# Utilities Included: Split Incentives in Commercial Electricity Contracts

Katrina Jessoe,[1] Maya Papineau,[2] and David Rapson[1]

[1]University of California, Davis

[2]Carleton University

October 18, 2018

# Motivation: Split Incentives and Energy Use

Efficiency costs from a principal agent problem

- Employment, credit, insurance and agricultural contracts
  - Stiglitz (1974), Grossman (1983), Chiappori and Salanie (2000), Finkelstein and McGarry (2006), Karlan and Zinman (2009), Einav et al. (2013)

Evidence of modest split incentive problem in residential energy setting

- Consumption effects of owner-paid utilities contracts
  - Levinson and Niemann (2004), Gillingham et al. (2012), Elinder et al. (2017), Myers and Souza (2018)
- Tenant paid contract and underinvestment by landlord
  - Davis (2012), Myers (2014)

# Split Incentives Matrix

| | Own | Rent |
|---|---|---|
| Tenant pays | (1) No split incentives | (2) (landlord) Under-insulation & less efficient appliances; optimal effort to reduce energy use |
| Tenant does not pay | (3) (both) Lower effort to reduce energy use; [Under-insulation & less efficient appliances] | (4) (tenant) Lower effort to reduce energy use; optimal insulation & appliances |

# Motivation: Magnitude in Commercial Setting

Commercial sector accounts for 35% end-use electricity consumption

- Close to half of units occupied by renters

Little is known about contract design and electricity use in commercial setting

- Kahn et al. (2014): energy bills 20% lower for tenant-paid contracts
- Difficult to separate split incentives from sorting on energy characteristics

Commercial users larger in size and smaller in number

- Potential efficiency gains from larger savings per customer, fewer points of contact

# How Might Split Incentives Affect Behaviour?

## Tenant-side

- Overcooling in the summer may increase energy use by 8%
- Keeping doors open in summer may increase energy use by 9%
- Miscellaneous equipment such as fans and space heaters account for 20% electricity use

## Owner-side

- Delay energy-related investments
- Purchase more energy inefficient equipment

# Our Paper

What is the effect of contract type on commercial electricity use?

Our approach: effect of temperature shocks on demand for cooling across contract type

- Variation in temperature: bill cycles
- Assignment to contract type: non-random

Data: Monthly billing data for 1126 commercial firms

- Contract type: building level
- Weather: billing-cycle zip code, cooling and heating degree days

# Results - Microeconomic Impacts of Climate Change?

Air conditioning usage primary channel of adaptation (Auffhammer and Mansur (2014))

- For largest firms, the AC response to temperature shocks depends on contract type
  - Tenant paid contracts lower electricity use by 1.4 % per daily CDD
  - About a 3% decrease in electricity use by top decile users
- A price signal dampens the response to temperature shocks among top consumers
- Consistent with bill savings not covering adjustment costs in small firms

# Conceptual Framework: Set up and Notation

Empirical predictions relate to the temperature response gradient: $\frac{\partial X}{\partial T}$

- Electricity consumption by tenant $k$ is $X = f(E, T, P_k(W))$
  - $E$ = energy efficiency capital
  - $T$ = temperature
  - $P_k(W)$ = price per kWh of electricity paid by tenant $k$
  - $W$ = contract type. $W$=0, owner-paid; $W$=1, tenant-paid.
- Demand for electricity is decreasing in $P$ and $E$, increasing in $T$

# Competing Split Incentives

When $W = 1$, k pays $p>0$ for every kWh. When $W = 0$, k pays $p=0$.

- Tenant $k$'s TRG will be shallower if $W = 1$ than if $W = 0$, all else equal (including $E$).

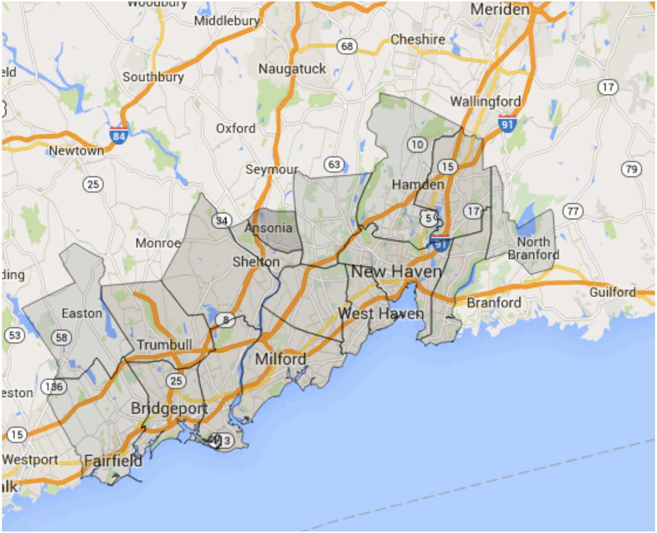
When $W = 1$, and the landlord cannot obtain a rent premium that accounts for the higher up-front costs of energy efficiency, E levels will be lower than if $W = 0$.

- Tenant $k$'s TRG will be steeper if $W = 1$ than if $W = 0$.

These are competing hypotheses about the electricity response gradient in tenant-paid buildings.

Any conservation benefit from a tenant paying their own energy bills could be mitigated or overwhelmed by building capital inefficiencies.

# Empirical Setting: Small C&I Customers in CT



# Empirical Setting: Small C&I Customers in CT

Metering regulations in CT

- Tenant level billing requires presence of a sub-meter
- Until summer 2013, sub-meter retrofits prohibited
- Presence of sub-metering determined at time of building construction
- Data on 2013 post-prohibition contract type
  - Observe firms in buildings that switched contract type

Area of study is 17 counties greater Bridgeport, Fairfield and New Haven

- Heating predominantly with fuel or natural gas
- Hypothesize electricity use most responsive to summer weather via AC

# Data

-Monthly billing data from UI spanning 10/2007 to 5/2011

-Panel of 40,962 observations from 1,126 firms

-Property level information on contract type and building characteristics

- 72% firms located in office buildings
- 84% firms on tenant paid contracts

-CDD and HDD in a zip code billing-month

- Daily temperature data at 10 stations from NOAA
- Difference in weather across 32 zip codes in UI's territory
- Difference in weather across 16 billing cycles

# Differences in Observables Across Contract Type

| | All Firms | | | | |
|---|---|---|---|---|---|
| | Tenant-Paid | | Owner-Paid | | t-Statistic |
| | Mean | St. Dev. | Mean | St. Dev. | |
| kW | 27.3 | 42.9 | 33.5 | 61.4 | 0.42 |
| kWh (000s) | 7.7 | 13.8 | 9.0 | 17.1 | 0.31 |
| Bill ($) | 627 | 999 | 720 | 1220 | 0.31 |
| Bill Length | 30.3 | 1.3 | 30.4 | 1.3 | 0.30 |
| Building S.F. (000s) | 57.2 | 59.7 | 66.8 | 93.6 | 0.43 |
| Year Built | 1974 | 26 | 1968 | 33 | 0.76 |
| Building Stories | 2.6 | 1.6 | 3.4 | 3.1 | 1.09 |
| Industry | 0.12 | 0.33 | 0.10 | 0.31 | 0.25 |
| Trade, Accommodation | 0.15 | 0.36 | 0.12 | 0.33 | 0.35 |
| Finance, Real Estate, Management | 0.47 | 0.36 | 0.55 | 0.50 | 0.66 |
| Education, Health, Pub. Admin. | 0.19 | 0.36 | 0.18 | 0.38 | 0.11 |
| Entertainment, Recreation, Services | 0.07 | 0.36 | 0.05 | 0.21 | 0.33 |
| North | 0.40 | 0.49 | 0.36 | 0.48 | 0.33 |
| South | 0.60 | 0.49 | 0.64 | 0.48 | 0.33 |
| City | 0.30 | 0.46 | 0.31 | 0.46 | 0.09 |
| Observations | 34,304 | | 6,658 | | |
| Firms | 948 | | 178 | | |

# Differences in Observables Top Consumption Decile

| | Top Decile Firms | | | | |
|---|---|---|---|---|---|
| | Tenant-Paid | | Owner-Paid | | t-Statistic |
| | Mean | St. Dev. | Mean | St. Dev. | |
| kW | 132.4 | 71.2 | 164.2 | 120.9 | 1.11 |
| kWh (000s) | 40.6 | 24.1 | 44.5 | 34.1 | 0.47 |
| Bill ($) | 3002 | 1759 | 3276 | 2403 | 0.47 |
| Bill Length | 30.4 | 1.3 | 30.4 | 1.3 | 0.03 |
| Building S.F. (000s) | 86.8 | 79.7 | 144.9 | 146.4 | 1.68 |
| Year Built | 1978 | 19 | 1973 | 24 | 0.85 |
| Building Stories | 3.0 | 2.4 | 6.1 | 5.1 | 2.61* |
| Industry | 0.22 | 0.41 | 0.18 | 0.39 | 0.40 |
| Trade, Accommodation | 0.09 | 0.28 | 0.04 | 0.20 | 0.92 |
| Finance, Real Estate, Management | 0.46 | 0.50 | 0.77 | 0.42 | 2.83* |
| Education, Health, Pub. Admin. | 0.09 | 0.29 | 0.00 | 0.00 | 2.96* |
| Entertainment, Recreation, Services | 0.15 | 0.35 | 0.00 | 0.00 | 4.09* |
| North | 0.39 | 0.49 | 0.27 | 0.44 | 1.06 |
| South | 0.61 | 0.49 | 0.73 | 0.44 | 1.06 |
| City | 0.27 | 0.45 | 0.40 | 0.49 | 1.07 |
| Observations | 3,202 | | 703 | | |
| Firms | 91 | | 19 | | |

# Empirical Approach: Electricity Use and Temperature Gradient

Idea: if split incentives problem, then differences in demand for cooling

Implementation: electricity response to CDD across contract type

$$Y_{it} = \beta_1 C_{zt} + \beta_2 H_{zt} + \theta_1 T_i \times C_{zt} + \theta_2 T_i \times H_{zt} + \eta_i t + \alpha_t + \gamma_i + \varepsilon_{it}$$

- Interact contract type with weather variables
- $\gamma_i$: firm fixed effect

Identifying Assumption: electricity response to temperature shocks differs only by contract type, or unobservables uncorrelated with contract type

- Allows for sorting into contract type based on fixed firm unobservables
- Assumes unobservables do not exhibit temperature response gradient correlated with contract type

# Testing Identifying Assumption: Augmented Regression

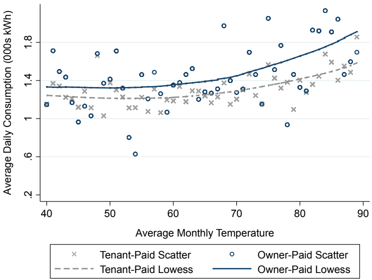
$$Y_{it} = \beta_1 C_{zt} + \theta_1 T_i \times C_{zt} + \xi X_i \times C_{zt} + Z_i t + \eta_i t + \alpha_t + \gamma_i + \varepsilon_{it}$$

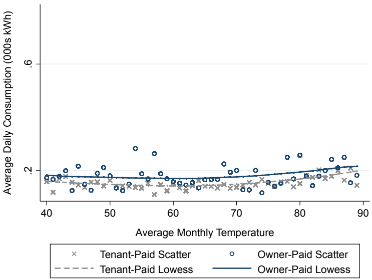
- $X_i \times C_{zt}$: interaction of building attributes and switchers with weather
- $Z_{it}$: bill length

Is consumption effect across contract type robust to inclusion of building attribute interaction terms?

Are "switchers" likely to drive the results?

# Consumption by Contract Type



# Split Incentive Effect

| Dependent variable: | Log Usage | | | | | Log Bill |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Tenant x CDD | -0.00001 | | | | | |
| | (0.00009) | | | | | |
| Tenant x CDD (10th Dec.) | | -0.013** | -0.015*** | -0.015** | -0.014** | -0.012** |
| | | (0.006) | (0.006) | (0.006) | (0.006) | (0.005) |
| Tenant x CDD (9th Dec.) | | 0.001 | 0.004 | 0.005 | 0.005 | 0.004 |
| | | (0.009) | (0.010) | (0.009) | (0.009) | (0.009) |
| Tenant x CDD (8th Dec.) | | -0.001 | 0.005 | 0.005 | 0.004 | 0.002 |
| | | (0.007) | (0.007) | (0.007) | (0.007) | (0.005) |
| Tenant x CDD (7th Dec.) | | -0.004 | -0.001 | 0.003 | 0.003 | 0.001 |
| | | (0.007) | (0.008) | (0.007) | (0.007) | (0.005) |
| Tenant x CDD (6th Dec.) | | 0.010 | 0.014* | 0.011 | 0.012 | 0.009* |
| | | (0.008) | (0.007) | (0.007) | (0.007) | (0.005) |
| Tenant x CDD (5th Dec.) | | 0.003 | 0.005 | 0.005 | 0.005 | 0.004 |
| | | (0.007) | (0.008) | (0.007) | (0.007) | (0.005) |
| Tenant x CDD (4th Dec.) | | 0.009 | 0.011 | 0.012 | 0.012 | 0.009 |
| | | (0.011) | (0.011) | (0.010) | (0.010) | (0.006) |
| Tenant x CDD (3rd Dec.) | | -0.017 | -0.017 | -0.012 | -0.012 | -0.006 |
| | | (0.014) | (0.014) | (0.013) | (0.013) | (0.008) |
| Tenant x CDD (2nd Dec.) | | 0.005 | 0.004 | 0.006 | 0.006 | 0.006 |
| | | (0.010) | (0.010) | (0.009) | (0.010) | (0.005) |
| Tenant x CDD (1st Dec.) | | -0.010 | -0.009 | -0.009 | -0.009 | -0.002 |
| | | (0.012) | (0.012) | (0.011) | (0.012) | (0.007) |
| Account & Time F.E.s, Acct. Trend | YES | YES | YES | YES | YES | YES |
| Characteristics Interactions | NO | NO | YES | YES | YES | YES |
| Characteristics Interactions w/ Year-Built | NO | NO | NO | YES | YES | YES |
| Switchers Controls | NO | NO | NO | NO | YES | YES |

# Interpreting our Results

Heterogeneity in who responds and when firms respond

For the top decile of firms, tenant-paid contracts

- lead to a 3 percent decrease in annual electricity
- would reduce electricity use by close to 14% in August
- Contract impacts narrow set of customers respond during concentrated times...but largest electricity users

Aggregate consumption impact: 19,200 kWh per firm annually

- 1.4% reduction in total use

# How Generalizable Are Our Results?

Estimates based on 110 firms

Representativeness of our sample to 1.8 commercial customers in U.S.

- Strong overlapping support in building attributes across CT and U.S.

Conjecture that split incentives problem more relevant in broader U.S.

- 34% floor space leased in CT vs. 39% in U.S.
- Owner-pay contracts: 16% in our sample vs. 24-45% in U.S.
- New England least energy-intense region in kWh per square foot

# What Have We Learned?

Split incentives problem among largest electricity users

- Tenant paid contract reduces electricity use by 1.4% per CDD
- Aggregate electricity savings of 1.4 percent

Channels to affect demand for AC under climate change

- Show that demand for cooling increases with heat
- Contract design attenuates this response
- First step to understand prices, demand for cooling, and heat

Energy efficiency and GHG reductions

- Private payback period less than a year
- Energy savings larger than many residential programs
- Cost-effective compared to other energy conservation programs