Can spot market power translate into market power in the hedge market?

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WEAI 85th Annual Conference - July 1, 2010 - Portland, Oregon

Background

- Forward pricing in electricity markets is troublesome.

  - Electricity non-storability implies that usual commodity pricing literature (and arbitrage/ cost of carry arguments) may not hold.

- Electricity markets frequently present additional complications.

  - Oligopoly, uniform-price auction and vertical integration.

- Theoretical literature discusses how forward contracts affect spot market power. How does spot market power affect forward prices?

The hybrid pricing approach

- Several papers try to mimic electricity price's stochastic behaviour in order to value its derivatives.

- Focus on seasonality and spikes (short-lived and abrupt oscillations).

- Ex. Schwartz (1997), Schwartz and Smith (2000), Deng (2000), Lucia and Schwartz (2002) and Cartea and Villaplana (2005).

- Alternative: hybrid pricing approach.

- Build on an equilibrium framework, explaining instantaneous price behaviour in terms of observable state variables (demand and supply). Keep track of fundamentals.

- Assume state variables follow dynamic processes and apply no-arbitrage methodologies to calculate derivatives.

Skantze, Gubina, and Ilic (2000), Barlow (2002), Pirrong and Jermakyan (2008), Cartea and Villaplana (2008) and Lyle and Elliott (2009).

→ Equilibrium ground is too simple and based on a competitive spot market.

Some definitions

- There are N firms (K generators and R retailers). Firms can participate in both markets (I=K+R-N gentailers).
- State variables: $\vec{W}_t = \{w_{1t}, w_{2t}, \ldots, w_{Lt}\}$
- The consumers' demand: $D_t(p_t^R, \vec{W}_t)$
- Generator i's cost function: $C_{it}(S_{it}, \vec{W}_t)$
- Contracts: $QC_{it} \quad PC_{it}$

Generators/gentailers' auction problem

- The conditional cumulative function of market clearing price is:

$$H_{it}(p, \hat{S}_{it}(p); QC_{it}) \equiv Pr(p_t^c \leq p \mid QC_{it}, \hat{S}_{it}(p))$$

- Generator/Gentailer i's maximization problem:

$$\max_{\hat{S}_{it}(p)} \int_{\underline{p}}^{\overline{p}} U_i[\hat{S}_{it}(p)p - C_{it}(\hat{S}_{it}(p), \vec{W}_t) + m_i(p_t^R - p_t^c)D_t(p^R, \vec{W}_t)$$
$$+ (PC_{it} - p)QC_{it}]dH_{it}(p, \hat{S}_{it}(p); QC_{it})$$

Optimal supply schedule

- At any time, assume supply function is additively separable:

$$S_i(p, QC_i, \vec{W}) = \alpha_i(p) + \beta_i(QC_i) + \sum_{j=1}^{L} \delta_{ji}(w_j)$$

- Then, extending Hortaçsu & Puller (2008), we have the following supply schedule:

$$p - MC_{it} = \frac{\hat{S}^*_{it}(p) - QC_{it} - m_i D_t}{\frac{\partial \sum_{j \neq i} S_{jt}}{\partial p_t}}$$

- Which is equivalent to:

$$\frac{p_t - MC_{it}}{p_t} = \frac{1}{\varepsilon_{it}(q_{it})}$$ ⟶ elasticity of net residual demand

Equilibrium spot price

- If we further assume that there are K>2 generators/gentailers and that marginal costs and demand can be approximated by a linear function…

$$MC_{it}(S_{it}, \vec{W}_t) = a + bS_{it} + \sum_{j=1}^{L} \rho_j w_{jt} \ \forall i = 1, 2, \ldots N$$

$$D_t(p_t^R, \vec{W}_t) = c - \kappa_o p^R + \sum_{j=1}^{L} \kappa_j w_{jt}$$

- …by the spot market clearing condition, we have:

$$p_t^c = A - B \sum_{i=1}^{K} QC_{it} + \sum_{j=1}^{L} C_j w_{jt}$$

$$\begin{aligned} A &= a + b\frac{(c - \kappa_o p^R)\left(K - (1 + \sum_{i=1}^{K} m_i)\right)}{K(K-2)} \\ B &= \frac{b}{K(K-2)} \\ C_j &= \rho_j + b\frac{\left(K - (1 + \sum_{i=1}^{K} m_i)\right)}{K(K-2)}\kappa_j \end{aligned}$$

Forward pricing

- To isolate the impact of generators contracts on spot prices in the model:

- Assume we have an economy where K=N, which means all retailers participate of the generation market.
- Assume also that only generators/gentailers transact in the forward market.

Ex: New Zealand: Market shares in 2008

Company	Generation	Retail
Contact Energy	26%	27%
Genesis Energy	22%	25%
Meridian Energy	28%	12%
Mighty River Power / Mercury Energy	14%	19%
Trust Power	5%	11%
Total	95%	94%

Source: Companies' annual reports 2008 and NZ Electricity Commission.

Forward pricing II

- There are two state variables: an inelastic demand and a cost shifter, say the water inflows. Interest rate is constant (forward=future).

$$
\begin{aligned}
D_t(p_t^R, \vec{W}_t) &= w_{1t} \\
MC_{it}(S_{it}, \vec{W}_t) &= a + bS_{it} + \rho w_{2t} \quad \forall i = 1, 2, \ldots, K
\end{aligned}
$$

- Under these assumptions the spot price equation simplifies to the following:

$$
p_t = a + \frac{b}{K} w_{1t} + \rho w_{2t}
$$

- Notice that in this case the generators' quantity contracted does not affect spot prices. But the number of generators still does. Price is equal to average marginal cost.

Forward pricing III

- Assume that the demand oscillates around a deterministic function of time (seasonality). Cost shifter oscillates around a long term mean.

$$
\begin{aligned}
w_{1t} &= f(t) + x_{1t} \\
dx_{1t} &= -\psi x_{1t} dt + \sigma_1 dZ_1 \\
dw_{2t} &= \mu dt + \sigma_2 dZ_2 \\
dZ_1 dZ_2 &= \phi dt
\end{aligned}
$$

- Then, by Lucia & Schwartz (2002) two factor model, we have:

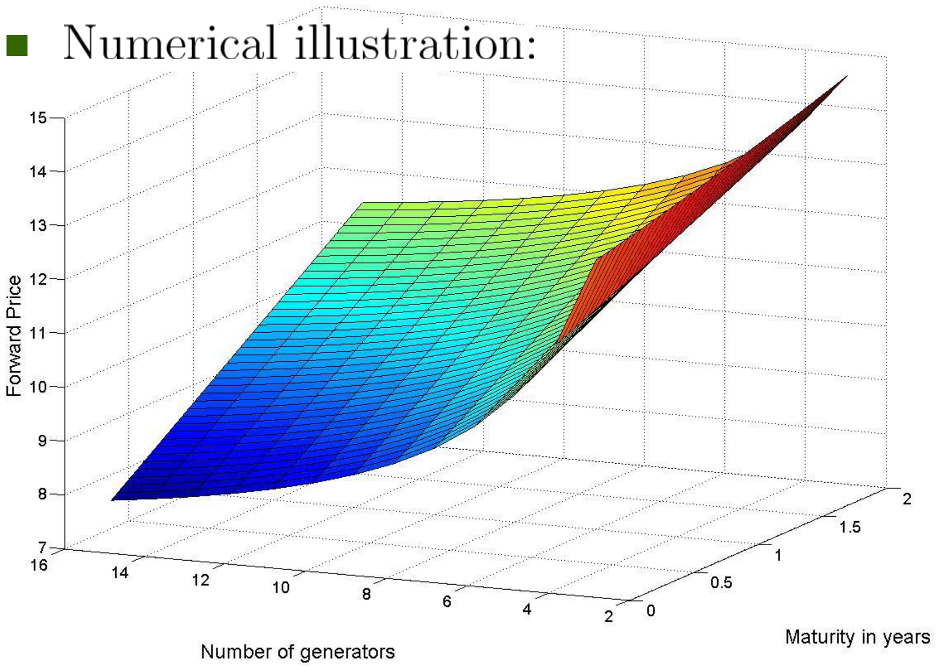
$$
\begin{aligned}
PC(p_t, T) &= a + \frac{b}{K} f(T) + \frac{b}{K} e^{-\frac{b}{K}\psi(T-t)} x_{1t} + \rho w_{2t} + \left(1 - e^{-\frac{b}{K}\psi(T-t)}\right) \eta^* + \mu^*(T-t) \\
\eta^* &= -\lambda_1 \sigma_1 / \psi \\
\mu^* &= \rho(\mu - \lambda_2 \sigma_2)
\end{aligned}
$$

Results

- Assume $a \geq 0$, $b \geq 0$, $\rho \geq 0$, $\mu \geq 0$, $\psi \geq 0$ and $f(T) \geq 0\ \forall T$.

- From the previous equation, we have the following:
$\frac{\partial PC}{\partial \sigma_1} \leq 0$, $\frac{\partial PC}{\partial \sigma_2} \leq 0$, $\frac{\partial PC}{\partial b} \geq 0$ and $\frac{\partial PC}{\partial K} \leq 0$.

- Numerical illustration:



$a = 5$, $b = 0.4$, $\rho = 0.1$, $\psi = 0.8$,
$\sigma_1 = 10$, $\lambda_1 = 0.5$,$x_{1t} = 50$,
$\mu = 20$,$\sigma_2 = 5$, $\lambda_2 = 0.5$ and $w_{2t} = 15$

Conclusion

- Hybrid pricing models offer a promising framework to relate equilibrium fundamentals to derivative pricing.
- Our model shows that, in a case where contracts are not significant in influencing spot prices, the spot market power may still shift the whole forward curve upwards.
- If market power affect forward prices it may affect the optimal quantity contracted.
- Unlike the assumptions of most of the theoretical literature, forward contracts are not exogenous. Its is important to fully understand its determinants to evaluate its relationship with market power.