Is More Always Better? A Comparison of Billing Regression Results Using Monthly, Daily, and Hourly AMI Data

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Presentation Outline

Comparison of Billing Regression Results Using Monthly, Daily and Hourly AMI Data

- Research Overview & Background
- Methodology
- Results
- Discussion
Research Overview

• **Goal:** Compare billing regression models using data aggregated at monthly, daily and hourly levels from a single AMI data source.

• **Research Questions:**
  - Do savings estimates change across different aggregation levels?
  - Does the precision of savings estimates change across different aggregation levels?
Advanced Metering Infrastructure (AMI)

- What is AMI?
- AMI data allow investigation of consumption at finer time intervals
- 30% homes have AMI nationally
- Rapidly expanding to more homes
- Will (hopefully) become standard data available to evaluators
Levels of Aggregation
AMI Billing Regression Research Project

• Compare FE billing regression based on hourly, daily, and monthly data

• Hourly AMI data for 678 homes in California

• New air conditioner installed between January 2013 and December 2014

• Each home has at least 9 months of billing data pre and post installation
Data Aggregation

- **Hourly Dataset:**
  - Hourly kW for 678 homes
  - Hourly temperature data (NOAA)
  - Hourly cooling / heating degree hours (Base 65°)

- **Daily Dataset:**
  - Daily kWh = Σ(Hourly kW)
  - Daily degree days = Σ(Degree hours)

- **Monthly Dataset:**
  - Monthly kWh = Σ(Daily kWh)
  - Monthly degree days = Σ(Degree days)
## Data Aggregation

<table>
<thead>
<tr>
<th></th>
<th>Observations</th>
<th>Households</th>
<th>Average kWh</th>
<th>Average CDD</th>
<th>Average HDD</th>
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<tbody>
<tr>
<td>Monthly</td>
<td>15,921</td>
<td>678</td>
<td>785.87 (25.85)</td>
<td>191.98</td>
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<td>Daily</td>
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<td>Hourly</td>
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<td>.27</td>
<td>.23</td>
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</table>
Fixed Effects Model Specification

\[ kWh_{i,t} = \alpha_i + \beta_1(\text{Post}_{i,t}) + \beta_2(C_{i,t}) + \beta_3(H_{i,t}) + \beta_4(C_{i,t} \times \text{Post}_{i,t}) + \beta_5(H_{i,t} \times \text{Post}_{i,t}) + \sum_{j=6}^{16} \beta_j(M_j) + \varepsilon_{i,t} \]

- Monthly Model:
  - kWh = Average Daily kWh
  - Weather = Monthly HDD / CDD (Base 65°F)

- Daily Model:
  - kWh = Actual Daily kWh
  - Weather = Daily HDD / CDD (Base 65°F)

- Hourly Model:
  - kWh = Actual Hourly kW
  - Weather = Hourly HDH / CDH (Base 65°F)
Fixed Effects Model Specification

\[ kWh_{i,t} = \alpha_i + \beta_1(\text{Post}_{i,t}) + \beta_2(C_{i,t}) + \beta_3(H_{i,t}) + \beta_4(C_{i,t} \times \text{Post}_{i,t}) + \beta_5(H_{i,t} \times \text{Post}_{i,t}) + \sum_{j=6}^{16} \beta_j(M_t) + \varepsilon_{i,t} \]

- Savings Equation:
  \[ kWh_{\text{Savings},i,t} = \beta_1 + \beta_4 \times \bar{C} + \beta_5 \times \bar{H} \]
- Confidence Intervals developed using Delta Method
Model Results

Estimated Average Savings per HH

Model 1: Monthly Savings (95% CI) 8.91%
Model 2: Daily Savings (95% CI) 9.68%
Model 3: Hourly Savings (95% CI) 9.74%
Discussion

• Do savings estimates change across different aggregation levels?
  ➢ Yes. Estimates of savings increased approximately 9 percent from monthly to hourly data.

• Does the precision of savings estimates change across different aggregation levels?
  ➢ Yes. We find more precision around our savings estimates with more granular data.
Discussion

• Limitations of models based on monthly or daily data:
  - Cannot reveal time of day savings:
    - Different measures may provide savings at different times of day
  - Cannot distinguish peak period savings

• Hourly interval data (or finer) - opportunity to identify time of day savings and peak period savings
Hourly Savings Estimates

Hour of Day

Energy Savings (kW)

Peak Period

Hourly Savings
Daily Savings
Monthly Savings
Future Research

• Alternative modeling approaches for AMI data
  - Example: Random coefficients model:
    - Estimates hourly savings
    - Estimates savings across home types and day types

• Compare billing regression using traditional monthly bill data and monthly AMI data
Summary

- AMI data provide opportunity to estimate billing regressions at more granular time intervals
- Savings estimates increase when fixed effects billing regression models used more granular time interval data
- Precision of savings estimates improves when fixed effects billing regression models used more granular time interval data
- Hourly (or finer) AMI data provides opportunity to identify time of day savings / peak period savings
Questions?

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