Investing in Vertical Integration

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Goal is to explore real options in an electricity market:
Introduction

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- Consider a short term increase in retail market share (e.g. an advertising campaign).
- When will the firm do this? What factors encourage/inhibit this.
Begin with an equilibrium model of electricity market.
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Three types of firms:
Background

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Market participants may have forward positions (QC).
Clearing the market

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\[ S_{it}(p_t, QC_{it}, \bar{W}_t) = -\frac{a(K - 2)}{b(K - 1)} + \frac{K - 2}{b(K - 1)} p_t + \frac{1}{K - 1} QC_{it} \]

\[ + \frac{m_i}{K - 1} D_t - \frac{(K - 2)}{b(K - 1)} \sum_{j=1}^{L} \rho_j w_{jt}. \]
Firm’s profit & prices

$$\pi_i = p^c S_i^*(p^c) - C(S^*(p^c)) + (PC - p^c)QC_i + m_i(p^R - p^c)D.$$  

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

Where

$$A = a + b \frac{(c - \kappa_0 p^R) \left(K - (1 + \sum_{i=1}^{K} m_i)\right)}{K(K - 2)}$$

$$B = \frac{b}{K(K - 2)}$$

$$C_j = \rho_j + b \frac{\left(K - (1 + \sum_{i=1}^{K} m_i)\right)}{K(K - 2)} \kappa_j$$
Generator/Gentailer can pay $l$ and increase market share of retail market by $\Delta m_i$. $\omega \Delta m_i$ will come from Gentailers. Remainder will be stolen from retailers.
Real options

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Now assume that
\[ dD_t = D_t \mu dt + D_t \sigma dW_t \Rightarrow V(D_t) = \tilde{A}D_t - BD^2_t - I. \]
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We then solve the ODE

\[
\frac{1}{2} \sigma^2 D^2 F''(D) + \mu DF'(D) - rF(D) = 0
\]

subject to $F(D) \geq V(D)$ with smooth pasting conditions.
Numerical example

- $K = 5$, $M = 0.5$, $m_i = M/K$.
- $I = 100$, $\Delta m_i = 2\%$, $h = 4$, $\omega = 60\%$.
- $QC = 10$, $a = 50$, $b = 3$.
- This gives a price of $72.5$/MWh for 37.5TWh output (NZ 22/1/2004-30/11/2010).
Concavity of $V(D_t)$

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Investing in Vertical Integration
Project value and investment policy (different risk free rates)
Project value and investment policy (different volatilities)
Concavities of $F(D)$ and $V(D)$
Project value and investment policy (different number of firms)
Project value and investment policy (quantity contracted)
Project value and investment policy (degree of vertical integration)

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Investing in Vertical Integration
Project value and investment policy (Retail prices)

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Investing in Vertical Integration
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Extending vertical integration can be profitable for a firm (increased market power, reduced risk).
Final thoughts

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Extension: updating contract prices (similar qualitative results).