Cambridge Working Papers in Economics CWPE 0406

UNIVERSITY OF
CAMBRIDGE
Department of Applied Economics

Retail Competition and Electricity Contracts

Richard Green

The Cambridge-MIT Institute

Massachusetts Institute of Technology
Center for Energy and
Environmental Policy Research

CMI Working Paper 33

DAE Working Paper Series

UNIVERSITY OF
CAMBRIDGE
Department of
Applied Economics

not to be quoted without permisson

The
Cambridge-MIT
Institute

Massachusetts Institute of Technology
Center for Energy and
Environmental Policy Research

CMI Working Paper Series

Retail Competition and Electricity Contracts

Richard Green*
University of Hull

The Business School
University of Hull
Hull HU6 7RX

Tel: +44 1482 465720
Fax: +44 1482 466216
Email: r.j.green@hull.ac.uk

December 2003

Abstract

Long-term contracts for electricity can counter market power and reduce prices in short-term markets. If electricity retailers face competition, however, companies signing long-term contracts are exposed to the risk that a fall in short-term prices would allow rivals to buy on the spot market and undercut them. Could this lead to less contracting and higher prices? This paper estimates the size of this effect, combining models of electricity retailing and of competition in the wholesale markets. Given enough volatility and an otherwise competitive long-term market, retail competition might raise wholesale prices by up to nineteen per cent.

JEL: L94

Keywords: Electricity, contract markets, retail competition

* I would like to thank David Newbery, Steve Puller, Steve Satchell, and seminar and conference participants at the University of California Energy Institute, the Institute d'Economie Industrielle, Toulouse, the University of Hull and the University of Kent at Canterbury for helpful comments.

1. Introduction

In many countries, the focus of electricity restructuring has moved on from creating competition in generation, to creating competitive retail markets for electricity. Norway allowed all its consumers to choose an electricity retailer in 1993, and progressively removed any barriers that prevented small consumers from exercising this choice. Sweden and Finland followed suit a few years later. In Great Britain, where large customers had been allowed to choose their supplier since 1990, all consumers were given a choice from 1999. In the United States, electricity restructuring at the wholesale level has frequently been accompanied by retail choice programmes, some more successful than others. In Germany, all consumers were allowed to choose their supplier from 1999, while there has arguably been little change in the operation of the generation sector. In some markets, few consumers have exercised this choice, but in the UK, more than one third of domestic electricity consumers, and a significant majority of industrial customers, have moved away from their local retailer.

Does this change have any implications for the operation of electricity wholesale markets? Supporters of retail competition, such as Littlechild (2003), argue that it will force retailers to be more careful in their purchasing decisions, and this active demand side will make the wholesale markets more competitive. Newbery (2002), however, has argued that the increase in competition at the retail level will make buyers in the wholesale market reluctant to sign long-term contracts with generators, fearing adverse movements in the price of electricity. If retailing is a regulated monopoly, the retailer may face some kind of prudential review, but can otherwise expect to be allowed to pass on the actual cost of its electricity purchases, even if these turn out to be more expensive than current wholesale prices.

In a competitive supply market, however, a company will not be able to pass its actual costs on to its consumers, but may only charge what the market will bear. This will depend upon the current level of wholesale prices, at which its rivals can purchase marginal supplies. If the wholesale price has fallen below the level expected when the company committed itself to purchases under long-term contracts, then the company may have to sell for less than the cost of those contracts.

This is naturally an unattractive prospect. Can companies avoid this risk? The obvious course is to minimise the number of long-term contracts bought by the company. If, as in the UK, retail prices are typically set for a year at a time (there is an annual contract round" concentrated in January and February), the company should buy most of its electricity in annual contracts. If the company bought multi-year contracts, wholesale prices might fall, making it impossible to recover the excess cost, while if the company bought a series of shorter contracts, there is a risk that wholesale prices might rise before retail prices could be adjusted. (The Californian debacle was an example of this kind of problem – retail prices had been fixed for four years, while wholesale prices varied day by day, and the companies had not hedged their purchases.)

What are the implications of this kind of purchasing strategy? The company's prices will be more volatile, the shorter the average length of its contracts, but this may not be a major concern to most of its customers, if electricity represents a small proportion of their budgets. Much more important is the impact on the wholesale market, however. A number of authors (Powell, 1993; Newbery, 1998; Green, 1999; Wolak, 2000) have shown that long-term contracts can reduce wholesale electricity prices in the presence of market power. Powell, Green and Wolak concentrated on the static impact of contracts on companies' bidding strategies, given the present structure of the market.

Newbery also considered the impact upon the market's structure – sufficiently long-term contracts effectively make entry contestable. An entrant can simultaneously lock in its fuel purchases and electricity sales, removing price risk, and the sunk costs of bringing a project to the point where contracts can be signed are relatively low. If there are buyers willing to sign contacts for the expected life of the plant (or at least until it has paid back its capital costs), then the cost of output from a new entrant effectively caps the price that incumbents can charge for similar contracts. This does not make the market for all kinds of contracts perfectly contestable, of course, for new entrants will place little pressure on the price of short-term contracts, which do not last long enough for them to recover their capital costs. Nevertheless, the incumbents must be aware that high short-term prices will encourage entry, and may well practice a form of limit pricing. If retailers are reluctant to sign contracts, however, new entrant generators will face much greater price risk, raising the entry price.

Both static and dynamic arguments imply that a high degree of long-term contracting in the electricity wholesale market is likely to reduce prices. If the trend towards retail competition reduces the demand for contracts, wholesale prices are likely to rise. This would be undesirable, but we do not yet know if the effect would be important – how much might prices rise? This paper aims to quantify this effect with a formal model that can be used to produce numerical solutions.

In the next section, we outline the broad structure of our model, which is adapted from Powell (1993). The succeeding sections analyse the decisions made by generators, by regulated retailers, and by retailers facing competition. Section 6 gives some numerical solutions, to show the quantitative impact of these issues. Brief conclusions are given in section 7.

2. The model

We will model two strategic generators and a number of incumbent regional retailers. They meet in two wholesale markets, in which the generators set quantities. One is for long-term contracts, which might need to last for ten or fifteen years if they are to help finance a new power station. The second market is for sales of a much shorter duration. The literature typically calls this second market the "spot" market, but in the UK, a high proportion of electricity is sold under annual contracts. Most large retail customers are also supplied under annual contracts, and so a retailer who signs an annual contract to buy power at the same time has hedged most of the price risk it faces. We will therefore refer to the second market as the "annual" market, and ignore inter-year variations in prices and quantities.[1] The long-term contracts could be financial, hedging the annual price, or for physical delivery – the two types are equivalent for our purposes. The strategic generators may also face a price-taking competitive fringe – their output would be subtracted from the gross consumer demand to give the net demand for the duopolists.

We assume that the strategic generators set quantities in the annual market, following Powell (1993). In earlier work (Green, 1999) I used a supply function model for

[1] As long as the retailers have hedged the bulk of their expected sales with one-year contracts, and the generators have hedged their fuel costs, they face relatively low risks over the course of a single year.

the spot market. In many ways, this is a better depiction of competition in the electricity industry, but it suffers from a multiplicity of equilibria. A linear supply function model has a unique equilibrium, but is a special case in so far as it turns out that neither generator would wish to sell long-term contracts, given Cournot competition (a zero conjectural variation) in that market. Using Cournot competition in the annual market provides a unique equilibrium, and one in which the impact of each contract sold on the wholesale price is greater than in the supply function model (although this raises the danger of over-estimating their importance).

In the long-term market, we use a model based on quantity-setting, but with each firm having a conjectural variation about its rival's response to changes in its quantity. Powell (1993) assumed price setting in the contract market, and found that prices would equal marginal cost unless the generators colluded. The conjectural variations model encompasses the two polar cases of price and quantity setting. It can be viewed as equivalent to a supply function model in terms of its equilibria – each firm could be offering a supply function passing through the equilibrium price and quantity, with its conjectural variation giving the slope of the rival's supply function.

We assume that each of the retailers in our model is a regional incumbent with a relatively small share of the national market, taking prices in that market as given.[2] This means that we can model them as non-strategic participants in the wholesale markets. Powell (1993) models a small number of retailers, and they have a strategic motive for contracting, knowing that this will affect the wholesale price. We will not model final electricity consumers, but Green (2001) presents a detailed model that justifies the demand side presented here for small consumers.

We will model the retailers under two regulatory regimes. In the first regime, typical of Great Britain until 1998, and of most other countries around the world, the incumbents are regulated monopolies. In many countries, such a firm would be allowed to pass the cost of electricity purchases through to final consumers. This would give the incumbent little incentive to control its purchase costs, however. We therefore model a slightly more sophisticated approach, yardstick regulation. Each incumbent is allowed to charge a price equal to the average purchase cost in the rest of the industry. For simplicity,

[2] A larger retailer would have a strategic incentive to buy more contracts in order to depress wholesale prices.

we normalise the retailer's own costs and profit margin to zero. In the second regime, which has prevailed since 1990 for large customers in Great Britain, and was introduced for small consumers in 2002, there is competition and the incumbent retailers are allowed to charge any price that the market will bear.[3] This does not necessarily imply that prices will be driven down to the level of marginal costs. Most domestic consumers still buy their power from their local supplier, even though other companies are undercutting them by 5% (or more). Green (2001) models this as due to switching costs, real or psychological. Giulietti *et al* (2000) take survey evidence on the savings that consumers would require to switch suppliers. Both papers conclude that incumbents would maximise their profits with prices significantly above those charged by entrants.

Our model has three stages. In the first stage, electricity retailers and generators meet in the long-term contract market – generators set quantities, taking their conjectural variation of the rival's response into account, and the level of demand determines the price. In the second stage, the price in the annual wholesale market is determined. This depends upon stochastic factors – the level of demand by large consumers, and perhaps the level of entry – that are not resolved until after the long-term contracts have been signed. In the third stage, retailers set their prices to consumers, and their profits are determined. Although our "long-term" contracts only last for a single period, this could be easily changed. The key point is that the terms of the contract are agreed before it is possible to accurately forecast prices in the short-term market. Much of the structure of the model is based on that of Powell (1993) – in particular, we assume that the total demand by small consumers is fixed, so that the regulated monopoly need only consider price risk.

We have deliberately chosen to make the level of the strategic generators' demand the unknown variable that is resolved at the start of the second stage. Fuel prices might be seen as a more important source of uncertainty, but they have a symmetric effect on both incumbents and entrants. Furthermore, it is possible to sign hedging contracts for fuel, or to link the wholesale price of a generator's output to an index of fuel prices. These techniques reduce the risk that an electricity retailer would be left holding contracts that were uncompetitive with current market prices. While the model needs to be solved by

[3] There are still some regulatory constraints on the incumbents' prices at present, so the UK is not quite in this second regime yet, but the regulator is proposing to remove them.

backward induction, it is most convenient to start with the generators' actions in the annual wholesale market, the second stage of the model.

3. The generators

The generators are identical, with constant marginal costs equal to c. Generator i sells an amount x_i in the forward market, at a price of f. We model their behaviour in this market after considering the annual wholesale market. In that market, they face a downwards-sloping demand curve, $p = A - b\ (q_i + q_j)$, where Q is the total quantity demanded, p is the price in the annual market, and A is the intercept of the demand curve, net of output from the competitive fringe (if any). A is a stochastic variable, but its value is known by the time that the annual market opens. Each generator aims to maximise its profits, given by the revenue from sales in the forward market (x_i) and the annual market ($q_i - x_i$), less the cost of generation:

(1) $$\pi_i = (A - b(q_i + q_j))(q_i - x_i) + f\,x_i - c\,q_i$$

We can differentiate equation (1) to get the generator's reaction function:

(2) $$q_i = \frac{A - c - bq_j + bx_i}{2b}$$

The other generator has a similar reaction function, and we can solve the pair to give us the generator's output and the annual price as a function of each firm's forward sales:

(3) $$q_i = \frac{A - c + 2bx_i - bx_j}{3b}$$

(4) $$p = c + \frac{A - c - b(x_i + x_j)}{3}$$

Each firm's output is increasing in its own forward sales and decreasing in its rival's, while the annual market price is decreasing in each firm's forward sales. These results are now standard (Allaz and Vila, 1993), as is the implication that if both firms signed contracts for $(A - c)/2b$, half of the output that the industry could sell at a price of c, then it would be optimal for them to produce this amount, driving the annual price down to marginal cost.

In the forward market, the generators have to choose the level of their forward sales before they know the value of A, and hence the out-turn price in the annual market. We will see below that the forward price will not necessarily equal the expected annual price, and that the difference will depend on the level of forward sales. The generators' expected profits are given by:

$$(5) \qquad \pi_i^e = \frac{A^e - c + 2bx_i - bx_j}{3b} \frac{A^e - c - b(x_i + x_j)}{3} + (f - p^e)x_i + \frac{\sigma^2 A^e}{9b}$$

Each generator wishes to maximise its expected profits by choosing the best level of contract sales, given its rival's sales, and its conjectural variation as to how they will change in response to a change in its own sales:

$$(6) \qquad \begin{aligned} \frac{\partial \pi_i^e}{\partial x_i} = {} & \frac{2\left(A^e - c - b(x_i + x_j)\right)}{9} - \frac{A^e - c + 2bx_i - bx_j}{9} + (f - p^e) + \frac{\partial (f - p^e)}{\partial x_i} x_i \\ & + \frac{\partial x_j}{\partial x_i}\left(- \frac{A^e - c - b(x_i + x_j)}{9} - \frac{A^e - c + 2bx_i - bx_j}{9} + \frac{\partial (f - p^e)}{\partial x_i} x_i \right) \end{aligned}$$

Denoting the conjectural variation, $\partial x_j/\partial x_i$, by γ, this can be manipulated to give us a reaction function:

$$(7) \qquad x_i = \frac{\left(A^e - c\right)(1 - 2\gamma) - bx_j(1 - 2\gamma) + 9(f - p^e)}{(4 + \gamma)b - 9(1 + \gamma)\, \partial (f - p^e)/\partial x_i}$$

To make further progress, we need to know how the expected forward price premium varies with the number of contracts sold, and for that, we need to model the retailers.

4. A regulated incumbent retailer

We assume that there are two classes of electricity consumers, large and small. Even if the incumbent has a monopoly over small customers, we assume that large consumers are able to choose their retailer,[4] have zero switching costs, and therefore face the price in the annual wholesale market, p. These customers have a price-sensitive demand for electricity, which ensures that there is a downwards-sloping curve in the annual wholesale market. For simplicity, we assume that the volume of electricity taken by small consumers is fixed and insensitive to price. It will therefore not depend upon the method of regulation.

If the incumbent is a monopoly incumbent, it will sell this fixed volume, V, to small consumers at a regulated price of s. This price is set by yardstick competition – that is, it equals the average purchase cost of the other (regional) monopolies in the industry. Each firm has the option of buying in the long-term contract market and paying the forward price, f, or waiting for the annual market and paying the current price, p. We denote the average proportion of electricity bought in the annual market by a. (We will allow the firms to buy more contracts than they will sell electricity, but cap a at a value of 0.) This gives us:

(8) $$s = a\,p + (1 - a)\,f$$

The retailer has bought x MWh of electricity through forward contracts, and buys the remaining $(V - x)$ MWh on the short-term market. We normalise all the firm's other costs to zero, and so its profits are equal to:

(9) $$\pi = s\,V - p\,(V - x) - f\,x$$

If we insert the value of s, we obtain:

[4] This is the minimum market opening now allowed by the European Union – small customers may remain "captive", but a gradually increasing number of large customers must be allowed to choose their supplier.

(10) $\pi = [a\,p + (1-a)\,f\,]V - p\,(V - x) - f\,x$

or

(11) $\pi = (p - f)\,(\,x - (1\text{-}a)V)$

If the variance of p is σ^2, (which implies that A has a variance of $9\sigma^2$) then we obtain:

(12) $\mathrm{var}(\pi) = \sigma^2\,(x - (1\text{-}a)V)^2$

We assume that the incumbent has a mean-variance utility over its profits, given by:

(13) $\mathrm{U} = (p^e - f)\,(x - (1\text{-}a)\,V) - \tfrac{1}{2}\,\lambda\sigma^2\,(x - (1\text{-}a)\,V)^2$

Differentiating this equation with respect to x allows us to derive the firm's demand for contracts:

(14) $$x = (1-a)V\; + \frac{p^e - f}{\lambda\sigma^2}$$

The retailer wants to cover the same proportion of its sales with contracts as the rest of the industry, since this minimises the variance of its profits, unless buying in the forward market is expected to be cheaper than spot purchasing. If there are n identical retailers, the market inverse demand for contracts, in terms of the margin between the forward price and the expected spot price, is:

(15) $$f - p^e \;=\; (1-a)V\lambda\sigma^2 \;-\; (x_i + x_j)\,\frac{\lambda\sigma^2}{n}$$

We can insert equation (15) and its derivative with respect to x_i, $-\lambda\sigma^2/n$, into the generator's reaction function (7):

(16) $$x_i = \frac{\left(A^e - c\right)(1-2\gamma) + 9(1-a)V\lambda\sigma^2 - x_j\left((1-2\gamma)b + 9\lambda\sigma^2/n\right)}{(4+\gamma)b + (18+9\gamma)\lambda\sigma^2/n}$$

We can solve for x_i, bearing in mind that the generators' contract sales will be symmetric in equilibrium. For some parameter values, the retailers will not be fully hedged in the forward market, and a will be determined endogenously in the model. This is because each of the retailers will end up buying the average proportion of its needs in the forward market, so that $x_i + x_j = n(1-a)V$:

(17) $$x_i = \frac{\left(A^e - c\right)(1-2\gamma)}{(5-\gamma)b + 9(1+\gamma)\lambda\sigma^2/n} \qquad \text{for}\,(x_i + x_j) \le nV$$

For other parameter values, however, this formula would imply that the retailers bought more than their physical requirements in the forward market. We assume that they are allowed to do so, but that they are regulated as if they had exactly matched their physical requirements. This means that we must replace (1-a)V in equations (11) to (15) with V, and this gives us a different equation for x_i:

(18) $$x_i = \frac{\left(A^e - c\right)(1-2\gamma) + 9V\lambda\sigma^2}{(5-\gamma)b + (27+9\gamma)\lambda\sigma^2/n} \qquad \text{for}\,\left(x_i + x_j\right) > nV$$

Equation (17) is easier to interpret than equation (18), although their implications are similar. Forward sales are falling in the level of uncertainty and of risk aversion, and rising in the (absolute) value of the coefficient of variation. Bertrand competition is represented by $\gamma = -1$, and this value of γ would give us contract sales of $(A^e - c)/2b$, if equation (17) held at the equilibrium. That would be sufficient to drive the expected price down to marginal cost, even though we have a Cournot duopoly in the annual market, because the generators had covered all of their expected output in the forward market.

In practice, the retailers would have covered all of their sales to small consumers before the generators had covered all of their expected output, and so the equilibrium would be given by equation (18). The forward price would be driven down to marginal cost, but the retailers would only be willing to hold contracts in excess of their sales to small consumers if the forward price was below the expected annual price. This would be the case, because the generators would not cover all of their expected output in the forward market, and so the annual price would exceed marginal cost.

Generators are aware that if they reduce the volume of electricity sold forward, they can raise its price. A conjectural variation of (minus) one means that neither generator expects to succeed in doing so – any reduction in its own sales will lead to an offsetting increase in the other generator's sales. Lower values of γ, however, give each generator an incentive to reduce its sales, and lead to higher prices.

5. Retail competition

Our second scenario has an unregulated incumbent which is free to choose its retail price, r, but is facing competition from other (entrant) retailers. These retailers are assumed to offer power at the annual price, p, (since their other costs are normalised to zero). Assuming that there will always be some entrants who can offer power at the spot price, it will not pay the other entrants to hedge by purchasing contracts at the expected spot price. The entrant would make money if the spot price turns out to exceed the contract price, but would make a loss if the contract price exceeds the spot price, being forced to sell at the spot price in any event.

We might assume that the incumbent would be forced by competition to set its own price equal to the annual price. This would then guarantee that the incumbent would be exposed to risk if it hedged any of its purchases in the long-term market, but would do so by assumption. A more realistic assumption, and one which might appear to leave the incumbent's exposure to risk as an open question, is that the incumbent is protected by switching costs, and will keep much of its market, even if other retailers are undercutting it. We can represent this with a demand curve:

$$(19) \qquad q = V - h\,(r - p) \qquad \text{for } r \geq p$$
$$\qquad\qquad = V \qquad \text{for } r < p$$

It will never be optimal for the incumbent to set a retail price below p, since this would imply selling below marginal cost! The incumbent's profits are given by:

(20) $$\pi = (V - h\,(r-p)\,)\,(r-p) - x(f-p)$$

Differentiating with respect to r, we get:

(21) $$r = p + \frac{V}{2h}$$

Note that the profit-maximising retail price does not depend upon the contract price, or the volume of contracts signed by the incumbent, but only upon the spot price and the shape of the firm's demand curve.[5] The incumbent is willing to lose half of its sales in order to drive up the price – if this sounds extreme, note that incumbents in the UK lost around one-third of their small customers in the three years after they faced competition. We then have:

(22) $$\pi = \frac{V^2}{4h} - x(f-p)$$

(23) $$\mathrm{var}(\pi) = \sigma^2 x^2$$

and

(24) $$U = \frac{V^2}{4h} - x(f-p^e) - \frac{1}{2}\lambda x^2 \sigma^2$$

Differentiating this equation with respect to x allows us to derive the firm's demand for contracts:

(25) $$x = \frac{p^e - f}{\lambda\sigma^2}$$

[5] Note that we could increase the degree of competitive pressure faced by the incumbent by reducing switching costs and hence raising the value of h: in the limit, r will become arbitrarily close to p. The results in this paper are independent of the value of h, except to the extent that a retailer protected by switching costs may be wealthier, and hence less risk-averse.

The retailer will only buy in the forward market if this is cheaper than the expected price in the annual market – any forward purchases raise the variance of the firm's profits. The overall inverse demand for contracts, in terms of the margin between the forward price and the expected spot price, is:

(26) $$f - p^e = -(x_i + x_j)\frac{\lambda\sigma^2}{n}$$

We can insert equation (26) and its derivative with respect to x_i, $-\lambda\sigma^2/n$, into the generator's reaction function (7):

(27) $$x_i = \frac{(A^e - c)(1-2\gamma) - x_j\left((1-2\gamma)b + 9\lambda\sigma^2/n\right)}{(4+\gamma)b + (18+9\gamma)\lambda\sigma^2/n}$$

Solving, we get the equilibrium number of contracts sold:

(28) $$x_i = \frac{(A^e - c)(1-2\gamma)}{(5-\gamma)b + (27+9\gamma)\lambda\sigma^2/n}$$

In equilibrium, generators sell less electricity in the forward market if the retailers face competition than if the retailers are regulated monopolies. The annual price is higher than with regulated monopolies. The forward price is lower than the annual price,[6] however, and might be lower with retail competition than with regulated monopolies – that would be the case if $9\lambda\sigma^2/n > b$. (This result does not depend upon the value of γ.)

6. Numerical Solutions

We have presented a model in which the combination of risk aversion and retail competition leads to a lower degree of forward contracting in the electricity wholesale

[6] This is in contrast to the more usual case when contracts do reduce retailers' risk, and their risk aversion makes them willing to pay a premium, as modelled by, for example, Bessembinder and Lemmon (2002).

market, as Newbery predicted. The aim of this paper, however, is to quantify that reduction, to show whether it is important. To do that, we need to set values for our parameters.

We will chose values that are representative of the market in England and Wales in the early 1990s, when there was a dominant duopoly in generation, and twelve retailing incumbents (so $n = 12$). We will set $c = 20$, representing a marginal cost of £20/MWh. The parameters for the inverse demand curve (or strictly speaking, the residual demand curve, for there was already a competitive fringe of smaller generators at this time) facing the generators are $A = 50$ and $b = 2/3$. This means that in the absence of contracts, the generators would set a price of 30, and produce 15 units each (representing 15 GW), while their competitive output would be 22.5 units apiece. With no risk aversion and conjectural variations of zero, each generator would sell 9 units in the forward market, raising its total output to 18, and the price of both forwards contracts and annual sales would be 26. Conjectural variations of minus one bring the forward and spot prices down to 20, in the absence of risk aversion. Contracting thus leads to sizeable reductions in the wholesale prices.

We set $V = 2.5$, representing total sales to small consumers from our 12 incumbent monopolists of 30 GW. We set h to 0.15, based on the fact that a 10% saving on the overall retail price (which is roughly £60/MWh) has been sufficient for the RECs to lose about one-third of their smaller customers (or 0.9 GW of sales, in this model). Larger customers, who are in a competitive retail market and effectively buy at the annual price, make up the rest of the demand. We will use two values for the variance of the annual price, σ^2. The variance of the annual average Pool Selling Price from 1990/1 to 2000/1 was 5.76, while the variance of the Oslo price for NordPool from 1993 to 2003 was 34.9 (measuring the prices in £/MWh). This is in case the Pool had an atypically low volatility at an annual level, due to the high level of contracting and the interaction of market power and regulatory pressure. The NordPool price is closely linked to the level of rainfall, given the importance of hydro-electric generation in the Nordic countries, and is therefore much more volatile from year to year. (Nordic electricity retailers sell much of their power via tariffs that allow prices to change each month, passing through such volatility.)

The coefficient of risk aversion is hard to pin down, but crucial for the model. We use evidence from the stock market, and Grinold's (1996) "grapes from wine" technique, to suggest a plausible value. An investor who has to split her wealth, *W,* between a portfolio of stocks, *S* (paying the market rate of return, *m*) and government bonds, (paying the risk-free rate, *r*) would have the following utility:

$$U = (W - S)\, r + S\, m - \tfrac{1}{2} \lambda S^2 \operatorname{var}(m) \tag{29}$$

Differentiating with respect to the amount of money held in stocks, we get:

$$\frac{\partial U}{\partial S} = m - r - \lambda S \operatorname{var}(m) \tag{30}$$

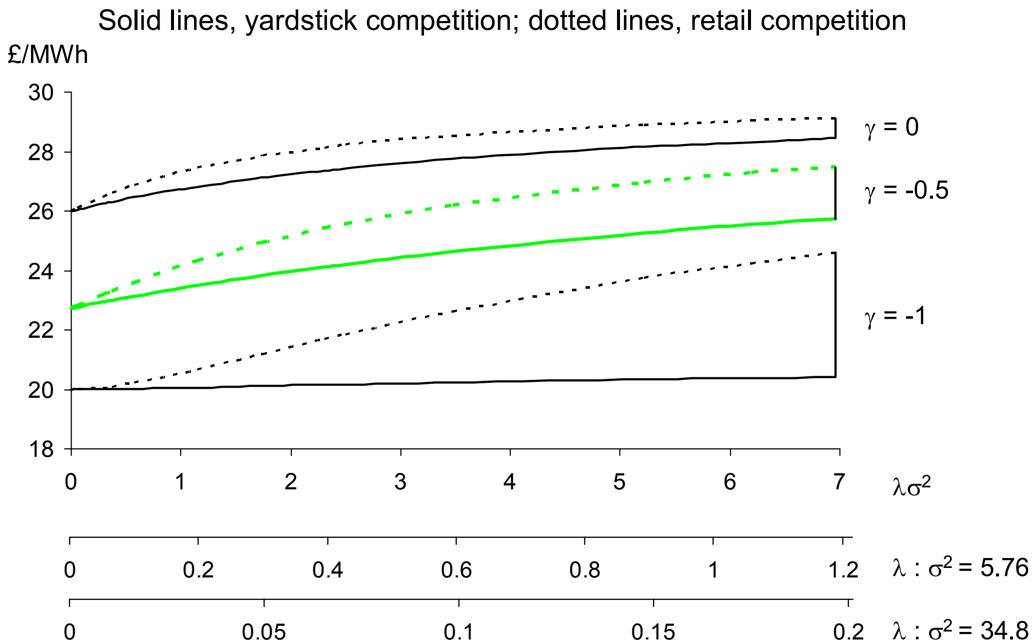
Solving for λ, we get:

$$\lambda = \frac{m - r}{S \operatorname{var}(m)} \tag{31}$$

Using annual data for the UK from 1955 to 2000, the mean real return on the FT All-share index (the market rate) was 6.3% per annum, with a variance of 0.0256. Taking the risk-free real rate as 2½%, we obtain λ = 1.48/*Stocks*, or 2.23/*Wealth*, if the investor holds two-thirds of her wealth in stocks.

What is the wealth of an electricity supplier? In 1998/9, electricity suppliers in the UK were making operating profits of £437 million on sales of around 300 TWh, or about £1.50/MWh (CRI, 2000). The present value of this would be about £12.50/MWh, discounting at a real rate of 12% (double the rate used in price control calculations, to reflect the greater risk in the supply business). Each supplier is selling 2.5 GW in the period we model, giving a "wealth" of 31.25, measured in our units of £1000/GWh. That gives λ = 0.071. In practice, part of the accounting profit reported above might represent an economic cost. The regulator allowed a profit margin of 1.5% of turnover when setting supply prices in 1998, or £0.90/MWh – if this is taken to reflect the economic cost that

Generators' expected revenues



should be deducted from accounting profits, we would have an economic profit of £0.60/MWh, "wealth" of 12.5, and $\lambda = 0.178$.

The figure shows how the parameters for risk aversion, the variance of demand and the conjectural variation interact to produce the realised wholesale price. The figure gives the expected weighted average of the two wholesale prices (forward and annual), weighted by the share of electricity that the duopolists sell at each price. The dotted lines are the average when there is actual competition, the solid lines the average with yardstick competition. Both prices increase with the level of risk aversion and uncertainty, but it is the gap between them that is most relevant for us. The two lines converge when there is either no risk aversion or no uncertainty, but rapidly diverge once both are present.

The lines are furthest apart when there is a high degree of risk aversion and uncertainty, and when the absolute value of the conjectural variation is high. With Bertrand competition in the forward market, the price of long-term contracts will be £20/MWh. Regulated retailers will not only cover all of their needs in this market, but will actually over-contract. The generators sell little at the spot price, itself depressed by the high level of contracting, and so their mean revenue per unit is close to £20/MWh. Retailers facing competition, however, buy many fewer contracts. The generators sell more of their output at the spot price, and this in turn is higher. With σ^2 = 34.8, and λ = 0.178, the mean price is nearly 19% higher with retail competition.

With the lower level of uncertainty, however, the generators' revenues are only 3% higher with retail competition than with yardstick competition. Similarly, a less competitive market for long-term contracts (in the sense of lower absolute values of the conjectural variation) gives much lower price increases if retail competition is introduced. A conjectural variation of –0.5 implies price increases of 3% and 7% for low and high uncertainty, while a conjectural variation of zero implies price increases of under 3%, whatever the degree of uncertainty.

7. Conclusions

The analysis in this paper has taken a deliberately simple model. An electricity retailer facing competition will be limited in its ability to pass on the costs of long-term contracts, should the spot price fall below the price in those contracts. This will reduce the optimal level of contracting for a risk-averse retailer, relative to a regulated incumbent that is allowed to pass on a yardstick measure of actual costs in the wholesale markets. Generators will enter the annual market with fewer forward sales when there is a competitive retail market. The fewer long-term sales the generators have made, the more willing they are to raise the annual price. With parameters reflecting the English electricity market of the 1990s, this might have raised wholesale electricity prices by about 3% on average. This might be offset if retail competition brings benefits such as a greater variety of offerings (in terms of customer service and payment methods), or if it allows a reduction in regulation.

Retail competition has a stronger impact on prices when price volatility is high, and when the conjectural variation is close to minus one. When the demand for contracts was strong, English generators were willing to cover most of their sales with long-term contracts, which is consistent with a conjectural variation near minus one. If the price volatility in the English market has been atypically low, then parameter values representing more normal conditions would imply that retail competition could raise wholesale prices by much more – up to 19%, with the level of volatility seen in the Norwegian market.

This paper has not modelled the dynamic impact of contracts – entry into the wholesale market is easier if retailers (or other parties) are willing to sign long-term contracts. If reluctance to contract impedes entry, this could place further upwards pressure on prices. The electricity market in England and Wales has changed significantly over the past five years, with retail competition, a trend towards vertical integration,[7] and a new set of wholesale trading arrangements. It may take time for companies to adjust to all of these changes, but once they have done so, we should study their contracting behaviour. The model in this paper suggests that if prices are sufficiently volatile from year to year, the move to retail competition in the electricity industry could lead to a significant reduction in long-term contracting, and higher prices overall.

Bibliography

Allaz, B. and J-L Vila (1993) `Cournot Competition, Forward Markets and Efficiency', *Journal of Economic Theory*, Vol. 59, No.1, February, pp.1-16

Bessembinder, H and M.L.Lemmon (2002) "Equilibrium Pricing and Optimal Hedging in Electricity Forward Markets", *Journal of Finance*, vol. LVII, no. 3, pp 1347-1382

CRI (2000) *The UK Electricity Industry: Financial and Operating Review 1998/99* Centre for the Study of Regulated Industries, The University of Bath

Giulietti, M., C.M.Waddams, and M.Waterson, (2000) *Redundant Regulation? Competition and Consumer Choice in the Residential Energy Markets*, CMuR Research Paper No. 00/4, University of Warwick

Green, R.J. (1999) "The Electricity Contract Market in England and Wales" *Journal of Industrial Economics*, Vol XLVII, No 1, pp.107-124

Green, R.J. (2001) *Can Competition Replace Regulation for Small Utility Customers?* CEPR Discussion Paper 2406, Centre for Economic Policy Research

[7] Modelling the impact of vertical integration in this setting is a task for future research.

Grinold, R.C. (1996) “Domestic grapes from imported wine”, *Journal of Portfolio Management*, vol 26, special issue (December), pp 29 - 40

Littlechild, S.C. (2003) “Wholesale spot price pass-through”, *Journal of Regulatory Economics*, vol. 23, no. 1, pp 61-91

Newbery, D.M. (1998) “Competition, contracts and entry in the electricity spot market”, *RAND Journal of Economics*, vol. 29 no 4 pp 726-749

Newbery, D.M. (2002) “Problems of liberalising the electricity industry” *European Economic Review*, vol. 46, pp 919-927

Powell, A. (1993) `Trading Forward in an Imperfect Market: The Case of Electricity in Britain', *Economic Journal*, vol. 103, No 417, March pp 444-53

Wolak, F. (2000) “An Empirical Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market”, *International Economic Journal,* vol. 14 no 2, pp 1-40