Online Appendix: "Smart Meters and Retail Competition: Trends and Challenges"

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A Data

Smart meter data

Data on smart meters have been digitalised from CNMC's *Equipment Integrated in the Remote Management System Reports*[1]. Smart meter penetration is reported as the proportion of metering points covered in each distribution area. Data are available from July 2015 to December 2019.

Market share data

We observe quarterly market shares at the firm-tariff-market level. The source of this data is CNMC's *2019 Electricity Retail Market Monitoring Report*[2]. Tariffs are differentiated according to the amount of contracted power (above or below 10KW) and the presence of time-of-use two-tiered pricing. For the residential sector, it amounts to four tariffs per firm and market. A market is defined as a geographical distribution area where one firm was traditionally regulated and vertically integrated. After the liberalization of the retailing sector, incumbent firms participate both as a regulated distributor and a retailer. The incumbent of a given market offers a regulated tariff and a competitive one, competing with the entrants for the tariff non-regulated segment. In pacticular, the incumbents are Endesa, Iberdrola, Naturgy (before Gas Natural), EDP and Repsol (before Viesgo). Non-incumbent retailers typically cannot offer regulated tariffs. Data are available from Q1 2011 to Q4 2019.

Flow data

The source of this data set is CNMC's *Quarterly Monitoring Reports on Changes of Retailer*[3]. From these reports, we obtain the following variables: (i) the number of supply points by retailer; (ii) the

[1] https://www.cnmc.es/expedientes?t=TELEGESTION&idambito=All&edit-submit-buscador-expedientes=Buscar&idtipoexp=All&hidprocedim=All

[2] https://www.cnmc.es/expedientes/isde02720

[3] https://www.cnmc.es/expedientes?t=IS+SOBRE+CAMBIOS+DE+COMERCIALIZADOR&idambito=All&edit-submit-buscador-expedientes=Buscar&idtipoexp=All&hidprocedim=All

number of dropouts; (iii) the number of new registrations broken down according to whether they are activated in favor of the vertically integrated group (incumbent) or not[4]; and (iv) the number of consumers switching in and out of the incumbent, and whether these consumers switch to another firm belonging to the same group but different tariff (regulated or competitive). Data are available from Q1 2016 to Q3 2020.

The main drawback of the *Quarterly Monitoring* reports is that, while we have consumer flows within and between firms, we do not know in which market these flows are occurring. However, given that a firm can only offer a regulated tariff within the market it acts as the incumbent, we can infer consumer flows entering or leaving incumbent firms at their respective geographical markets.

Price data

Historical retail electricity prices were kindly provided by CNMC[5]. The selected prices represent the yearly average pretax energy component per kWh for a typical household under the four residential tariffs. For each incumbent we have computed the average price weighted by the number of consumers under each tariff.

B Estimation details

We use data on market shares and flows to estimate the structural parameters. The eleven moments that we match at the period-market level are as follows:

- $N_{mt}^{r\to i}$: flows from regulated tariff to incumbent commercial tariff;
- $N_{mt}^{r\to o}$: flows from regulated tariff to non-incumbent (other) commercial tariffs;
- $N_{mt}^{i\to r}$: flows from incumbent commercial tariff to regulated tariff;
- $N_{mt}^{o\to r}$: flows from non-incumbent (other) commercial tariffs to regulated tariff;
- A_{mt}^{r}: New customers that chose the regulated tariff;
- N_{jmt}: Number of households on a given firm and market, $\forall j = 0, \ldots, 6$.

In each market, we treat the regulated and the incumbent as separate firms. Define the stacked observations for each market-time as $\mathbf{Y}_{mt}$. We use predicted vs observed moments to estimate the parameters using a GMM estimator:

$$\min_{\beta,\theta} \sum_{m,t} \left(\mathbf{Y}_{mt} - \hat{\mathbf{Y}}_{mt}(\beta,\theta)\right)' \omega_{mt} \left(\mathbf{Y}_{mt} - \hat{\mathbf{Y}}_{mt}(\beta,\theta)\right) \tag{1}$$

[4]Since Nov. 2, 2018, Viesgo retailers belong to Repsol and thus is no longer a vertically integrated group.

[5]Current prices can be found on CNMC's official compasion website, `https://comparador.cnmc.gob.es/`. This site collects electricity and gas tariffs offered by both the regulated and commercial retailers with the aim of informing consumers about their options.

where ω_{mt} are the total number of customers in a given market m at time t.

The predictions for a given parameter guess for each of the above objects are as follows:

- $\hat{N}_{mt}^{r\to i} = \lambda_{rmt}(\beta)(1-\phi)N_{rm,t-1}P_{imt}(\theta)$,
- $\hat{N}_{mt}^{r\to o} = \lambda_{rmt}(\beta)(1-\phi)N_{rm,t-1}\sum_{j\notin r,i}P_{jmt}(\theta)$,
- $\hat{N}_{mt}^{i\to r} = \lambda_{imt}(\beta)(1-\phi)N_{im,t-1}P_{rmt}(\theta)$,
- $\hat{N}_{mt}^{o\to r} = (1-\phi)P_{rmt}(\theta)\sum_{j\notin i,r}\lambda_{jmt}(\beta)N_{jm,t-1}$,
- $\hat{A}_{mt}^{r} = A_{mt}P_{rmt}(\theta)$,
- $\hat{N}_{jmt} = (1-\phi)\Big((1-\lambda_{jmt}(\beta))N_{jm,t-1} + P_{jmt}(\theta)\sum_{k}\lambda_{kmt}(\beta)N_{km,t-1}\Big) + A_{mt}P_{jmt}(\theta)$, $\forall j = 0,\ldots,6$,

where ϕ is a common constant rate of attrition of households in market m at time t.[6] We parameterize the search and choice functions as follows. Starting with the search function,

$$\lambda_{jmt}(\beta) = \frac{e^{W_{jmt}(\beta)}}{1+e^{W_{jmt}(\beta)}},$$

with

$$W_{jmt}(\beta) = \sum_{h=\{r,i\}}\mathbb{1}[j=h]\beta^h + \beta^s SM_{mt} + \beta_m + \beta_t.$$

where SM_{mt} is the proportion of households with a smart meter. This equation corresponds to Specification (3) in Table 1. Note that, in practice, we do not differentiate the parameter λ at firm level, only whether it acts as the incumbent or the regulated firm at martket m. For the choice probabilities, setting new entrants as the outside option, we have:

$$P_{jmt}(\theta) = \frac{e^{X_{jmt}(\theta)}}{1+\sum_k e^{X_{kmt}(\theta)}},$$

where

$$X_{jmt} = \sum_{h=\{r,i\}}\mathbb{1}[j=h]\theta^h + \theta^p p_{jt} + \theta^s SM_{mt} + \theta^{s,i}SM_{mt}\mathbb{1}[j=i] + \theta_m + \theta_t.$$

C Additional Figures

[6] We abstract away from modeling heterogeneous exits at the firm level as the exit rate is very small, $\phi \approx 0.003$

Figure C.1: Smart meter penetration over time

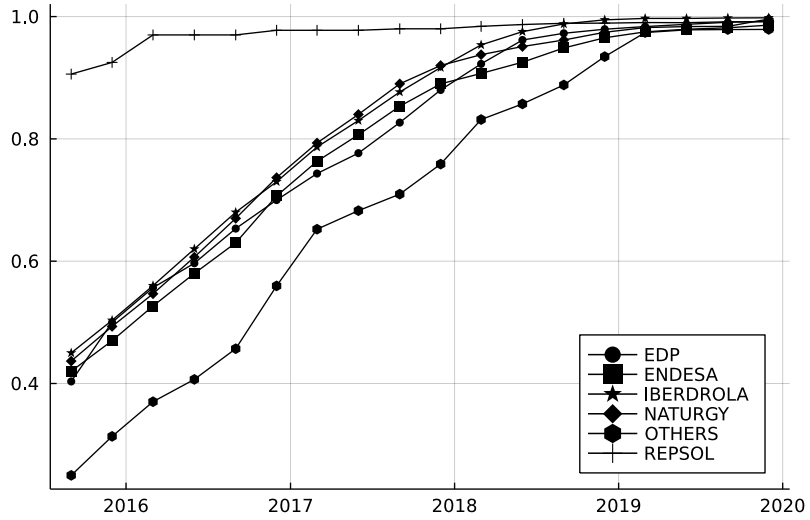


Figure C.1 shows the smart meter deployment in each distribution area. In mid-2015, all 5 traditional distributors had a coverage of around 40%, except for Repsol (before Viesgo) which had a coverage as high as 90%. By 2019, universal coverage was reached in all distribution areas.

Figure C.2: Market shares over time

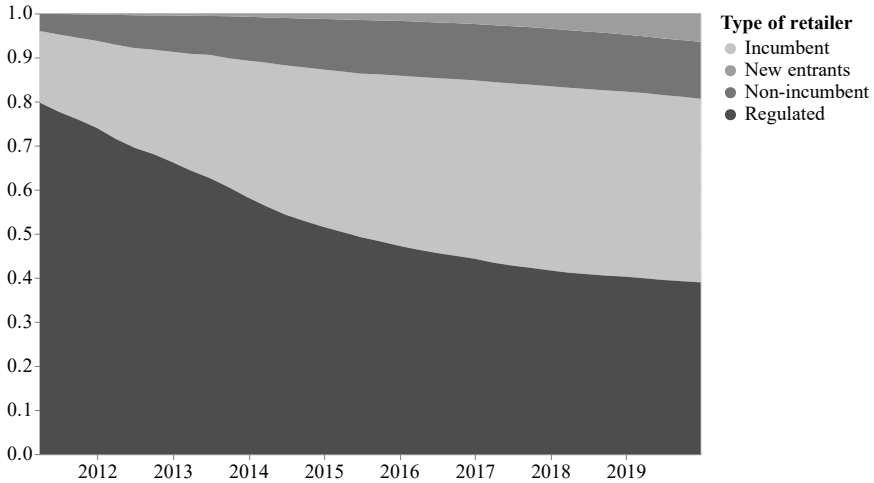


Figure C.2 displays the evolution of the share of consumers across the 5 markets. Although the share of regulated retailers has decreased since 2011, the share of commercial incumbents has made up partially for this decline so that the share of incumbent retailers (both regulated and commercial) continues to be over 80% in 2019.

Figure C.3: Markups over time

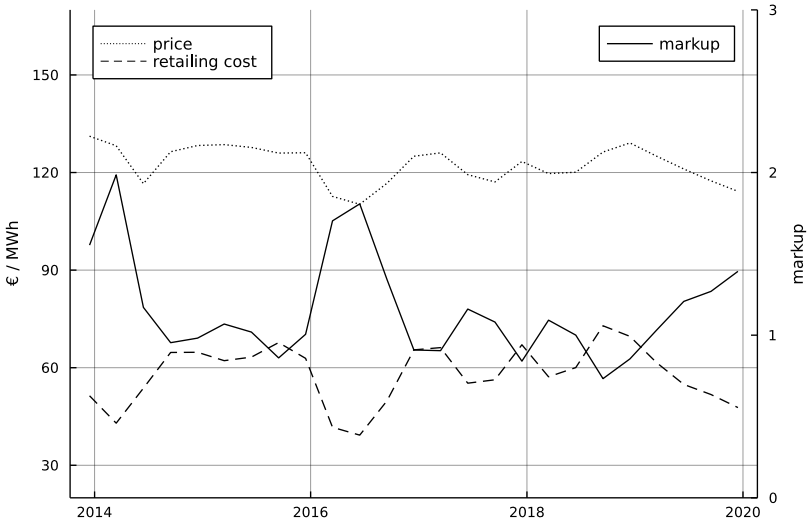
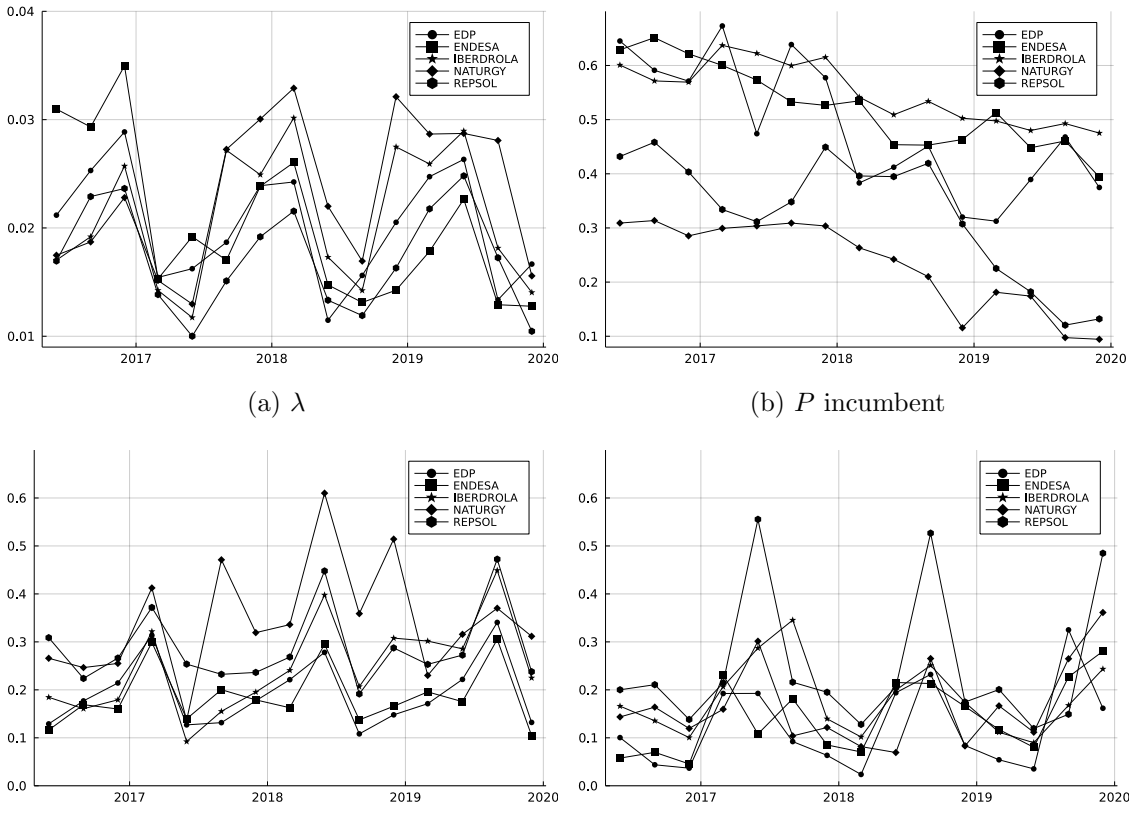


Figure C.4: Calibration estimates



(a) λ

(b) P incumbent

(c) P regulated

(d) P new entrants

Figure C.4 shows the estimated λ and P parameters calibrated by the GMM model's non-parametric specification for each market and period. Search patterns present clear seasonality and the probability of choosing the incumbent is declining over time.