# Real-Time Pricing in the Spanish Residential Electricity Market

Mar Reguant
Northwestern U

PSE – 2020.12.14

## Assessing the impacts of real-time pricing

- **Efficiency impacts**:
  - Shif away consumption from high-demand expensive hours
  - Long-run savings in the generation mix, e.g., less need for peakers or batteries
- **Equity impacts**:
  - Distributional effects based on load profiles: peak consumers lose under RTP
  - Bill shocks due to inability to respond in high price events

**We study these issues in the context of the Spanish electricity market, which rolled out real-time pricing for a large share of residential customers.**

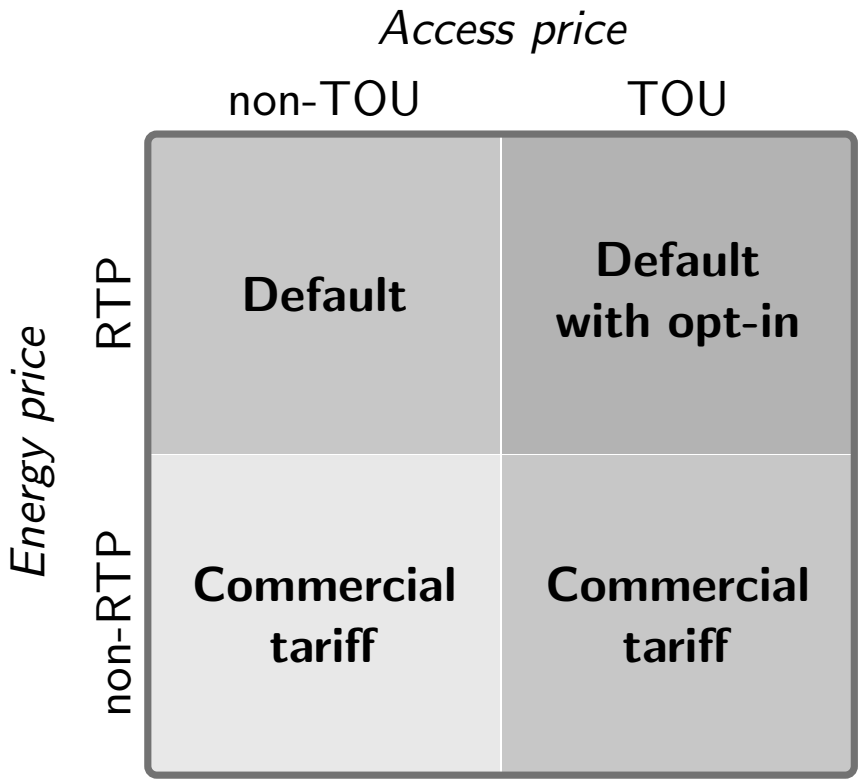
# Two projects

- **Efficiency impacts**:
  - **Estimating the Elasticity to Real-Time Prices**, joint work with David Rapson (UC Davis), Natalia Fabra (UC3M) and Jingyuan Wang (Northwestern), in preparation for AER P&P
- **Equity impacts**:
  - **The Distributional Implications of Real-time pricing**, joint work with Michael Cahana (UChicago), Natalia Fabra (UC3M) and Jingyuan Wang (Northwestern)

# Dynamic electricity pricing in Spain

- April 2014: Spain becomes the only country in which RTP is the **default option for all households**
  - *The case of Spain with a regulated default dynamic price contract is unique* (EC, 2019)
- Electricity **marginal price** composed of two parts:
  - **Energy price**: determined hourly as a function of the wholesale electricity market (**RTP**), or time-invariant
  - **Access price**: regulated costs charged as a function of consumption; peak/off-peak prices (**TOU**) or time-invariant
- Customers defaulted into RTP and non-TOU

# Tariff taxonomy



# Tariff taxonomy: prices over the day

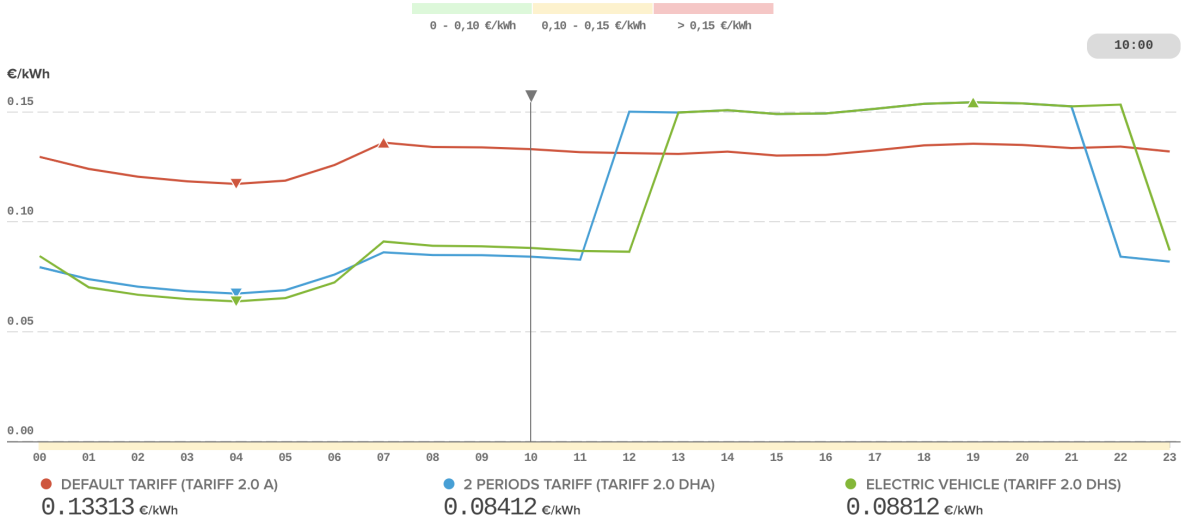



Figure: Electricity prices over day: RTP and Non-TOU (red) and RTP and TOU (blue)

# Data

- We obtain smart-meter data for over 4M households, from two large Spanish utilities.
- For each household (January 2016-July 2017):
  - hourly electricity consumption
  - plan characteristics (pricing, maximum capacity)
  - postal code
- We link the postal code with detailed Census data:
  - education, income and age distribution, avg number of rooms...

# Data: electricity consumption area

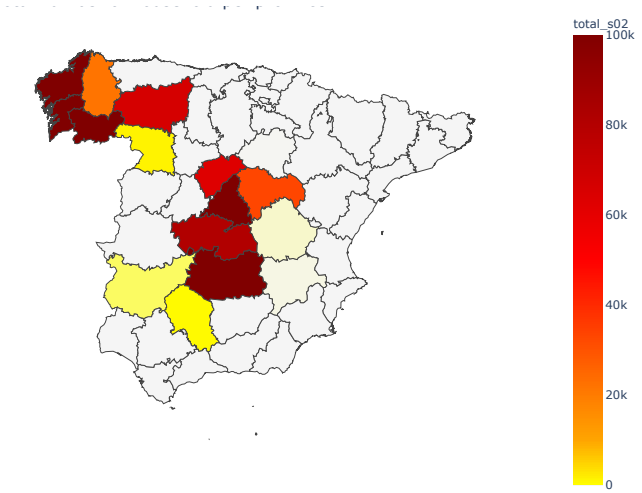



Figure: Naturgy area

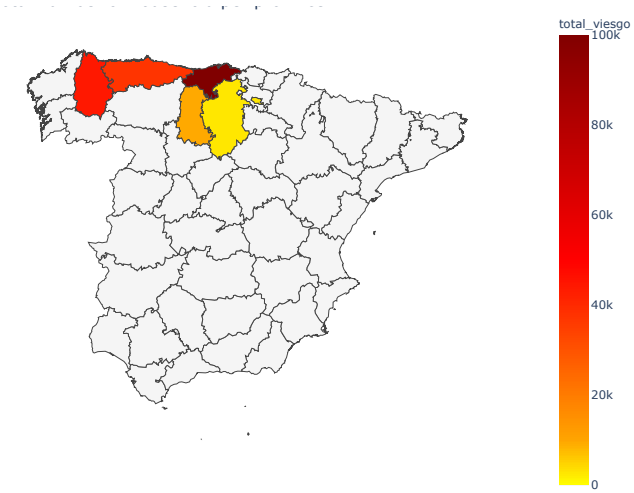



Figure: Viesgo area

# A first look at the data: prices

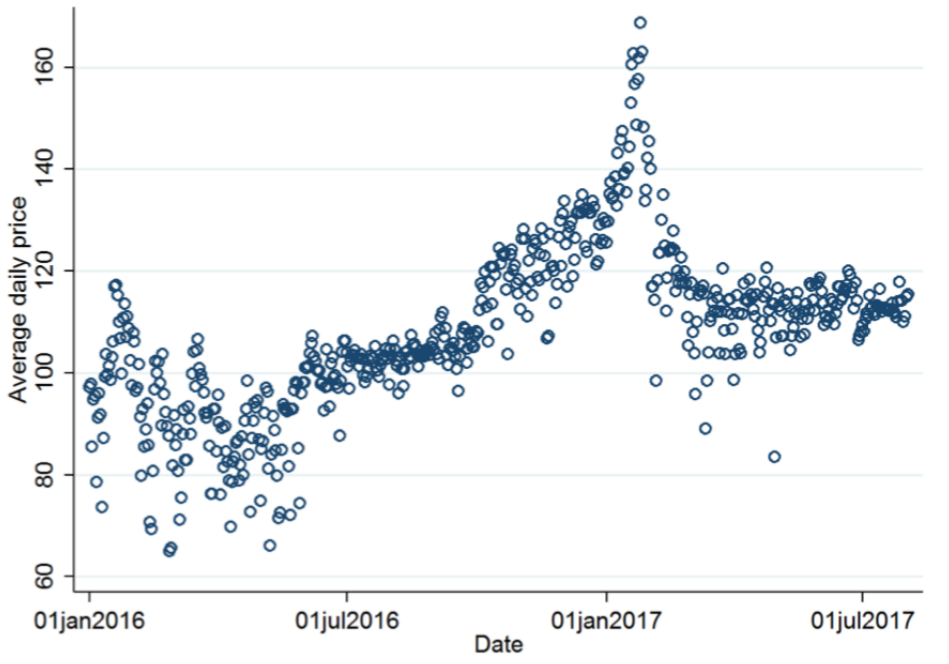



Figure: Average prices over the sample period

# A first look at the data: price variation

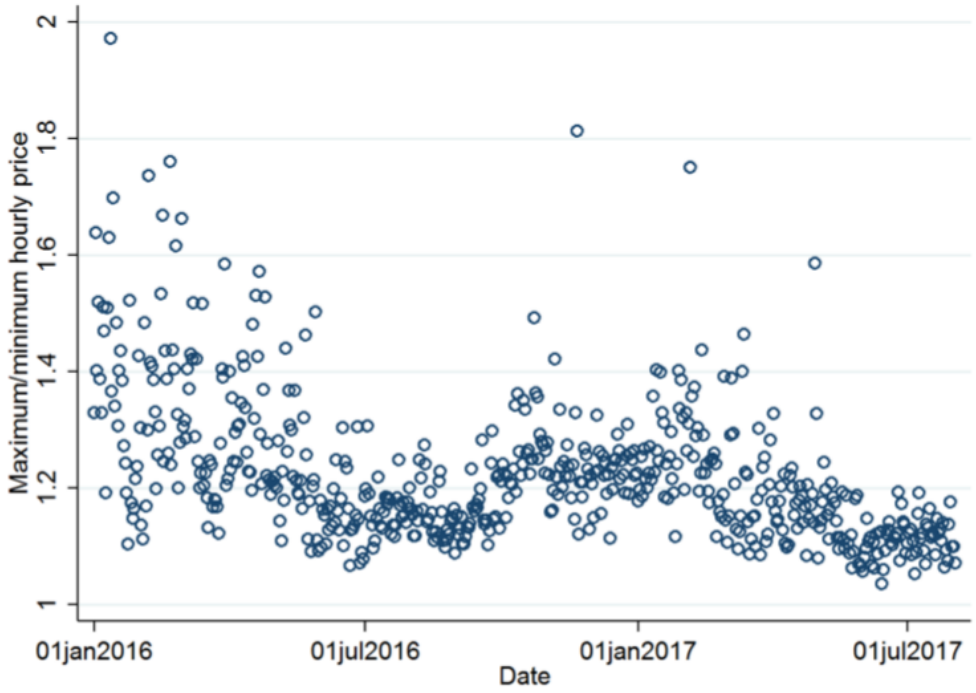



Figure: Ratio of the highest to lowest price every day

# Project 1: Objectives and findings

**Objectives:**

- Measure households' demand response to RTP.
- Compare households' price response to RTP and TOU.

**Main findings:**

- **RTP vs non-RTP** consumers appear to mostly not respond.
  $\rightarrow$ No impact of short run variation of RTP on demand
- **TOU vs non-TOU** consumers appear to behave differently.
  $\rightarrow$ Selection or actual response?
  $\rightarrow$ Important to disentangle for policy implications

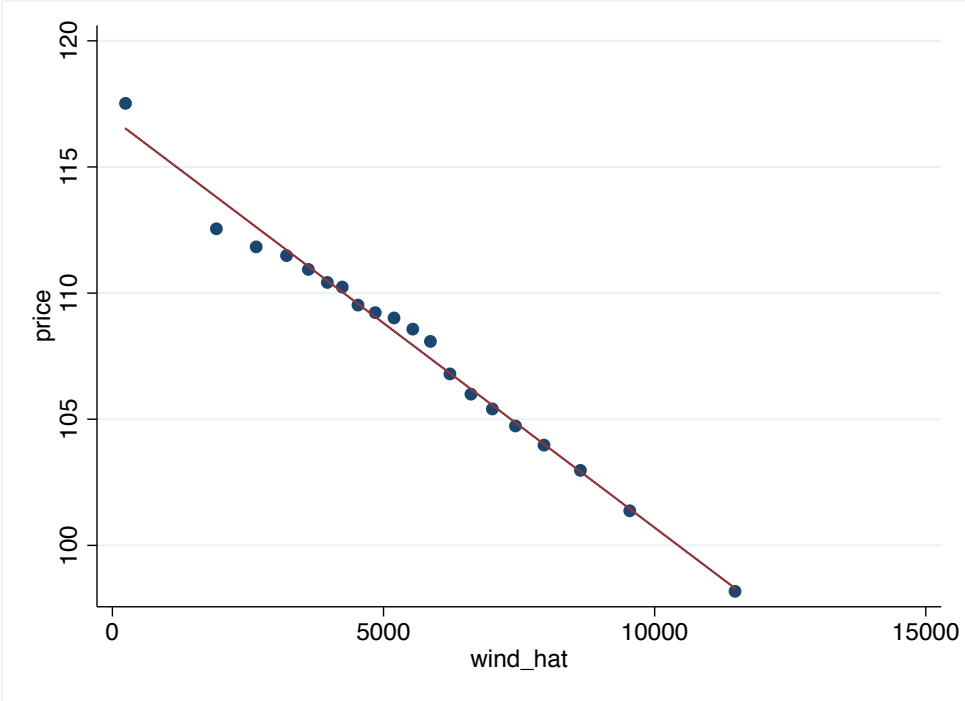
# Empirical strategy for RTP response

- We estimate the short-run price elasticity of households.
- Main regression (individual by individual):

$$\ln q_{ith} = \beta \ln p_{ith} + \phi X_{ith} + \gamma_{ith} + \epsilon_{ith}$$

- In baseline specifications, we control for:
  - Temperature bins by hour
  - Fixed effects: hour x month, year x month, day of week
  - Wind power forecasts as an IV for short-run price changes

# Instrumental Variable strategy



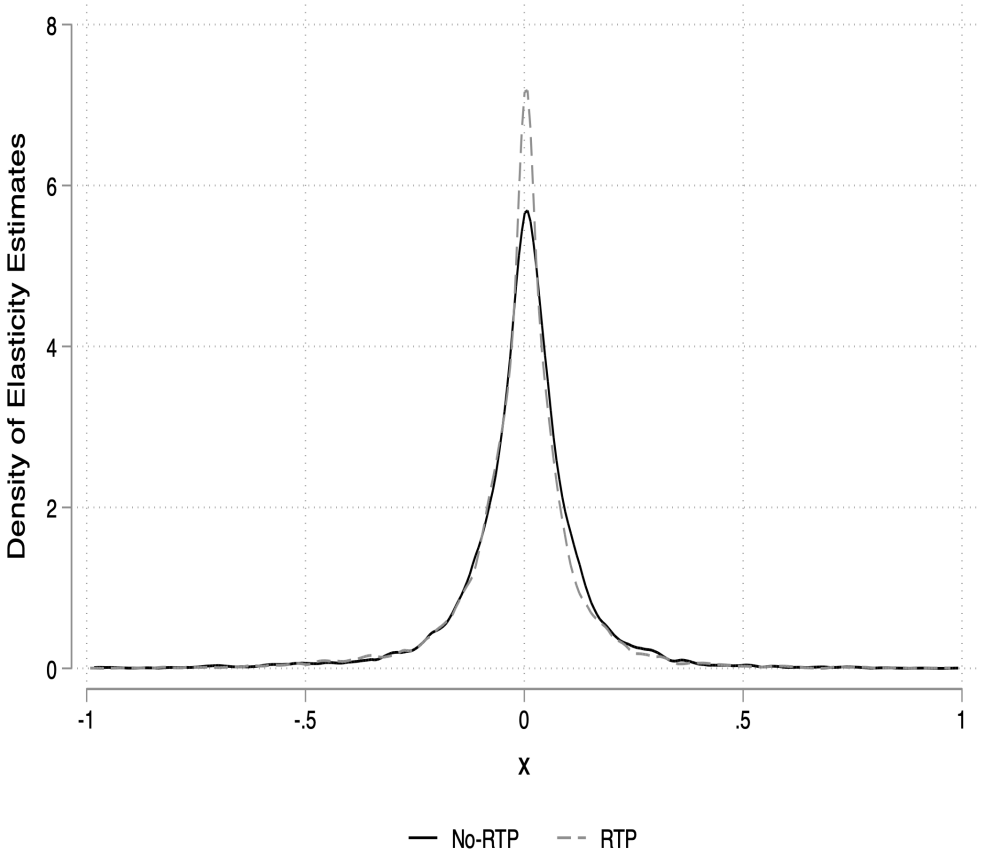

- Instrument shows strong first stage, also after conditioning
- Plausibly exogenous after controlling for local weather conditions

## Instrumental Variable challenges

- Most consumers do not consume electricity explicitly based on wind patterns, so exclusion restriction plausibly valid.
- Yet, wind patterns are intertwined with weather.
- Weather can affect electricity consumption in many ways: temperature control, sunset/sunrise, type of activities, time at home, etc.
- Difficult to control for potentially all confounders.
- High-frequency data can easily lead to significant spurious patterns due to omitted variable bias.

**We consider an array of fixed-effect individual specifications together with a lasso estimator.**

# We find similar distributions of price elasticities




- Distribution centered around zero, median of no response.

# Average elasticities by group are close to zero

| | (1)<br>p_iv11 | (2)<br>p_iv21 | (3)<br>p_iv31 | (4)<br>p_lasso |
|---|---|---|---|---|
| rtp | -0.00513 | -0.00430 | -0.00374 | -0.00468 |
| | (0.00238) | (0.00237) | (0.00220) | (0.00217) |
| Constant | -0.00473 | -0.00883 | -0.0117 | -0.0237 |
| | (0.00244) | (0.00252) | (0.00182) | (0.00274) |
| Observations | 14598 | 14598 | 14598 | 14598 |

Standard errors in parentheses

- Not much of an effect from RTP.

# Heterogeneity in responses

- We link the individual estimates to Census demographic information at the zip code level.
  - We do **not** find covariates that could pick up potential heterogeneity in responses.
- For one of the utilities, we also observe whether consumers use an app (weekly).
  - We do **not** find any systematic differences in behavior for consumers that use the app frequently.

# TOU vs non-TOU

- Compare **TOU vs non-TOU customers**:
  - Are TOU conssumers more responsive?
- Evidence suggests at the very least they are aware of pricing scheme.

| TOU | Off-Peak | Peak |
|---|---|---|
| 0 | 0.53 | 0.47 |
| 1 | 0.58 | 0.42 |

**Caution:** Comparison is endogenous due to selection, but suggests consumers either self-select or react to prices.

# Policy implications: RTP vs TOU

- Currently, RTP does not appear to induce large responses.
  - Demand response with automatic devices?
  - Demand response with larger price differences?
  - Demand response in the medium-run?
- TOU potentially **more effective** (certainty, salience?)...
- ...but theoretical literature emphasizes the **limits of TOU** to delivering all benefits from demand response
- **Key challenge**: intermittency really not addressed with TOU, at the very least it requires general patterns with seasonal adjustments (e.g., solar), but it doesn't work for wind