Producers, Retailers and Risk-Averse Consumers

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Introduction

1. Changes in EU markets and renewables
2. TOU to smooth demand peaks, with positive consequences both on the environment and on prices. Experiments US & Europe (1/3): negative relation between high peak price and consumption, (3% - 6%)
3. Electrification envisaged for the next years
4. Option for the consumers to choose between TOU tariffs and a flat rate has been applied in the Nord Pool market and, more recently, in Spain.

Introduction - The problem

Change from fixed-tariff to spot-base pricing mechanism has several potential consequences:

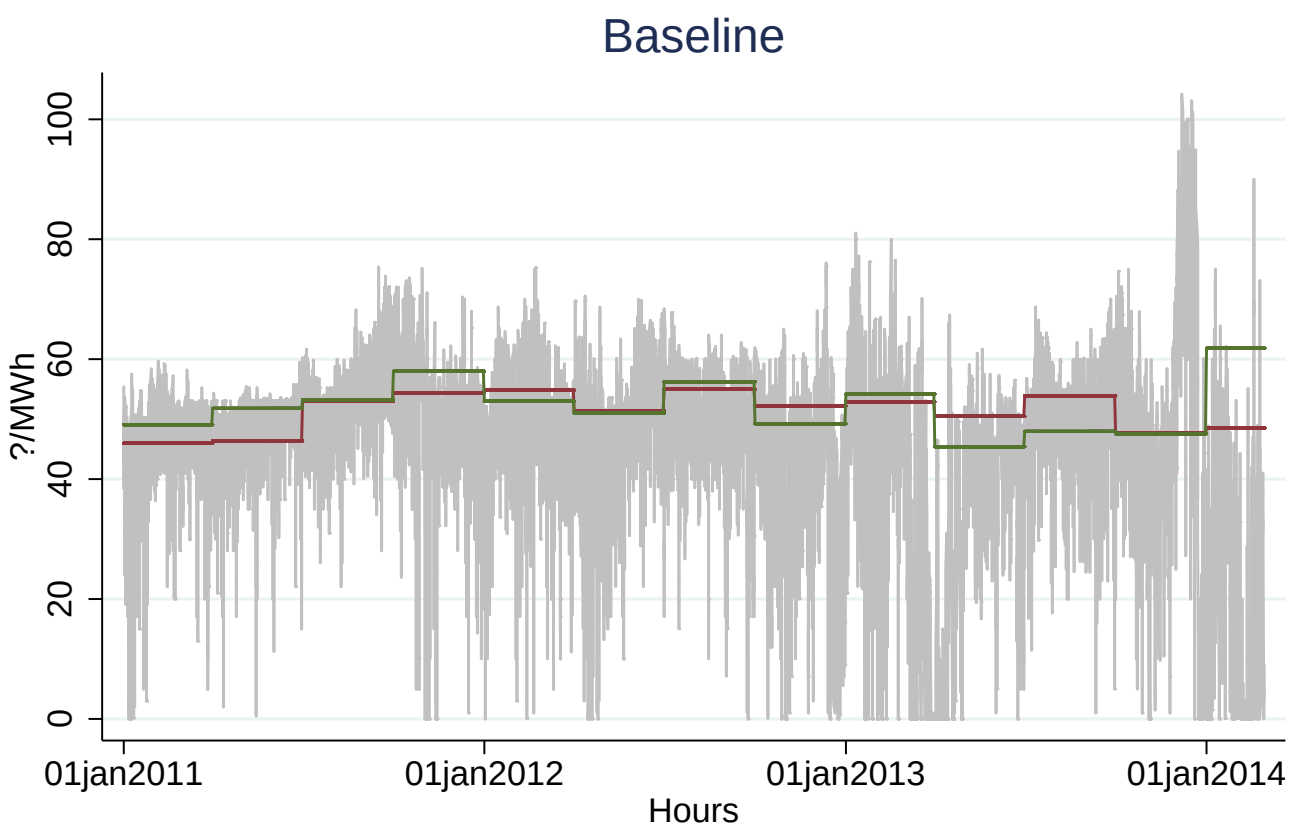
1. Consumers choose a fixed tariff because they want to pay a premium to be insured against the risk of high spikes (Lambrecht and Skiera, 2006), (Herweg and Mierendorff, 2013).
2. Retailers may incur in some extra-costs to hedge their position.
3. Producers are affected by the choices made by the consumers both in forward and spot markets. Role of forward markets in enhancing competition in the spot markets Allaz and Vila (1993)

This paper

- Develops a theoretical model that studies the relation between risk averse consumers, retailers and producers, and the quantity sold (bought) by these agents both in the spot and in the forward markets.
- Calibrates the model with a real market case - Spain. Change from quarterly auction based retail price to TOU (spot, PVPC) and determine the "risk aversion parameter" λ
- Simulates agents behavior and markets performance, depending on consumers risk aversion and compare the results.

The Spanish market: Spot, Future and Auction - (2011-2014)

Figure: Prices at delivery date



The Spanish market: from Auction to TOU (2014-today)

Last auction, 19th December 2013, for Q1-2014. Auction price, 61.83 €/MWh and 67.99 €/MWh, base/peak.

- 20th December 2013, the NRA did not validate the results, "*given the atypical circumstances in which the auction was held*" (CNMC, 2014).
- Auction pricing system was suppressed, for Q1-2014 transition procedure was used (based on price for Q1-2014 of future during the last 6 months).
- In April 2014 a new mechanism was implemented to default service Voluntary Price for Small Consumer (PVPC), the spot market price is now used to set the wholesale cost.

The Spanish market: Spot, Future and Auction - Delivery

Table: Summary statistics: spot, auction and future (6 months average), 2011-2014

Variable	Obs	Mean	Std. Dev.	Skew
Spot price	26,304	47.14	15.61	- 0.85
Spot price (Base)	20,824	45.59	15.52	- 0.96
Spot price (Peak)	5,480	53.00	14.53	- 0.50
Auction price (Base)	26,301	51.39	3.58	
Auction price (Peak)	26,301	57.01	3.21	
Future (6m, Base)	26,301	51.52	3.09	
Future (6m, Peak)	26,301	56.05	3.06	

The Model

- Bessembinder and Lemmon (2002) identify the optimal problem of retailers and producers both in the spot and in the forward market.
- In our model, we complete this scheme introducing consumers, who can choose whether to buy electricity from the spot market (at the spot prices p_W) or buy from retailers the electricity at a fixed price p_R.
- In the forward market, retailers and producers contract the quantities that should be sold (bought) forward.
- In the spot market, consumers maximise their utility, determining the quantity of electricity that they buy in the spot market and the quantity they buy at the fixed price.

Spot Market - Consumers

Consumers: The utility function of the consumers is of the type $u - \mu$ in which $\mu = \lambda(\max(p_W - p_R, 0))$ where p_W is the tariff the consumer has to pay for the electricity and λ is the parameter that reflects the consumer's risk aversion. They maximise the following utility function:

$$u(q_{Ci}) = \theta q_{Ci} - \frac{1}{2}(q_{Ci})^2 - F - p_W * q_{Ci} - \lambda p_W * q_{Ci} \qquad (1)$$

Producers have a quadratic cost function and **retailers** adjust their position in the spot market.

The Model - Spot Market - Equilibrium

- **Producers:**

$$p_W = a\frac{(q_W)}{(N^P)}$$

- **Consumers:**

$$q^*_{Ci} = \theta - p_W(1+\lambda)$$

- **Retailers:**

$$q_R = q_W - q^*_{Ci}$$

The Model - Forward Market - Equilibrium- Price

$$\sum_i q_F^{Ri} + \sum_i q_F^{Pi} = 0$$

$$p_F = E(p_W) + \gamma Skew(p_W) + 2\gamma E(p_W) Var(p_W) - \left(\frac{N^P}{Na} + \frac{(1+\lambda)}{N}\right) N^R p_R$$

in which:

$\gamma = \frac{2N^R(N^P + a(1+\lambda)) - N^P}{2aN}$

$N = \frac{Nr + Np}{A}$

The Model - Forward Market - Equilibrium- Quantities

$$PREM = p_F - E(p_W)$$

$$q_F^{Pi} = \frac{E(q_W)}{N^P + a(1+\lambda)} + \frac{PREM}{AVar(p_W)} + \frac{1}{2a}\frac{Skew(p_W)}{Var(p_W)}$$

$$q_F^{Ri} = \frac{PREM}{AVar(p_W)} + (\frac{N^P}{a} + (1+\lambda))[\frac{p_R - Skew(p_W)}{Var(p_W)}] - 2 * E(q_R)$$

Calibration - λ

We use the **average** of the spot, auction and forward prices, as well as the variance and the skewness of the spot price between 2011 and 2014 to calibrate our model.

Table: Summary statistics 2011-2014

Variable	Obs	Mean	Std. Dev.	Skew
Spot price	26,304	47.14	15.61	- 0.85
Spot price (Base)	20,824	45.59	15.52	- 0.96
Spot price (Peak)	5,480	53.00	14.53	- 0.50

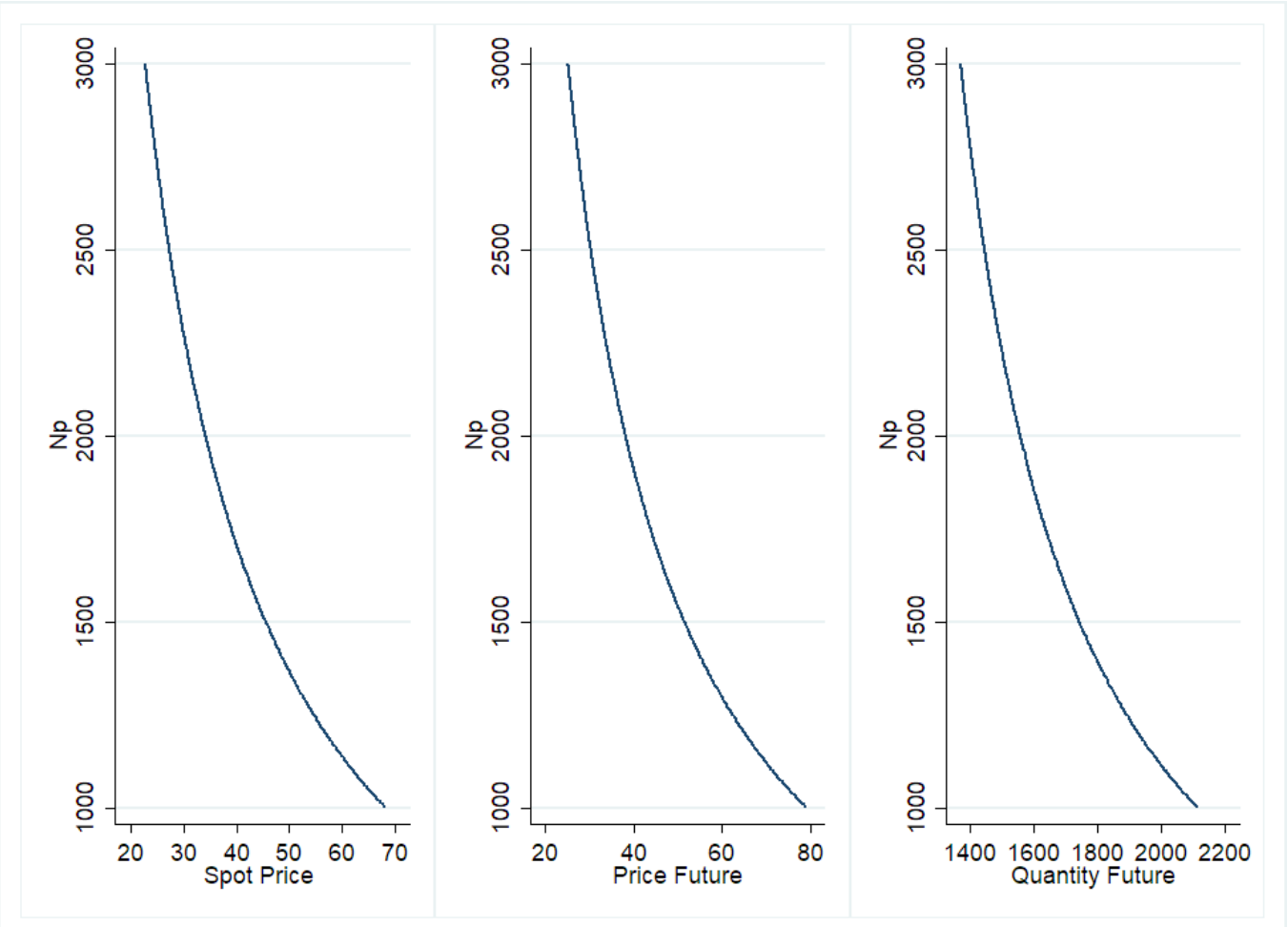
We also assume the following parameters:

- $Np = 1500$
- $Nr = 5$

Solving our model for lambda, we found $\lambda = 0.65$

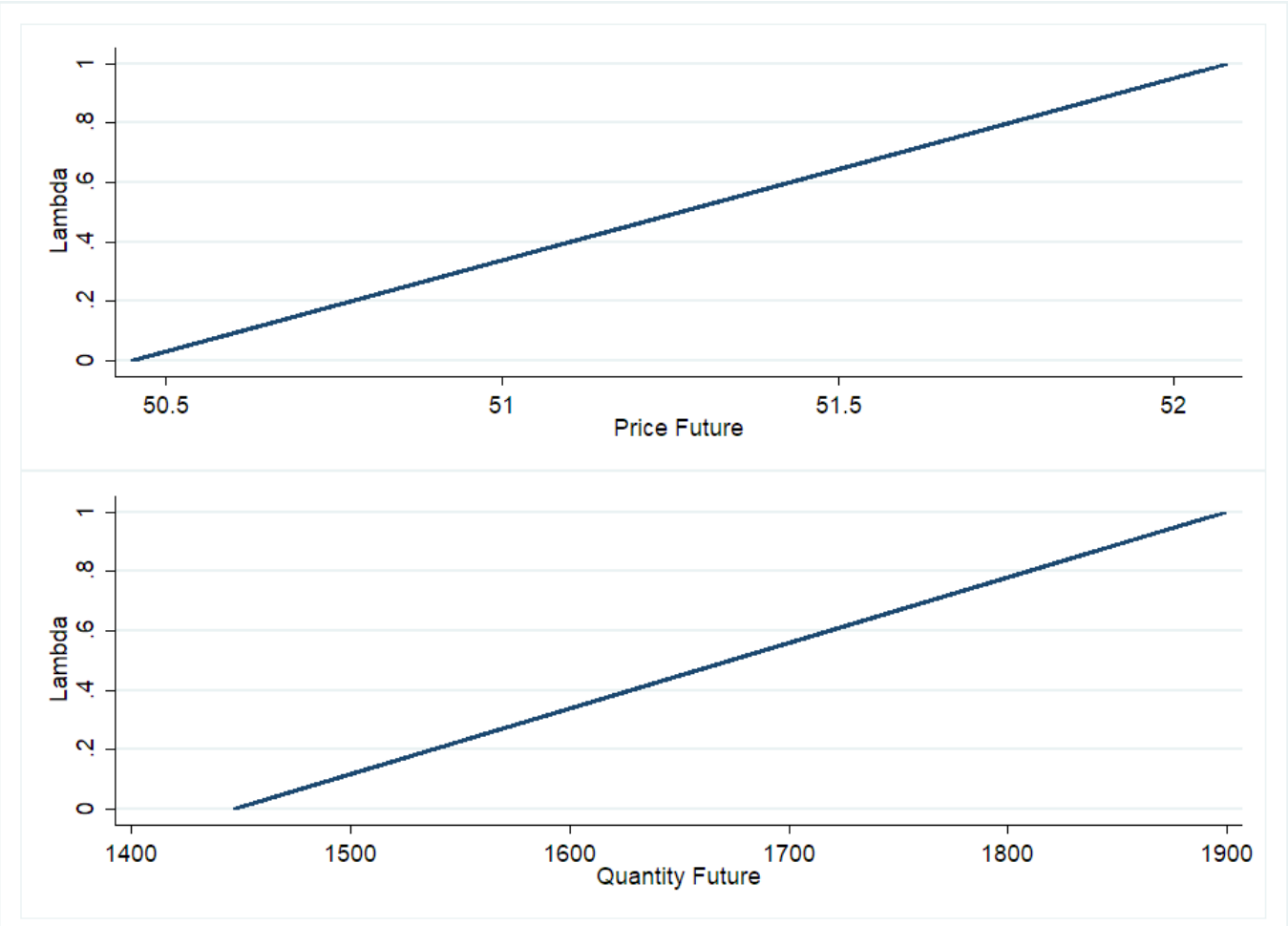
Results - changes in *Np*

Figure: Prices at delivery date



Results - changes in λ

Figure: Prices at delivery date



Conclusions

Results from the model show that:

1. The quantities the retailers buy in the forward market are positively related with the risk aversion of consumers and negatively related with the skewness of the spot prices
2. On the contrary, quantity sold forward by producers are positively related with the skewness of the spot prices (high probability of getting high prices increase the forward sale) and proportionally related with the total market demand
3. In the retail market, the degree of consumers' risk aversions determines the quantity bought in the spot market (the more the consumers are risk averse, the more they buy at the fixed price determined by the retailers -auction in our case)
4. Finally, the quantity sold by retailers is positively related with the consumers' risk aversion.

Thank you

Calibration and simulation

We are now replacing the real values of forward, auction prices and spot prices to determine the value of *lambda*, making realistic assumptions on the other parameters such as *Np* and *Nr*. We get a risk aversion parameter between 0.5 and 0.7 but this is very preliminary.
Then we will make *lambda* change, together with demand, *Np* and *Nr* to check how future prices and future quantities (as well as spot quantities and prices) change

The Model - Spot Market - Consumers

Consumers : on uncertainty and preferences for fixed tariff see: (Train et al., 1989) Herweg and Mierendorff (2013) A consumer is risk adverse in the sense that he incurs in a loss when the price is higher than his reference price p_R. Following HM, we assume here that the reference price comes from the past bills, that were linked to the auction (fixed) price.
The utility function is of the type $u - \mu$ in which
$\mu = \lambda(\max(T - p_R, 0))$ where T is the tariff the consumer has to pay for the electricity and λ is the parameter that reflects the consumer's risk aversion.

When $\lambda = 0$ the preferences of the consumer are risk neutral.
When $\lambda > 0$ consumers are loss averse. Reference price p_R should reflect both the fixed costs of the producers F and the retailers' hedging premium.

The Model - Spot Market - Retailers

Retailers face an uncertain demand both markets. Following Bessembinder and Lemmon (2002), the profit equation for the retailers is:

$$\pi R_i = p_R * q_{Ri} - p_F * q^{Ri} - p_W(q_{Ri} + q_F^{Ri}) \tag{2}$$

Appendix - Spot Market - Producers

Producers maximise the following profit function:

$$\pi P_i = p_W * q_{Wi} + p_F * q_F^{Pi} - TC \tag{3}$$

q_{Wi} is the quantity they have to sell in the spot market, q_F^{Pi} is the quantity they commit in the forward market (here taken as given) and TC are the total costs they face in their production process, equal to

$$TC = F + \frac{a}{2} * q^2 \tag{4}$$

where F reflects the fixed costs and the quadratic (variable) component reflect the convex cost function that characterizes the electricity markets.

Appendix- Forward Market

We follow (Hirshleifer and Subrahmanyam, 1993):

$$q_F^{P,R} = \frac{p_F - E(p_W)}{AVar(p_W)} + \frac{Cov(\pi^F_{P,R}, p_W)}{Var(p_W)}$$

- **Producers**

$$q_F^{Pi} = \frac{p_F - E(p_W)}{AVar(p_W)} + \frac{\frac{1}{2a} Cov(p_W^2, p_W)}{Var(p_W)}$$

- **Retailers**

$$q_F^{Ri} = \frac{p_F - E(p_W)}{AVar(p_W)} + \frac{p_R Cov(q_{Ri}, p_W) - Cov(p_W q_{Ri}, p_W)}{Var(p_W)}$$

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