Do Firms Sell Forward Contracts for Strategic Reasons? An Application to the Dutch Wholesale Market for Natural Gas

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Introduction

↦ Energy markets have undergone a liberalization process worldwide

↦ The standard of trade used to be bilateral negotiations

↦ The aim is to develop liquid spot markets

↦ However, spot market trade is still not very prominent; most trade is forward (bilateral negotiations, via brokers, or via exchanges)

Introduction

↦ There exist various incentives to trade forward contracts

- Hedging against risks: To mitigate the exposure to price shocks in the spot market
- Strategic reasons: To affect the competitors' spot market strategy (Allaz, 1992; Allaz and Vila, 1993)
  - Relies on the assumption of observability (Kao and Hughes, 1997)

↦ Results from experiments suggest that firms trade in forward markets for strategic reasons (LeCoq and Orzen, 2006; Brandts et al., 2008)

↦ Empirical evidence it still lacking at the moment

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Introduction

Objective

- *To develop an empirical strategy which enables us to discern whether firms use forward contracts for strategic motives*
- *To apply this empirical strategy to the Dutch wholesale market for natural gas*

Model

↦ There are n firms supplying a homogeneous good against cost c_i

↦ Firm i's total production is denoted by q_i; part of it is sold forward (x_i), the rest is sold spot ($q_i - x_i$)

↦ We consider a random demand function:

$$p = P(Q, \epsilon), \ \epsilon \sim (0, \sigma^2)$$

↦ Assumptions on demand: $P' < 0$ and $P'' \leq 0$

Model

$\mapsto$ The profits of the firm are given by:

$$\pi_i = (p - c_i)(q_i - x_i) + (f - c_i)x_i$$

$\mapsto$ We assume an efficient forward market, so $f = E(p)$

$\mapsto$ Firms maximize expected utility $EU(\pi_i)$, with $U' > 0$ and $U'' < 0$

Timing of the model

$\mapsto$ The timing of the game is as follows:

- Stage 1: Firms offer forward contracts
- Stage 2: Forward positions become observable or not
- Stage 3: Demand uncertainty is resolved
- Stage 4: Firms compete in quantities in the spot market and delivery of total output (forward+spot) takes place

Spot market stage

$\mapsto$ Given the amount of forward sales, the firm maximixes spot market profits:

$$\pi_i^s = (p - c_i)(q_i - x_i)$$

$\mapsto$ The FOC is given by:

$$p + P(Q)'(q_i - x_i) - c_i = 0$$

$\mapsto$ Note:

$$\frac{dq_i}{dx_i} = \frac{P(Q)'}{2P(Q)' + P(Q)''(q_i - x_i)} > 0$$

Forward market stage

$\mapsto$ At the forward stage, firm i chooses the amount of forward sales that maximizes expected utility:

$$\max_{x_i} EU(\pi_i(x_i))$$

where

$$\begin{aligned}\pi_i(x_i) &\equiv \left(P\left(q_i(x_i,\epsilon), \sum_{j\neq i}^{n} q_j(x_i,\epsilon), \epsilon\right) - c_i\right)(q_i(x_i,\epsilon) - x_i) \\ &+ (f - c_i)x_i\end{aligned}$$

Forward market stage

↦ The optimal level of forward contracting solves:

$$E\left(U'\frac{d\pi_i}{dx_i}\right) = 0$$

↦ In case the strategic effect is present, the FOC boils down to:

$$\underbrace{Cov\left(U', -p\right)}_{>0} + \underbrace{E(U')E\left(\frac{\partial \pi_i}{\partial x_i} + \frac{\partial \pi_i}{\partial q_i}\frac{\partial q_i}{\partial x_i}\right)}_{<0}$$
$$+ \underbrace{E(U')E\left(\sum_{j\neq i}^{n}\frac{\partial \pi_i}{\partial q_j}\frac{\partial q_j}{\partial x_i}\right)}_{>0} = 0 \qquad (1)$$

↦ If the forward positions are not observed, the third term of the FOC becomes zero

Functional form

$\mapsto$ For estimation purposes, we consider:

- Linear demand: $P = a + \epsilon - \sum_{i=1}^{n} q_i$
- CARA utility: $U(\pi_i) = -e^{-\rho_i \pi_i}$
- Forward sales are observed by rivals with probability γ

Equilibrium properties

↦ We are interested in the equilibrium (expected) total-to-forward sales ratio $\Gamma(\equiv E\left(\frac{q_i^*}{x_i^*}\right))$:

$$\Gamma = \frac{(n+1)^2(1+n+(n-1)\gamma) + 2(3+\gamma+(3-\gamma)n)\lambda_i}{2(n+1)((n^2-1)\gamma + 2\lambda_i)},$$

with $\lambda_i \equiv \rho_i \sigma^2$

↦ The (expected) total-to-forward-sales ratio has some interesting properties:

- $\frac{\partial \Gamma}{\partial \lambda_i} < 0$ and $\frac{\partial \Gamma}{\partial \gamma} < 0$ for all λ_i, γ and n
- $\frac{\partial \Gamma}{\partial n} < 0$ for $\gamma > \tilde{\gamma}(\lambda_i, b, n)$ for some $\tilde{\gamma} \in [0, 1]$; $\frac{\partial \Gamma}{\partial n} \geq 0$ otherwise

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Equilibrium properties

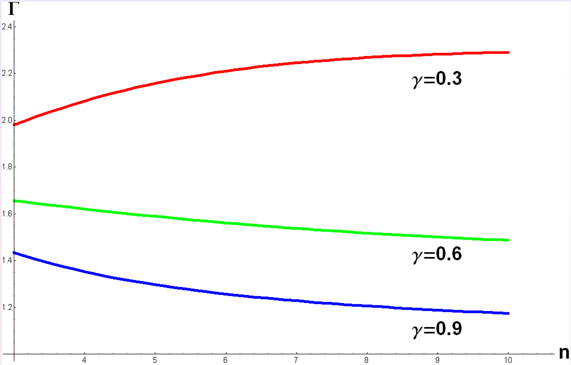

Figure: Relation between number of firms and total-to-forward-sales ratio ($\rho_i = 4$, $\sigma^2 = 1$)

Empirical analysis

$\mapsto$ Our data set consists of net monthly volumes traded at the Dutch gas hub TTF (both spot and forward)

$\mapsto$ We also have data on the number of wholesalers active at TTF

$\mapsto$ We analyze the period running from April '03 until June '08

Empirical analysis

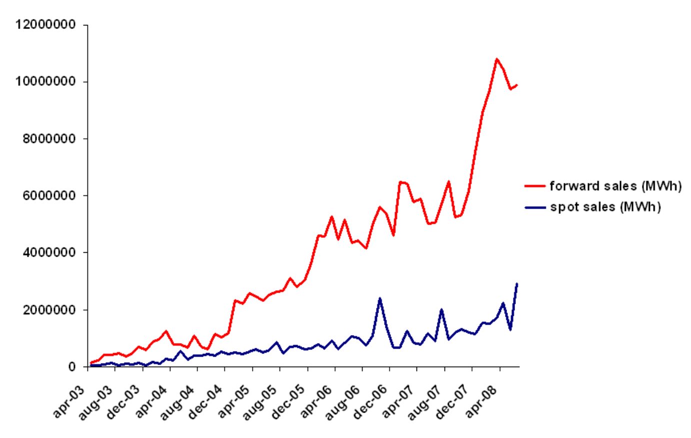

Figure: Forward sales and spot sales

Empirical analysis

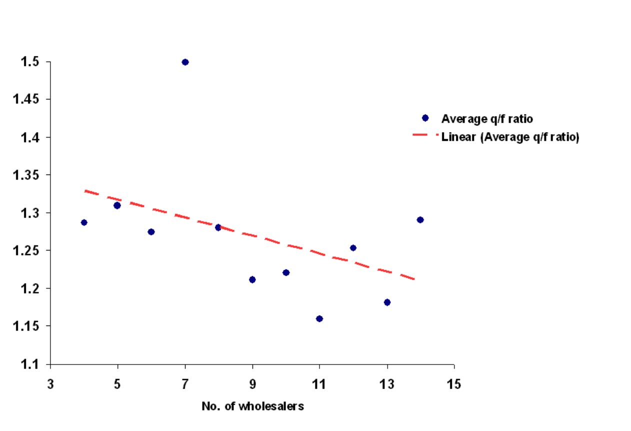

Figure: Relation between the number of wholesalers and the total-to-forward-sales ratio

Empirical analysis

↦ The econometric model we test is as follows:

$$\frac{n_t + 1}{n_t} Q_t = \frac{n_t + 1}{n_t} \Gamma(n_t, \gamma, \lambda) X_t + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon^2)$$

↦ We use Nonlinear Least Squares (NLS) to estimate our econometric model

Table: Regression

Variable	*Estimates*	$t - $ *Statistic*
$\hat{\lambda}$	11.975	0.450
$\hat{\gamma}$	0.828*	25.961
$R^2 = 0.704$		

* Significant at the 1 percent significance level

↦ Firms seem to use forward contracts as strategic instruments

↦ However, the results suggest that firms do not trade forward contracts for risk-hedging reasons

Conclusions

$\mapsto$ Theory suggests there may exist various motives for gas wholesalers to trade forward

$\mapsto$ Our theoretical model enables us to identify the strategic effect

$\mapsto$ For the Dutch wholesale gas market, we indeed find that firms trade forward contracts for strategic reasons

$\mapsto$ The risk-hedging incentive turns out to be insignificant for this market