Online Appendix for

"Market Power and Price Exposure:
Learning from Changes in Renewable Energy Regulation"

Natalia Fabra and Imelda

June 3, 2022

Appendix A: Additional Results and Proofs

A.1 Proofs

In this section we provide closed-form solutions for the equilibrium prices of the model described in Section 3. All proofs for the lemmas and propositions in the main text follow from these expressions.

One-Shot Market (Lemma 1) Solving the profit maximization problem in (1) and (2) under *market prices* and *fixed prices* shows that

$$p^M = \frac{(A-(1-\delta)\,w)+bc}{2b} \tag{1}$$

$$p^F = \frac{(A-w)+bc}{2b} \tag{2}$$

It immediately follows that

$$\begin{aligned}
\frac{\partial p^F}{\partial w} &= -\frac{1}{2b} < 0 \text{ and } \frac{\partial p^M}{\partial w} = -\frac{1-\delta}{2b} \leq 0 \\
\left|\frac{\partial p^F}{\partial w}\right| &= \frac{1}{2b} > \left|\frac{\partial p^M}{\partial w}\right| = \frac{1-\delta}{2b} \geq 0 \\
\frac{\partial p^F}{\partial w \partial \delta} &= 0 \text{ and } \frac{\partial p^M}{\partial w} = \frac{1}{2b} > 0.
\end{aligned}$$

Sequential Markets with No Arbitrage We first solve the profit maximization problems in (6) for the spot market, and (8) under *market prices* and (9) under *fixed prices* for the day-ahead market. We do so by backward induction, with $D_1(p_1) = A - bp_1 - (1-\delta)\,w$ and $D_2(p_1,p_2) = b\Delta p$. For given p_1, the spot market solution is given by, under both pricing rules,

$$p_2 = \frac{p_1+c}{2}, \text{ implying } q_2 = b\frac{p_1-c}{2}. \tag{3}$$

To solve the day-ahead market problem, we first consider *market prices* and then *fixed prices*.

Under ***market prices***, plugging (3) into the day-ahead problem (8), one can find the day-ahead market solution

$$p_1^M = \frac{2\left(A - (1-\delta)\,w\right) + bc}{3b} \tag{4}$$

implying

$$q_1^M = \frac{A - (1-\delta)\,w - bc}{3}.$$

Plugging this back into the spot market solution gives

$$p_2^M = \frac{A - (1-\delta)\,w + 2bc}{3b}$$

implying

$$q_2^M = \frac{A - (1-\delta)\,w - bc}{3}.$$

Taking the difference between the two prices,

$$\Delta p^M \equiv p_1^M - p_2^M = \frac{A - (1-\delta)\,w - bc}{3b}.$$

Since we have assumed $A - w - bc > 0$, it follows that $q_1^M > 0$, and $p_1^M > p_2^M > \delta w/3b + c \geq c$. Note that the solution is the same as Ito and Reguant (2016)'s Result 1, with $A - (1-\delta)\,w$ here in the place of A there. Last, comparing (4) and (1) shows that $p_1^M > p^M$.

Under ***fixed prices***, plugging (3) into the day-ahead problem (9), one can find the day-ahead market solution,

$$\begin{aligned} p_1^F &= \frac{2\left(A - w\right) + bc}{3b} \\ &= p_1^M - \frac{2\delta w}{3b} \end{aligned} \tag{5}$$

implying

$$\begin{aligned} q_1^F &= \frac{\left(A + w\left(3\delta - 1\right) - bc\right)}{3} \\ &= q_1^M + \frac{2\delta w}{3}. \end{aligned}$$

Comparing (5) and (2) shows that $p_1^F > p^F$.

Plugging p_1^F back into the spot market solution gives

$$\begin{aligned} p_2^F &= \frac{A - w + 2bc}{3b} \\ &= p_2^M - \frac{\delta w}{3b}. \end{aligned} \tag{6}$$

implying

$$\begin{aligned} q_2^F &= \frac{A - w - bc}{3} \\ &= q_2^M - \frac{\delta w}{3}. \end{aligned}$$

Taking the difference between the two prices,

$$\begin{aligned} \Delta p^F &= \frac{A - w - bc}{3b} \\ &= \Delta p^M - \frac{\delta w}{3b} > 0. \end{aligned} \tag{7}$$

Last, using the above expressions, we obtain

$$\begin{aligned} q_2^F &= \frac{A - w - bc}{3} \\ &= q_2^M - \frac{\delta w}{3} > 0. \end{aligned}$$

The comparative statics of the equilibrium prices with respect to w and δ are:

$$\begin{aligned} \frac{\partial p_1^F}{\partial w} &= -\frac{2}{3}b < 0 \text{ and } \frac{\partial p_1^F}{\partial \delta} = 0 \\ \frac{\partial p_2^F}{\partial w} &= -\frac{1}{3}b < 0 \text{ and } \frac{\partial p_2^F}{\partial \delta} = 0 \\ \frac{\partial \Delta p^F}{\partial w} &= -\frac{1}{3}b < 0 \text{ and } \frac{\partial \Delta p^F}{\partial \delta} = 0 \\ \frac{\partial p_1^F}{\partial w \partial \delta} &= \frac{\partial p_2^F}{\partial w \partial \delta} = \frac{\partial \Delta p^F}{\partial w \partial \delta} = 0. \end{aligned}$$

Sequential Markets with Unlimited Arbitrage (Proposition 1 and 2) As a first step to solve the problem under ***market prices*** with limited arbitrage, we first allow for unlimited arbitrage s, which adjusts so that the two prices converge. We again proceed by backward induction. For given p_1, the spot market solution is given by, under both pricing rules,

$$p_2 = \frac{p_1 + c}{2} + \frac{s}{2b}, \text{ implying } q_2 = b\frac{p_1 - c}{2} + \frac{s}{2}. \tag{8}$$

Plugging (8) into the day-ahead problem (8), one can find the day-ahead market solution

$$p_1^M = \frac{2\left(A - (1-\delta)\,w\right) + bc - s}{3b} \tag{9}$$

implying

$$q_1^M = \frac{A - (1-\delta)\,w - bc - 2s}{3}.$$

Plugging this back into the spot market solution gives

$$p_2^M = \frac{A - (1-\delta)\,w + 2bc + s}{3b} \tag{10}$$

implying

$$q_2^M = \frac{A - (1-\delta)\,w - bc + s}{3}.$$

Taking the difference between the two prices,

$$\Delta p^M \equiv p_1^M - p_2^M = \frac{A - (1-\delta)\,w - bc - 2s}{3b}.$$

Setting $p_1^M = p_2^M$, we find

$$s^M = \left(A - (1-\delta)\,w - bc\right)/2.$$

Plugging this back into the price expressions,

$$p_1^M = p_2^M = \frac{A - (1-\delta)\,w + bc}{2b}$$

which coincides with solution (4) when there is a single one-shot market.

Sequential Markets with Limited Arbitrage If arbitrage is limited, the degree of arbitrage needed to achieve full price convergence exceeds the fringe's idle capacity, $s^M > (1-\delta)\,(k-w)$. The solution under limited arbitrage is found by simply plugging $s = (1-\delta)\,(k-w)$ into equations (9) and (10) above. This gives rise to the following equilibrium prices

$$
\begin{aligned}
p_1^M &= \frac{2A-(1-\delta)(k+w)+bc}{3b} && (11)\\
p_2^M &= \frac{A+(1-\delta)(k-2w)+2bc}{3b} && (12)\\
\Delta p^M &= \frac{A-(1-\delta)(2k-w)-bc}{3b} && (13)
\end{aligned}
$$

The comparative statics of prices with respect to w and δ are:

$$
\begin{aligned}
\frac{\partial p_1^M}{\partial w} &= -\frac{1-\delta}{3b} \leq 0 \text{ and } \frac{\partial p_1^M}{\partial \delta} = \frac{k+w}{3b} > 0\\
\frac{\partial p_2^M}{\partial w} &= -\frac{2(1-\delta)}{3b} \leq 0 \text{ and } \frac{\partial p_2^M}{\partial \delta} = -\frac{k-2w}{3b}\\
\frac{\partial \Delta p^M}{\partial w} &= \frac{1-\delta}{3b} \geq 0 \text{ and } \frac{\partial \Delta p^M}{\partial \delta} = \frac{2k-w}{3b} > 0\\
\frac{\partial p_1^M}{\partial w \partial \delta} &= \frac{1}{2}\frac{\partial p_2^M}{\partial w \partial \delta} = \frac{1}{3b} > 0.
\end{aligned}
$$

We can now compare the equilibrium outcomes under limited arbitrage across pricing rules assuming that the arbitrage constraint is binding.

Comparing the expressions for p_1, (5) and (11):

$$p_1^M - p_1^F = [-(1-\delta)(k-w) + 2\delta w]/3b.$$

Hence, $p_1^M > p_1^F$ if and only if $\delta w > (1-\delta)(k-w)/2$. Solving for δ,

$$\delta > \delta\widehat{\delta} \equiv \frac{k-w}{k+w} \in [0,1].$$

Comparing the expressions for p_2, (6) and (12):

$$p_2^M - p_2^F = \frac{(1-\delta)(k-w)+\delta w}{3b} > 0.$$

A.2 Extensions: Cournot Competition

In the main text we have assumed that there is a single dominant firm. We now analyze the case with $n > 1$ strategic firms competing *à la* Cournot in sequential markets. Our solution in the main text can be recovered by setting $n = 1$.

We use q_{it} to denote firm i's production in market t, $q_{-it} = \sum_{j\neq i}^{n} q_{jt}$ to denote its rivals' production in market t, and $q_t = q_{it} + q_{-it}$ to denote total production in market

t, for $i = 1, ..., n$ and $t = 1, 2$. Each strategic firm owns a fraction δ/n of the renewable capacity, where $\delta \in [0, 1]$. They can all produce conventional output at constant marginal costs c.

We first solve the baseline case (denoted by B) with *market prices* and no arbitrage, and then solve the games with *market prices* and limited arbitrage, and the game with *fixed prices*.

Baseline. The problem of the strategic firms $i = 1, ..., n$ is solved by backwards induction. In the spot market, firm i chooses q_{i2} so as to maximize its profits, taking as given the quantities chosen by its rivals in the spot market as well as the day-ahead quantities. We can express the spot market problem as in (6), but we now express it as a function of firms' quantities,

$$\max_{q_{i2}} \left[p_2 \left(q_1, q_2 \right) q_{i2} - c \left(q_{i1} + q_{i2} - \delta w/n \right) \right], \tag{14}$$

where, using (5), spot market demand can be expressed as $p_2 \left(q_1, q_2 \right) = p_1 \left(q_1 \right) - q_2/b$.

Solving the FOC, each firm's reaction function in the spot market is

$$q_{i2} \left(q_{-i2} \right) = b \frac{p_1 - c}{2} - \frac{1}{2} q_{-i2}.$$

In a symmetric equilibrium,

$$q_{i2}^* \left(q_1 \right) = \frac{b}{n+1} \left(p_1 \left(q_1 \right) - c \right) \text{ and } p_2^* \left(q_1 \right) = \frac{p_1 \left(q_1 \right) + cn}{n+1}. \tag{15}$$

The day-ahead market problem becomes

$$\max_{p_1} \left[p_1 \left(q_1 \right) q_1 + p_2^* \left(q_1 \right) q_2^* \left(q_1 \right) - c \left(q_{i1} + q_{i2} - \delta w/n \right) + \underline{p} \delta w/n \right] \tag{16}$$

where, using (4), the day-ahead demand can be expressed as

$$p_1 \left(q_1 \right) = \left(A - w \left(1 - \delta \right) - q_1 \right) / b. \tag{17}$$

Solving the FOC, each firm's reaction function in the day-ahead market is

$$q_{i1} \left(q_{-i1} \right) = \frac{\left(n^2 + 2n - 1 \right)}{2n \left(n + 2 \right)} \left[A - w \left(1 - \delta \right) - bc - q_{-i1} \right].$$

In a subgame-perfect symmetric equilibrium under the baseline case,

$$q_{i1}^B = \Delta(n)\left(n^2 + 2n - 1\right)(A - w(1-\delta) - bc),$$

where to simplify notation, we have used $\Delta(n) = \left(n^3 + 3n^2 + n + 1\right)^{-1} > 0$.

The equilibrium price p_1^B can be found by plugging $q_1 = nq_{i1}^B$ into (4). The spot price p_2^B can be found by plugging p_1^B into (15). Using the resulting equilibrium expressions, the price difference across markets is given by

$$\Delta p^B \equiv p_1^B - p_2^B = \Delta(n)\, n(n+1)(A - w(1-\delta) - bc)/b.$$

Market Prices with Limited Arbitrage. The spot market problem is the same as in (14), but the demand is now given by $p_2(q_2) = p_1 + (k-w)(1-\delta)/b - q_2/b$ since the fringe has incentives to arbitrage $(k-w)(1-\delta)$.

Each firm's reaction function in the spot market becomes

$$q_2(q_{-i2}) = b\frac{p_1 - c}{2} + \frac{(k-w)(1-\delta)}{2} - \frac{1}{2}q_{-i2}.$$

In a symmetric equilibrium,

$$\begin{aligned}
q_{i2}^*(q_1) &= \frac{b}{n+1}(p_1(q_1) - c) + \frac{(k-w)(1-\delta)}{n+1} \\
p_2^*(q_1) &= \frac{p_1(q_1) + cn}{n+1} + \frac{1}{b}\frac{(k-w)(1-\delta)}{n+1}.
\end{aligned}$$

The day-ahead market problem is the same as in (16), but demand is now given by $p_1(q_1) = (A - k(1-\delta) - q_1)/b$ since the fringe offers its full renewable capacity $k(1-\delta)$. After some algebra, the solution is given by

$$\begin{aligned}
p_1^M &= p_1^B - \Delta(n)\left(n^2+1\right)(1-\delta)(k-w)/b && (18) \\
p_2^M &= p_2^B + \Delta(n)\, n(n+1)(1-\delta)(k-w)/b && (19) \\
\Delta p^M &= \Delta p^B - \Delta(n)\left(2n^2+n+1\right)(1-\delta)(k-w)/b.
\end{aligned}$$

Performing comparative statics with respect to w,

$$\frac{\partial p_1^M}{\partial w} = -2\Delta(n)\, n(1-\delta)/b \le 0 \tag{20}$$

$$\frac{\partial p_2^M}{\partial w} = -\Delta(n)(n+1)^2(1-\delta)/b \le 0 \tag{21}$$

$$\frac{\partial \Delta p^M}{\partial w} = \Delta(n)\left(n^2+1\right)(1-\delta)/b \ge 0. \tag{22}$$

All the inequalities are strict for $\delta < 1$.

Computing the cross-derivatives with respect to δ,

$$\frac{\partial p_2^M}{\partial w \partial \delta} \ge \frac{\partial p_1^M}{\partial w \partial \delta} > 0 \ge \frac{\partial \Delta p^M}{\partial w \partial \delta}.$$

Fixed Prices. The solution to the spot market problem is the same as in the baseline model, (14). In the day-ahead market, the problem becomes

$$\max_{q_{i1}} \left[p_1(q_1)(q_{i1} - \delta w/n) + p_2(p_1)\, q_2(p_1) - c(q_{i1} + q_{i2} - \delta w/n) + \overline{p}\delta w/n\right]$$

where $p_1(q_1) = (A - w(1-\delta) - q_1)/b$. Following the same steps as before, the solution is given by

$$p_1^F = p_1^B - \Delta(n)(n+1)^2 w\delta/b \tag{23}$$

$$p_2^F = p_2^B - \Delta(n)(n+1)\, w\delta/b \tag{24}$$

$$\Delta p^F = \Delta p^B - \Delta(n)(n+1)\, nw\delta/b$$

Performing comparative statics with respect to w,

$$\frac{\partial p_1^F}{\partial w} = -(n+1)^2 \Delta(n)/b < 0 \tag{25}$$

$$\frac{\partial p_2^F}{\partial w} = -(n+1)\Delta(n)/b < 0 \tag{26}$$

$$\frac{\partial \Delta p^F}{\partial w} = -n(n+1)\Delta(n)/b < 0 \tag{27}$$

All the cross-derivatives with respect to δ equal 0.

Comparison across Pricing Rules. We are now ready to prove the analogous of Proposition 1 for the case $n > 1$.

(i) Comparing the expressions for p_1, (18) and (23):

$$p_1^F - p_1^M = \Delta(n)\left[\left(n^2+1\right)(1-\delta)(k-w) - (n+1)^2 w\delta\right]/b.$$

Hence, $p_1^F < p_1^M$ if and only if the term in brackets is positive. Solving for δ,

$$\delta > \widehat{\delta\delta}(n) \equiv \frac{k-w}{k+\frac{2n}{n^2+1}w}. \tag{28}$$

Since $\widehat{\delta\delta}(n)$ is increasing in n, it follows that

$$\widehat{\delta\delta}(n) \in \left[\frac{k-w}{k+w}, \frac{k-w}{k}\right].$$

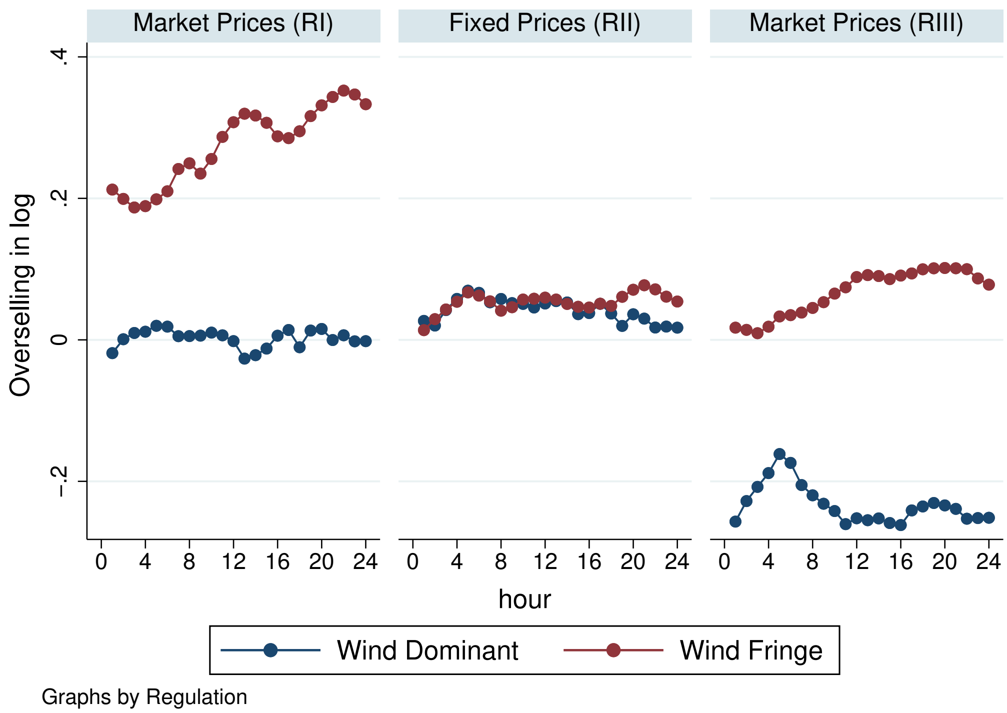
(ii) Comparing the expressions for p_2, (19) and (24):

$$p_2^F - p_2^M = -w\frac{(n+1)}{b\left(k+kn^2+2nw\right)}(k-w) < 0.$$

Similarly, the analogous of Proposition 2 for the case $n > 1$ follows from the comparative statics reported above.

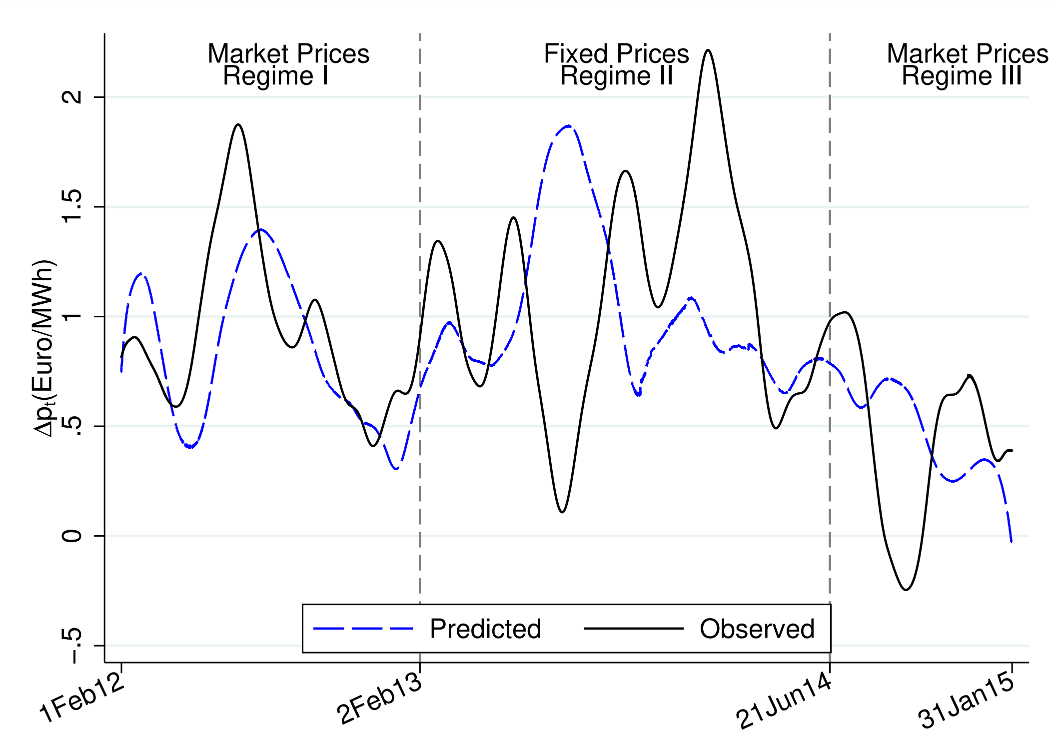
Appendix B & C: Additional Figures and Tables

Figure B.1: Overselling and Withholding by Wind Producers



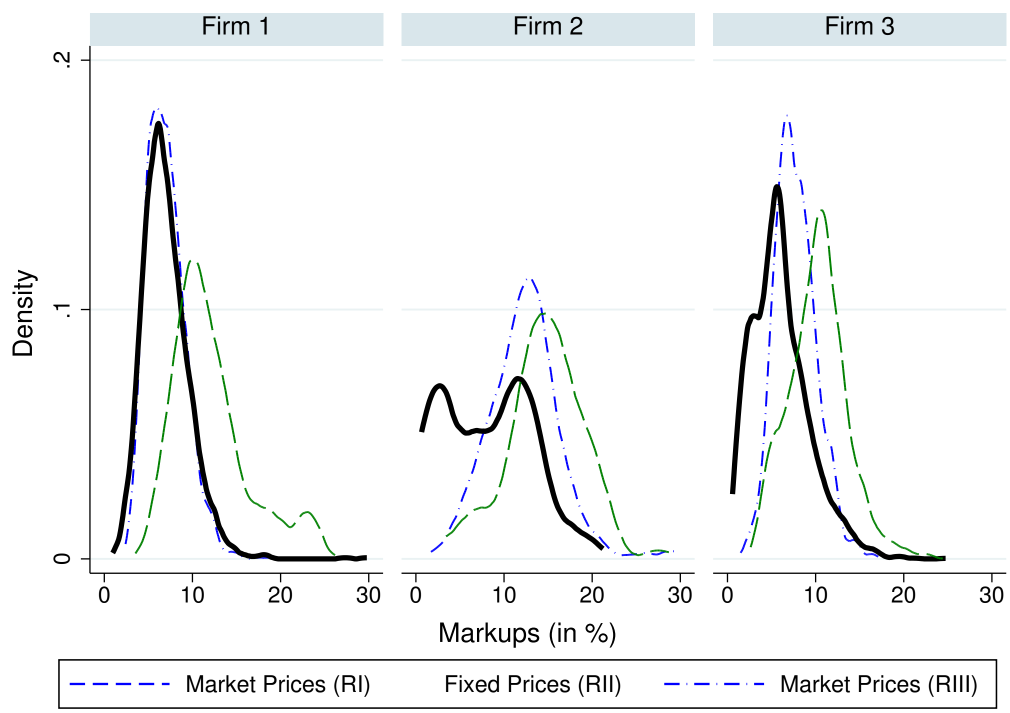
Notes: This figure shows the weekly average of the day-ahead commitments relative to the final commitments of the wind producers, split in three regulatory regimes. Sample is from February 2012 to February 2015. Regime I - Market Prices is from 1 February 2012 to 31 January 2013; Regime II - Fixed Prices is from 1 February 2013 to 21 June 2014; Regime III - Market Prices is from 22 June 2014 to 31 January 2015.

Figure B.2: Predicted and Observed Price Premium



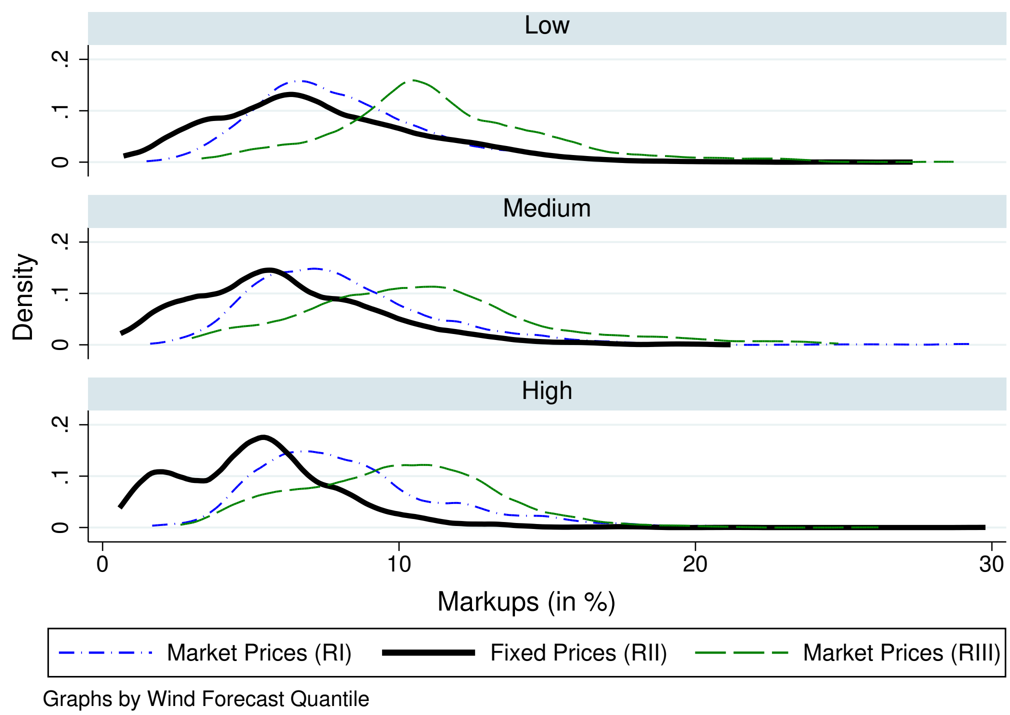
Notes: This figure shows locally weighted linear regressions of $\Delta\hat{p}_t$ (predicted) and Δp_t (observed) from February 2012 to February 2015. The weights are applied using a tricube weighting function (Cleveland, 1979) with a bandwidth of 0.1. The predictions ($\Delta\hat{p}_t$) are done using the estimated coefficients obtained from equation in footnote 47. These $\Delta\hat{p}_t$ are used in equation (13).

Figure B.3: Markup Distribution by Firm



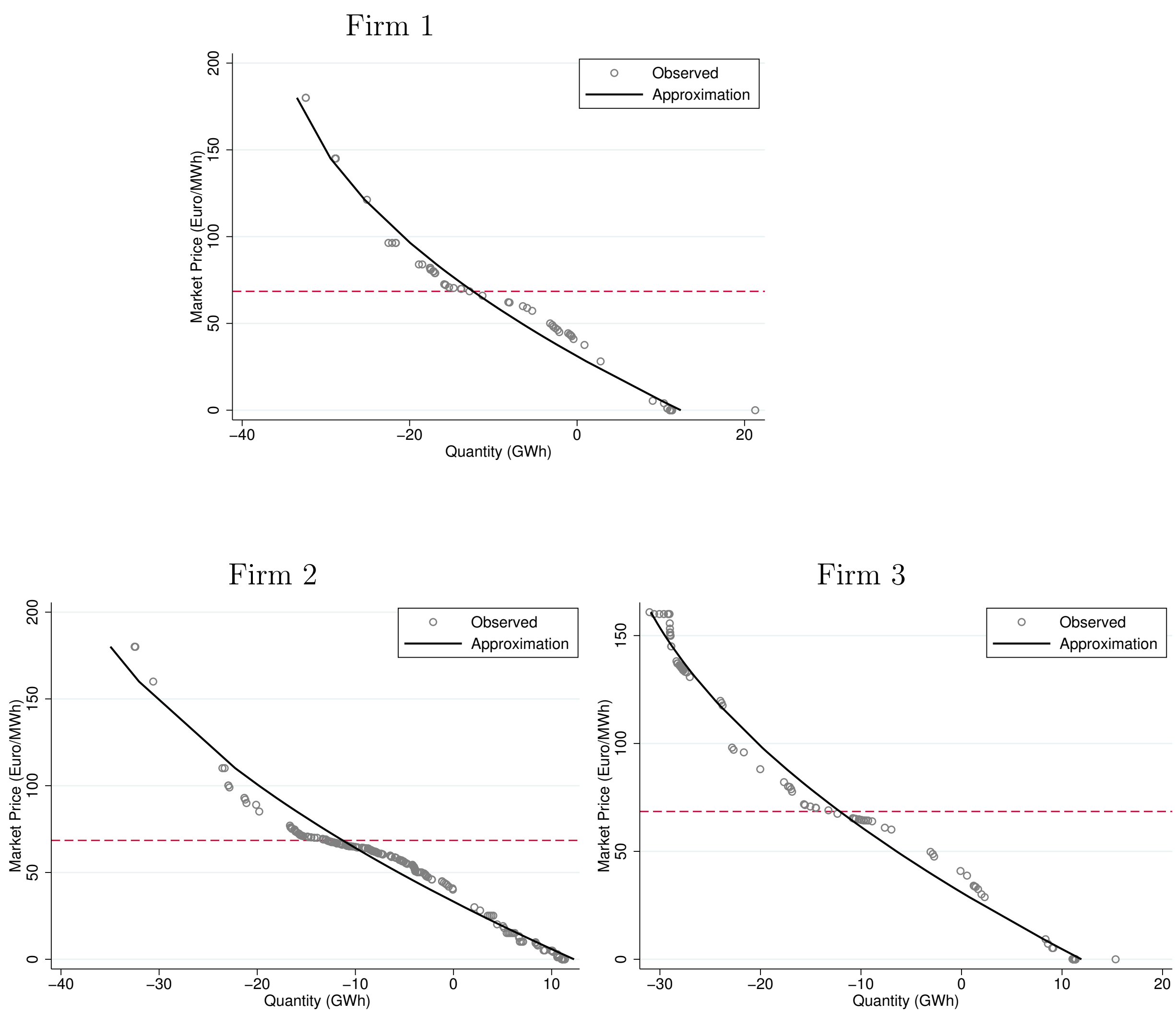
Notes: This figure plots the markup distributions for each of the strategic firms by their pricing regimes for hours with prices above 25 Euro/MWh.

Figure B.4: Markup Distribution by Wind Quartiles



Notes: This figure compares markups distribution by wind forecast quartiles (low, medium, and high wind days) in three different pricing regimes for hours with prices above 25 Euro/MWh.

Figure B.5: Approximating the slopes of the residual demands



Notes: This figure illustrates how we use quadratic approximation to compute the local slope around the market clearing price (the horizontal line) for each of the dominant firm's residual demand curve. Here, we show each firm's the residual demand curve in October 10, 2014, 18.00.

Table C.1: The Forward Contract Effect with Various Clusterings

	2SLS			
	(1)	(2)	(3)	(4)
Market Prices (RI) x $\frac{w_{it}}{DR'_{it}}$	6.35	9.31	9.10	5.54
Firm-month-year	(8.58)	(9.20)	(8.70)	(7.43)
Firm-week	(7.12)	(7.20)	(6.98)	(6.97)
Firm-day	(5.35)	(5.50)	(5.37)	(5.58)
Market Prices (RII) x $\frac{w_{it}}{DR'_{it}}$	-14.24	-14.54	-14.92	-14.26
Firm-month-year	(6.43)	(6.16)	(6.30)	(8.68)
Firm-week	(7.11)	(7.05)	(7.17)	(8.24)
Firm-day	(7.22)	(7.15)	(7.24)	(8.46)
Market Prices (RIII) x $\frac{w_{it}}{DR'_{it}}$	1.72	0.05	0.60	5.69
Firm-month-year	(6.81)	(5.87)	(5.56)	(7.67)
Firm-week	(6.71)	(5.98)	(5.81)	(8.50)
Firm-day	(4.04)	(3.45)	(3.32)	(6.84)
Linear Trends	N	Y	Y	Y
Quad. Trends	N	N	Y	Y
Observations	19,805	19,805	19,805	19,805

Notes: See the notes in Table 2 which uses plant level clustering. Here we report three different standard errors from three alternative clusterings: firm-day, firm-month-year, and firm-week levels.

Table C.2: The Forward Contract Effect Accounting for Vertical Integration

	2SLS			
	(1)	(2)	(3)	(4)
Market Prices (RI) $\times \frac{w_{it}}{DR'_{it}}$	11.9	12.5	12.4	18.5
	(6.45)	(6.59)	(6.41)	(8.79)
Fixed Prices (RII) $\times \frac{w_{it}}{DR'_{it}}$	-14.1	-12.7	-13.1	-7.48
	(3.47)	(2.83)	(2.97)	(3.48)
Market Prices (RIII) $\times \frac{w_{it}}{DR'_{it}}$	1.09	1.15	1.78	7.57
	(3.91)	(3.74)	(3.43)	(4.18)
Expected spot price ($\hat{p}_{2t}$)	0.94	0.96	0.96	1.18
	(0.064)	(0.067)	(0.067)	(0.10)
Markup term ($\frac{q_{it}}{DR'_{it}}$)				3.36
				(0.93)
Linear Trends	N	Y	Y	Y
Quad. Trends	N	N	Y	Y
Observations	19,805	19,805	19,805	19,805

Notes: This table shows the estimation results of equation (11) using 2SLS. All regressions include unit, firm and quarterly dummies, time trends, while in columns (2)-(4) we add day-of-the-week dummies, hour fixed effects, and quadratic time trends are added in a cumulative fashion. We constrain the coefficient for markups from firms' total output to be one in columns (1) to (3), and we relax this by allowing the markup coefficient to vary in column (4). We limit hourly prices to be within 5 Euro/MWh range relative to the market price and exclude the outliers (bids with market prices below the 1st percentile and above the 99th percentile). We instrument our markups with wind speed, precipitation, and each of them interacted with the three pricing scheme indicators. The standard errors are clustered at the plant level.

Table C.3: The Response of Overselling to the Price Premium

	Wind	Non-wind Renewables	Downstream Suppliers	Diff	
	(1)	(2)	(3)	(1)-(2)	(1)-(3)
Market Prices (RI)	0.052	0.012	0.046	-0.061	-0.018
	(0.000)	(0.000)	(0.000)	(0.000)	(0.028)
Fixed Prices (RII)	-0.002	-0.003	0.067	-0.002	0.051
	(0.523)	(0.001)	(0.000)	(0.486)	(0.000)
Market Prices (RIII)	0.058	-0.008	0.099	-0.068	0.016
	(0.000)	(0.000)	(0.000)	(0.000)	(0.127)
RI→RII	-0.055	-0.015	0.015	-0.059	-0.069
	(0.000)	(0.000)	(0.016)	(0.000)	(0.000)
RII→RIII	0.053	-0.005	0.024	0.07	0.035
	(0.000)	(0.046)	(0.004)	(0.000)	(0.007)

Notes: This table reports the coefficient of $\Delta\hat{p_t}$ from 25 different regressions similar to equation (13). Columns (1)-(3) only use overselling quantity from each group on the corresponding column header. The two columns on the right compare the difference in overselling from either columns (1) and (2) or columns (1) and (3). The last two rows compare two pricing regimes, either from Regime I to II or from Regime II to III. The corresponding P-values for each coefficient are in parentheses. Pre-trend assumptions are supported by the p-values in columns (1)-(2) row 2 – under Regime II, wind and non-wind renewables face the same incentives to oversell – and columns (1)-(3) row 1 or row 3 – under Regime III, wind, and suppliers face the same incentives to oversell. The impact on the price response of overselling can be seen in the last two rows in columns (1)-(2) and (1)-(3), and it is similar to numbers reported in Table 3.

Table C.4: The Impact of Pricing Schemes on Price Differences across Markets

	2SLS			
	(1)	(2)	(3)	(4)
Slope Day-ahead Residual Demand	-0.014	-0.0080	-0.014	-0.0080
	(0.0058)	(0.0061)	(0.0062)	(0.0066)
Slope Intra-day Residual Demand	0.091	0.089	0.091	0.089
	(0.024)	(0.024)	(0.024)	(0.025)
Wind Forecast (GWh)	0.060	0.0029	0.060	0.0029
	(0.046)	(0.050)	(0.049)	(0.056)
Dominant Wind Share ($\frac{w_{dt}}{W_t}$)	-0.59	-0.50	-0.59	-0.50
	(0.18)	(0.17)	(0.18)	(0.18)
Market Prices (RI)	-0.46	-0.52	-0.46	-0.52
	(0.16)	(0.16)	(0.15)	(0.17)
Fixed Prices (RII)	-1.16	-1.01	-1.16	-1.01
	(0.21)	(0.22)	(0.23)	(0.23)
Market Prices (RI) $\times \frac{w_{dt}}{W_t}$	0.44	0.46	0.44	0.46
	(0.21)	(0.19)	(0.21)	(0.21)
Fixed Prices (RII) $\times \frac{w_{dt}}{W_t}$	0.46	0.41	0.46	0.41
	(0.18)	(0.17)	(0.16)	(0.17)
Demand Forecast (GWh)	-0.0029	0.079	-0.0029	0.079
	(0.017)	(0.024)	(0.019)	(0.027)
Weekend FE	N	N	Y	Y
Peak Hour FE	N	Y	N	Y
Observations	25334	25334	25334	25334

Notes: This table shows the coefficients from equation (14). The slopes of the residual demands DR'_1 and DR'_2 are instrumented using daily average, minimum, and maximum temperature, and average temperature interacted with hourly dummies. Fixed Prices period (RII) is the reference period. We use bootstrap standard errors with 200 replications.

Table C.5: Average Markups in the Day-ahead Market

	Market Prices (RI)		Fixed Prices (RII)		Market Prices (RIII)	
	Mean	SD	Mean	SD	Mean	SD
Markups (in %) – Simple average						
All	8.3	(3.3)	6.3	(3.3)	10.7	(3.7)
Firm 1	7.0	(2.2)	7.0	(2.6)	12.1	(4.4)
Firm 2	12.3	(4.1)	8.2	(5.1)	14.7	(4.4)
Firm 3	7.7	(2.3)	6.0	(3.3)	10.3	(3.3)
Slope of day-ahead residual demand (in MWh/euros)						
All	524.2	(78.2)	553.6	(120.7)	418.2	(73.0)
Firm 1	506.6	(50.5)	458.4	(72.7)	411.0	(62.3)
Firm 2	508.5	(71.8)	556.3	(165.0)	453.8	(99.7)
Firm 3	538.2	(88.7)	573.3	(117.2)	417.9	(73.2)

Notes: Sample from February 2012 to January 2015, includes the markups for those units bidding within a 5 Euro/MWh range around the market price, for hours with prices above 25 Euro/MWh. Regime I is from 1 February 2012 to 31 January 2013; Regime II is from 1 February 2013 to 21 June 2014; Regime III is from 22 June 2014 to 31 January 2015.

References

Cleveland, William S. 1979. "Robust Locally Weighted Regression and Smoothing Scatterplots." *Journal of the American statistical association*, 74(368): 829–836.

Ito, Koichiro, and Mar Reguant. 2016. "Sequential Markets, Market Power, and Arbitrage." *American Economic Review*, 106(7): 1921–57.