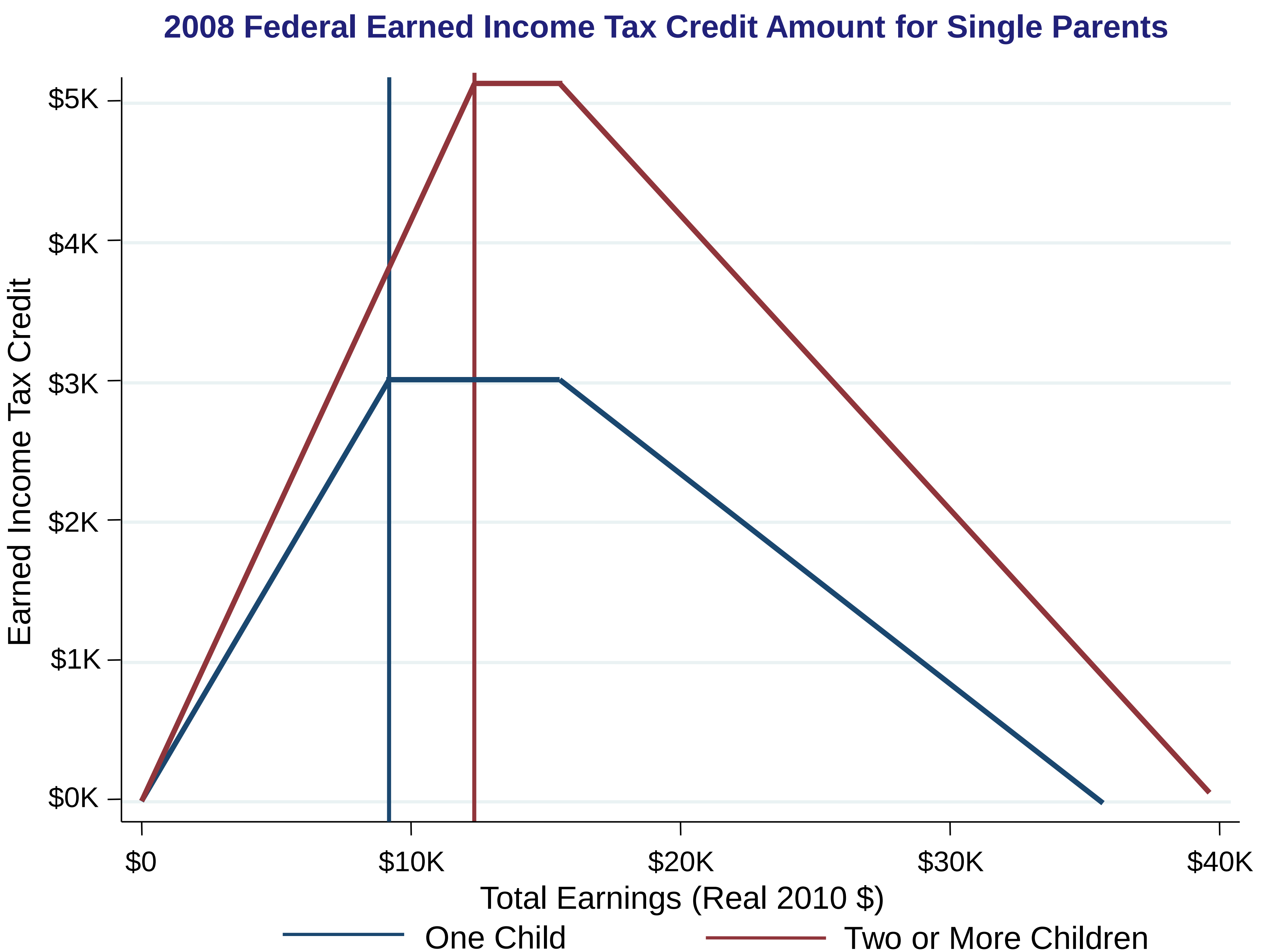
- Electricity is priced using tiered rates: price of an additional kilowatt is higher when you are already using a lot of electricity

- Intended to discourage heavy usage without making electricity very expensive for the poor

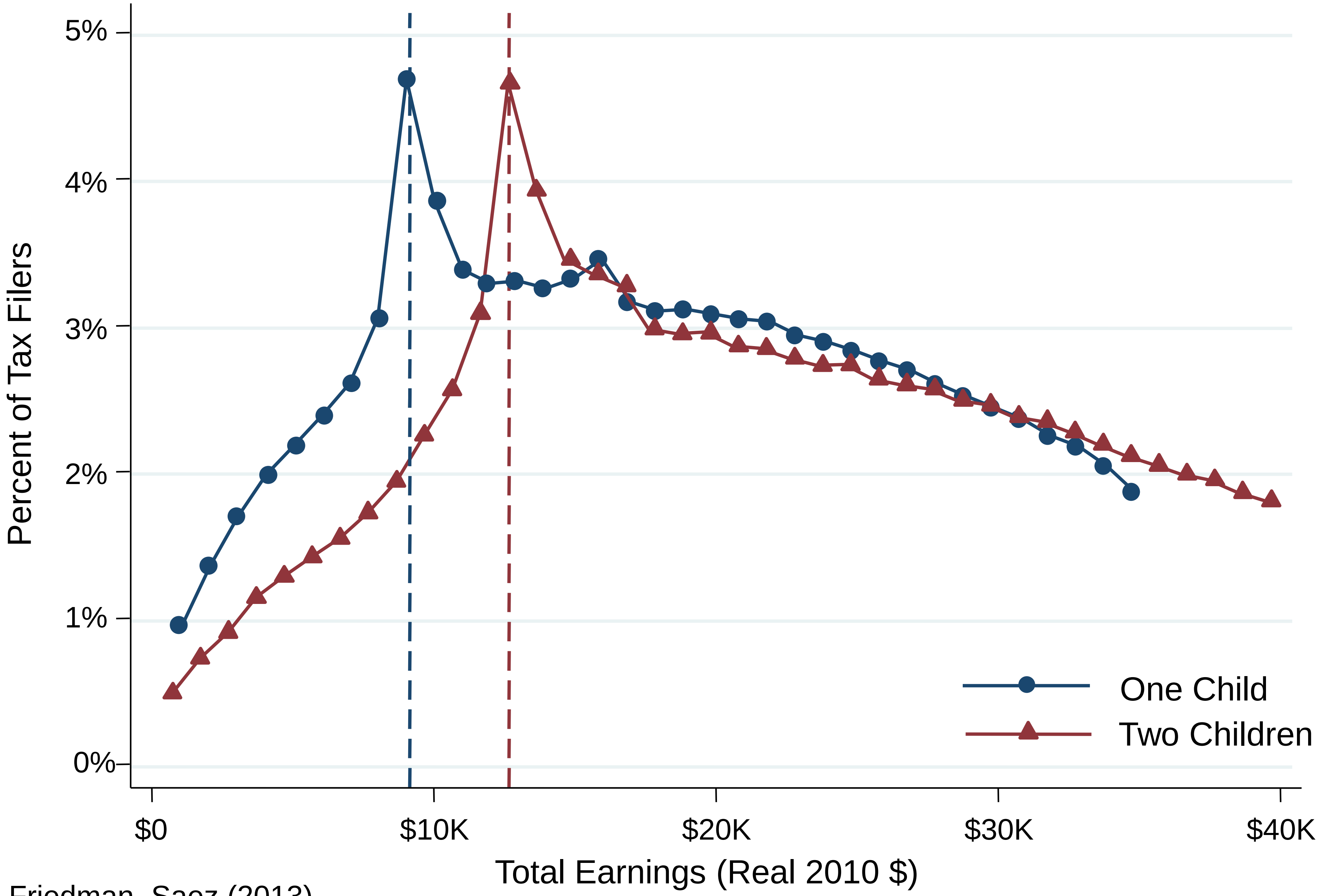
- Does tiered pricing work?

Analyzing Impacts of Tiered Price Schedules

- Impacts of tiered price schedules can be analyzed by examining distribution of outcome variable
- At points where prices change, we expect "bunching" in the distribution if people are responding [Saez 2010]
- Simplest example: progressive income tax schedule
  - Tax rate changes discontinuously at certain thresholds, analogous to a tiered pricing plan
- Ex: low-income households receive Earned Income Tax Credit, which provides subsidies for earning more up to certain cutoffs


2008 Federal Earned Income Tax Credit Amount for Single Parents
Earned Income Tax Credit
$5K
$4K
$3K
$2K
$1K
$0K
$0
$10K
$20K
$30K
$40K
Total Earnings (Real 2010 $)
One Child
Two or More Children

Income Distributions for Individuals with Children in 2008 Based on U.S. Tax Data



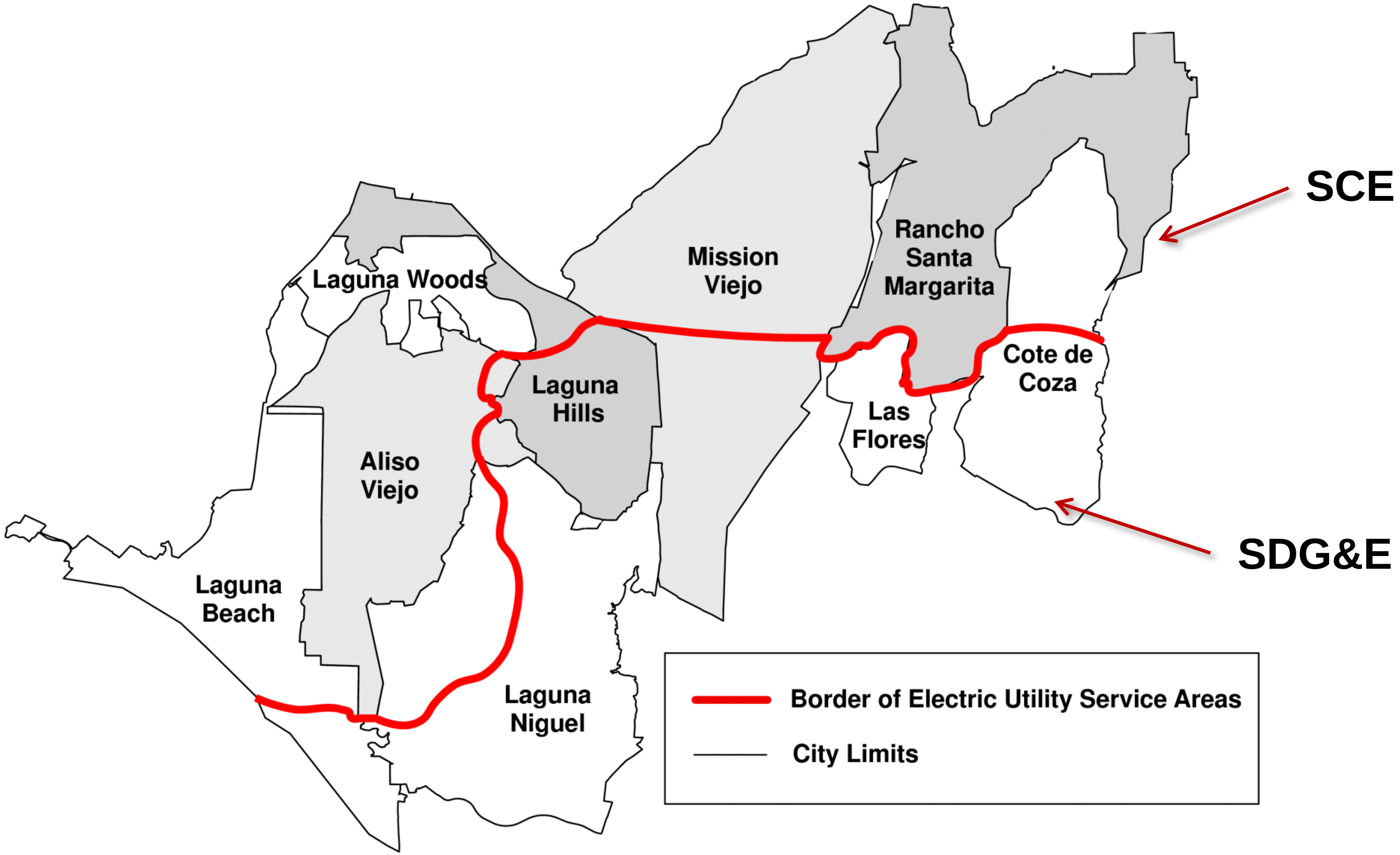
Source: Chetty, Friedman, Saez (2013)

Effects of Tiered Prices on Electricity Usage

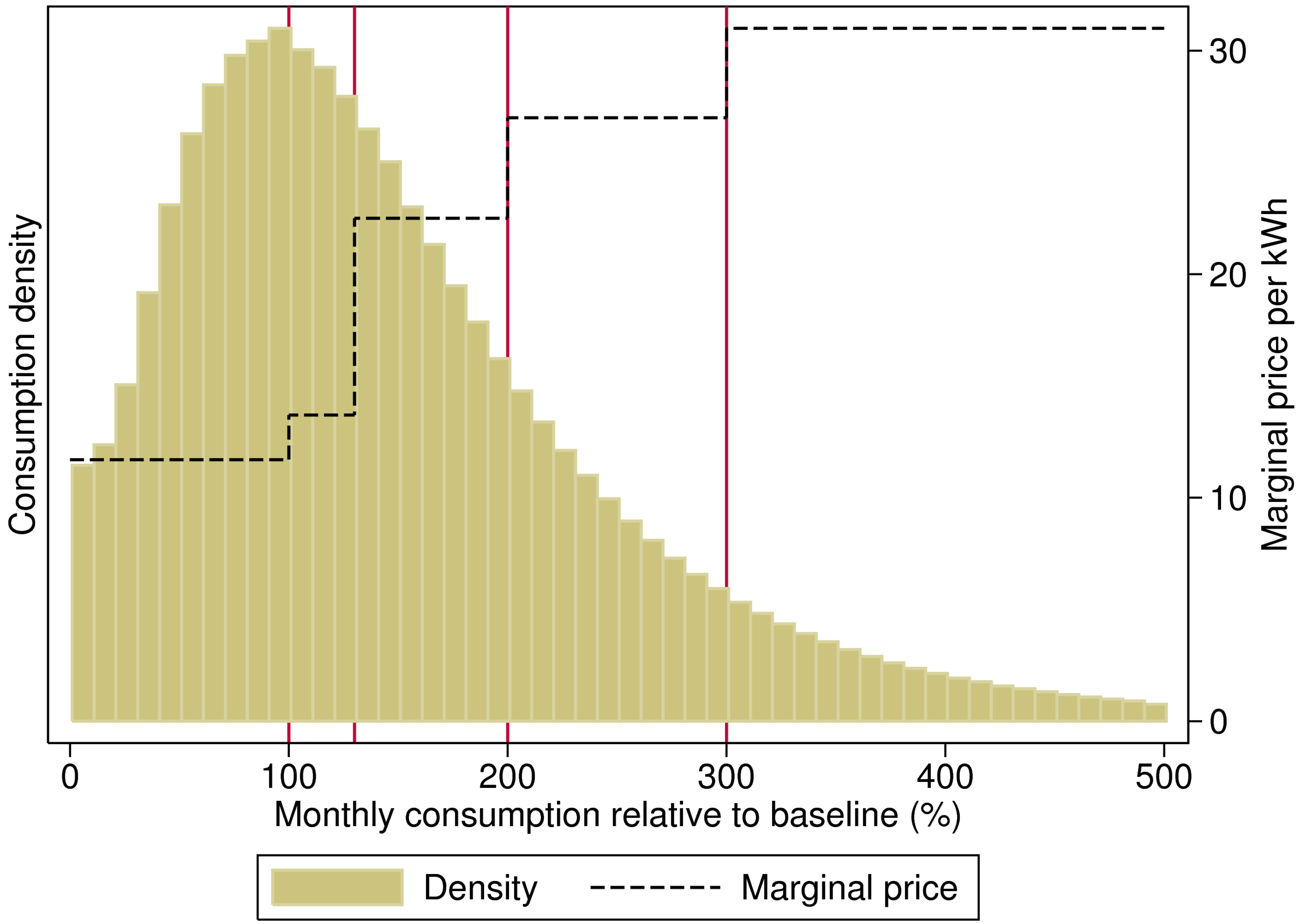
- Ito (2014) studies impact of prices on electricity usage using household-level billing data from utility companies in Orange County, CA

- Utility company that provides service depends upon where families live: Southern California Edison (SCE) vs. San Diego Gas and Electric (SDG&E)

A Spatial Discontinuity in Electric Utility Service Areas in Orange County, California



Prices and Distribution of Electricity Consumption for SCE Customers in 2007



Effects of Tiered Prices on Electricity Usage

- No evidence of bunching at points where electricity prices jump → suggests that consumers are not responding to changes in tiered pricing

- Two interpretations:

  1. Lack of salience: consumers are unaware of electricity price schedule

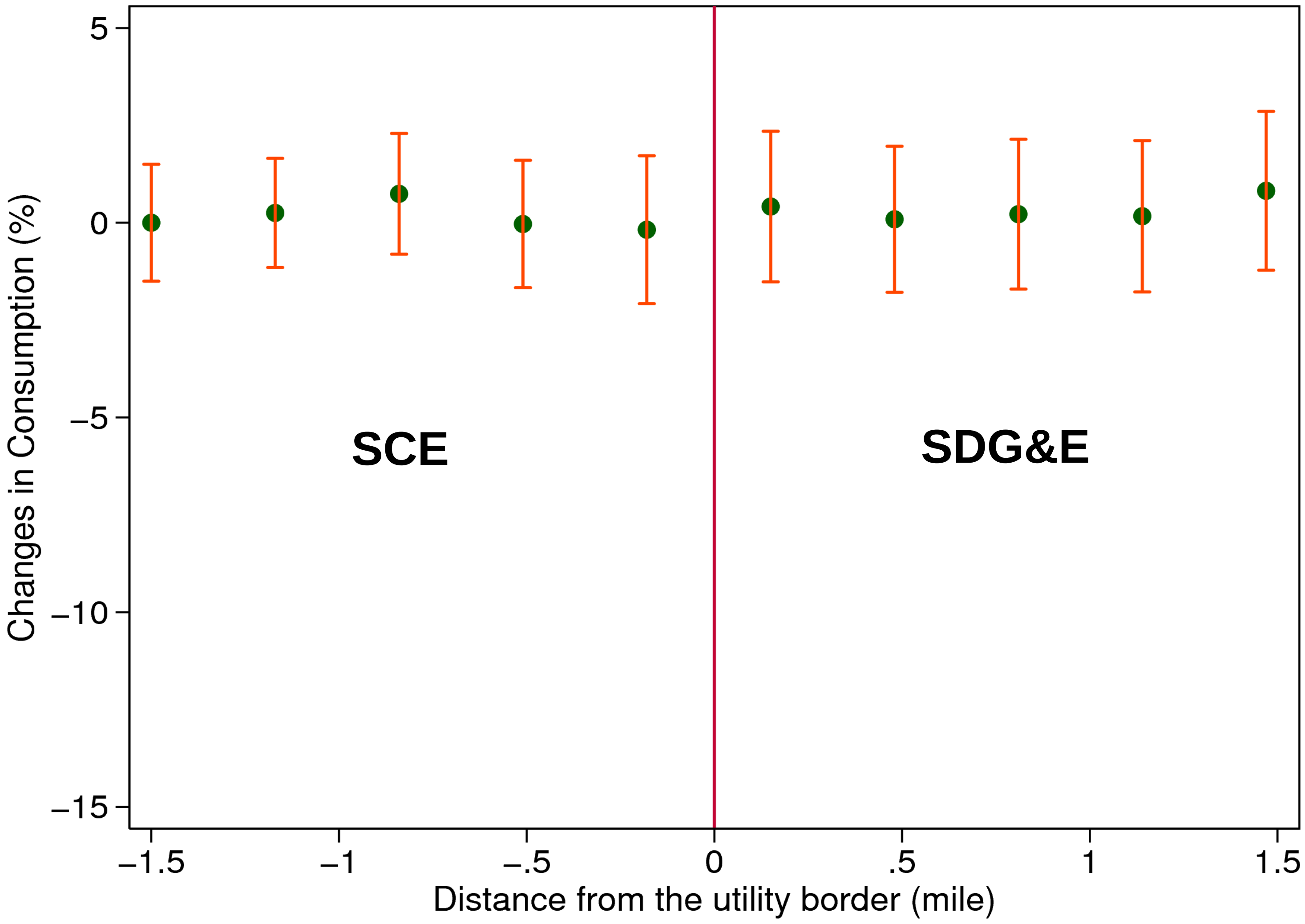
  2. Consumer demand for electricity is insensitive to price

- To distinguish between these explanations, Ito uses a second strategy

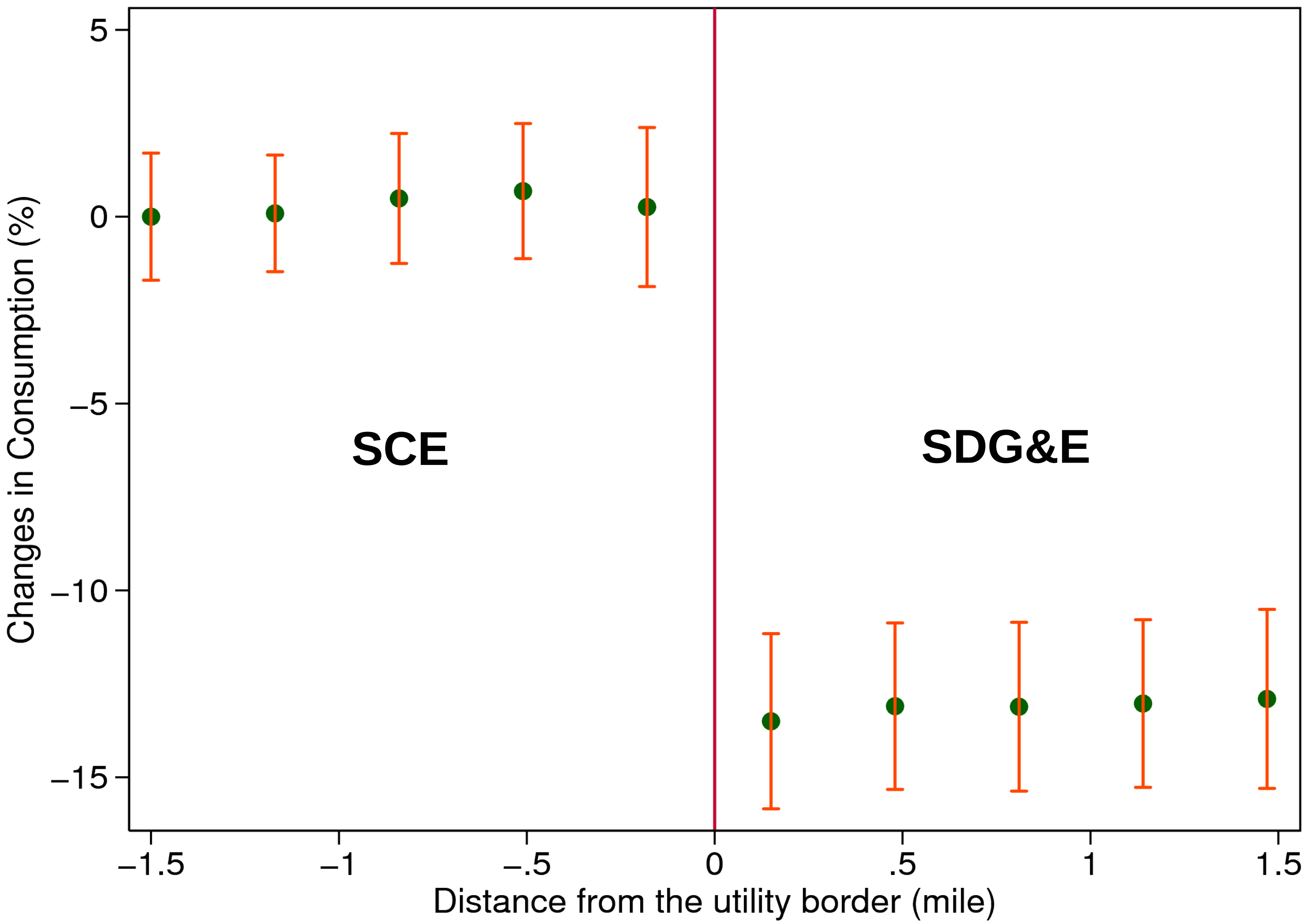
- In summer 2000, SDG&E raised average electricity prices, while SCE did not

  - Uses a regression-discontinuity design to estimate effect of this change

Changes in Consumption from July 1999 to July 2000, by Distance from the Utility Border



Changes in Consumption from August 1999 to August 2000, by Distance from the Utility Border



Effects of Tiered Prices on Electricity Usage

- Result: consumers are very sensitive to electricity prices when change is clearly visible, but do not respond to tiered pricing schedule

- Implies that most consumers are not aware of the price they are paying for using additional electricity

- Reinforces message that when designing corrective taxes, salience and structure of incentives matters as much as the dollars involved

    - Traditional economics assumption that consumers are fully rational and perfectly informed about prices does not hold

How Can We Reduce Electricity Consumption More Effectively?

- Two potential remedies to lack of effectiveness of tiered prices:

1. Make prices more salient to consumers using smart meters
    - Pioneering technological work in this area done by O-Power
    - Will discuss this approach further in Alex Laskey's guest lecture next Tuesday

2. Use non-price tools motivated by results in social psychology
    - Cialdini and collaborators (2007) demonstrate that social comparisons and injunctive social norms have significant effects on electricity use

Last Month Neighbor Comparison | You used **42% more** natural gas than your efficient neighbors.

* Therms: Standard unit of measuring heat energy

How you're doing:

Great

GOOD

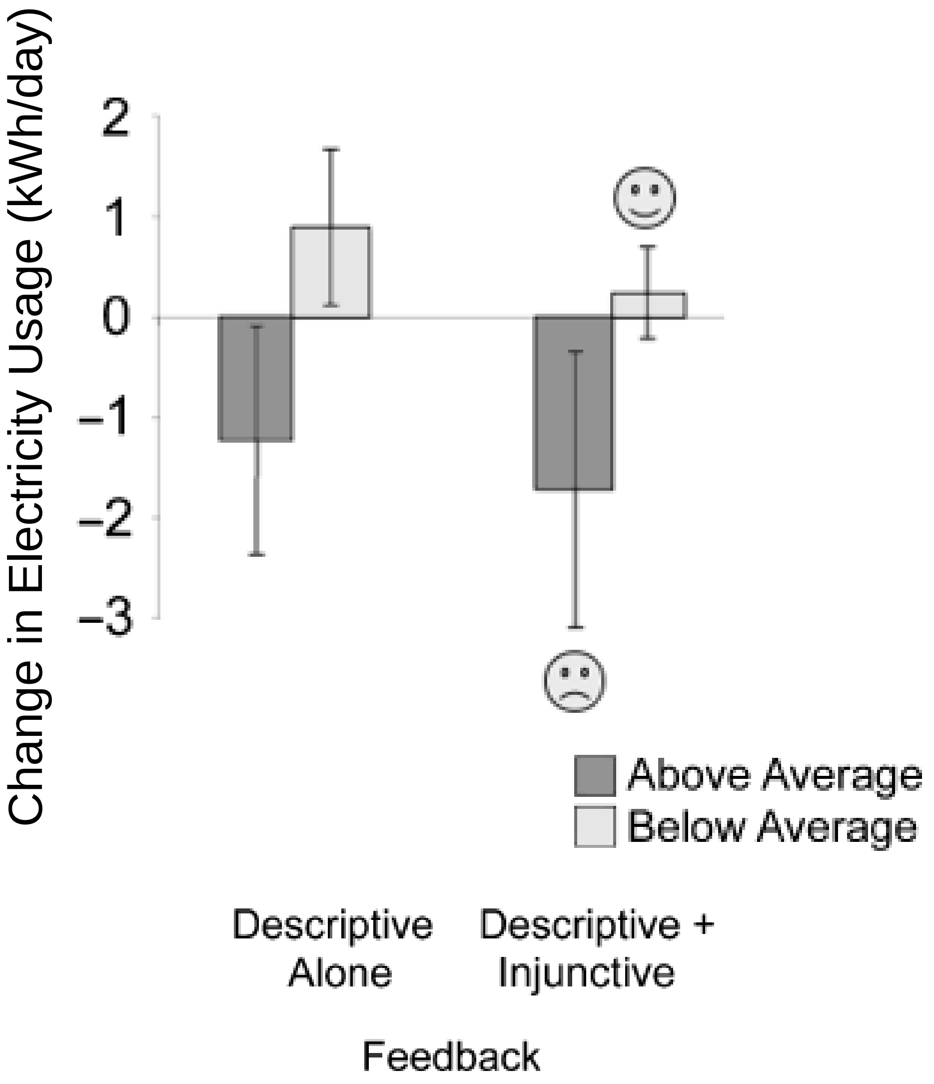
More than average

Who are your Neighbors?

All Neighbors: Approximately 100 occupied, nearby homes that are similar in size to yours (avg 1,517 sq ft)

Efficient Neighbors: The most efficient 20 percent from the "All Neighbors" group

Effects of Social Norm Treatments on Daily Electricity Consumption



Source: Schultz et al. (2007)

Magnitude of Social Norm Treatment

- Social norms treatment reduces electricity usage by about 1 kilowatt-hour per day
    - Equivalent to about a 2.5% reduction in electricity usage
    - Analogous to turning off 10 hundred-watt lightbulbs for an hour a day
    - Modest effect, but does not require charging consumers higher prices